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A Case Study of Multidimensional Analysis for Student-staff Collective Cognitive Responsibility in Active Learning Classrooms

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Is each participant's collective cognitive responsibility fostered in long-term working experience? To answer this question, this study conducted two investigations focused on university student-staff working to improve an active learning classroom at a university. The investigation used social network analysis (SNA) and coding-and-counting analysis. We applied these analytical methods to discourse in Social-Networking Service (SNS) used by student-staff and instructors working together for improving and maintaining an active-learning-classroom. The SNA and its visualization in four years indicated that the instructors actively mediated any non-ideal communication between the student-staff in the SNS. Conversely, a coding-and-counting method for two-and-a-half years revealed the occurrence of trend changes in student-staff discourse based on a time-series. The results from the SNA and coding-and-counting method illuminate different dimensions of student-staff improvement of collective cognitive responsibility. The effect of multidimensional analysis and how to interpret the combination of the results were also discussed.

Keywords: Active-learning classroom, Coding-and-counting analysis , Collective cognitive responsibility, Social network analysis, Student-staff.

Introduction

Recently, universities have been equipped with active learning spaces, and support for learning in such spaces has been progressing. Simultaneously, it is without a doubt that staff teams who support learning in active learning spaces are challenged in maintaining and improving the space because work in active learning spaces is distinguished as new types of work. Accordingly, collaborative knowledge creation (Nonaka & Takeuchi, 1995) is vital and contributions from every learner's "collective cognitive responsibility" are essential for this (Ma, Matsuzawa & Scardamalia, 2016). Some research has suggested externalization methods for the improvement of collective cognitive responsibility using social network analysis (SNA) and discourse analysis (Zhang, Scardamalia, Reeve, & Messina, 2009; Ma, Matsuzawa & Scardamalia, 2016). A condition of rotating leadership was observed in previous research in classrooms as externalized collective cognitive responsibility in the research. Participants in classrooms gradually shared responsibilities. However, such research focused on pedagogical knowledge creation in an elementary school. In contrast, we intended to analyze university students working as student-staff to maintain and improve active learning classrooms from the viewpoint of the improvement of collective cognitive responsibility. Discourse in SNS was analyzed by both SNA and a traditional discourse analysis called "coding-and-counting analysis" (Vogel & Weinberger, 2018) to contrast these results. Research was conducted over four years using SNA, and discourse analysis used two-and-a-half-years of data.

Aims of this study

This study develops a new multi-dimensional analysis method using SNA and coding-and-counting analysis for analyzing improvement to collective cognitive responsibility. Accordingly, we adopted two investigations. The first

used SNA, and the second used coding-and-counting analysis. Both focused on the same organization designed for instructors fostering student-staff collective cognitive responsibility. The dataset was recorded by SNS, which is used by the participants of the organization. The first externalizes the changing process of the organization over four years which includes exchanging members in the organization. During the four years, some participants left the organization, and some joined. Thus, the first analysis illuminates the state of each stage of the organization. The second one describes the two-and-a-half years' changing process of each participant in the organization. Initially, the participants worked as novices; however, they eventually became experts through their own working experiences. The first investigation focused on the formation of the organization and the second investigation specialized in each participant's change. The combination of the two is expected to propose a new multidimensional analytical framework for the improvement of collective cognitive responsibility.

Research Backgrounds

Collective cognitive responsibility

Collective cognitive responsibility is a state where individuals within an organization understand each other's knowledge and, in a state of mutual review, each feels responsible for organizational knowledge (Bereiter & Scardamalia, 1993; Scardamalia, 2002). Contributions from every learner's collective cognitive responsibility are essential in collaborative knowledge creation (Ma, Matsuzawa & Scardamalia, 2016). Knowledge creation means the ability to create new knowledge, expand it to the whole organization, and solidify it as products, services, and systems (Nonaka & Takeuchi, 1995). However, evaluating the improvement of collective cognitive responsibility is difficult because it is treated like a general skill for broader working situations and cannot be easily observed as a discipline or concrete knowledge.

Some previous studies suggested externalization methods for the improvement of collective cognitive responsibility (Zhang, Scardamalia, Reeve, & Messina, 2009; Ma, Matsuzawa & Scardamalia, 2016). Zhang et al.'s research, which leads in this field, investigated the effects of changes in the learning format on learning by conducting a study on the characteristics of light in a fourth-year elementary school class over three years. The first year involved a division-of-labor-style collaborative learning in fixed groups, the second year involved collaborative learning, which employed strategies such as jigsaw learning as groups interacted as they were reconfigured, and the third year involved collaborative learning which allowed learners to independently form and rearrange groups and formulate inquiries according to their interests under the shared theme of "light."

These investigations into collective cognitive responsibility used both face-to-face discussions and data from an SNS-based learning support system called the "Knowledge Forum" (Scardamalia & Bereiter, 1994). Individuals were analyzed as nodes regarding viewing and citation logs of student and teacher notes. Conducting an SNA in which each participant was treated as one node and then visualizing the results in graph form showed that students in the first year mainly viewed and cited their notes and those of group members, with the teacher being the one who "connected" groups by viewing and citing notes. Students in the second year interacted between groups and independently viewed and cited the notes of various groups; however, the teacher was the "center" of all interaction. In the third year, students were given the freedom to create and rearrange their groups and proactively view and cite each other's notes in the class; the teacher was, for the first time, removed from the central position. In line with the increased vitality of interaction, students' understanding of the content was deeper in the third year than in the first and second years.

Assessment

The above-mentioned studies suggested that students' data-collecting and scaffold tool play an essential role for evaluation. van Aalst (2013) reported the importance of providing these tools, how to use them in classrooms, and how to interpret data saved by these tools. This suggests the importance of the mutuality of students' learning activities and assessment. The importance is also indicated by twenty-first-century skills, which is an elaborated definition of skills to develop all students (Griffin, McGaw & Care, 2012).

However, a combination of students' learning activities and assessment is difficult to realize in actual learning environments especially if we use qualitative analysis, because typically this is time-consuming. Accordingly, van Aalst (2012) suggested that SNA and qualitative analysis (such as coding-and-counting analysis) be used in combination (Vogel & Weinberger, 2018).

Social Network Analysis. It is well known that network analysis enables the data-based visualization of changes

involving nodal interactions (Barab´asi, 2005; Strogatz, 2001). SNA is the ideas applied to educational contexts to externalize relationships between the students or words using discourse as data and the analytical method (Ma et al., 2016; Oshima, Oshima & Matsuzawa, 2012; Zhang et al. 2009). It enables the automated data-based visualization of changes in the ways people interact and the analysis of the interaction between participants and time-based changes. Oshima et al. (2012) used KBDeX for group work in a physics class to show the significant influence of the oral communications of TA's on the quality of the oral communications of groups from the viewpoint of knowledge creation. Using SNA, Zhang et al. (2009) found increases in students' degree centrality and betweenness centrality in classrooms which were designed to improve students' collective cognitive responsibility in knowledge creation activity. This study showed that it is possible to investigate collective cognitive responsibility by calculating the degree of centrality and betweenness centrality of such interactions.

In the context of an SNA using discourse, metrics of betweenness centrality, degree centrality, and closeness centrality are used to reveal the transformation of individual relationships (Oshima et al. 2012). Values of betweenness centrality illustrate the importance of each participant node as a community mediator. A higher betweenness-centrality value for a specific node means that that a participant effectively mediates other participants by referring to or being called by other participants.

Recently, a new analytical method called epistemic network analysis based on network analysis was used instead of SNA. Csanadi, Eagan, Kollar, Shaffer, & Fischer (2018) used epistemic network analysis which models temporal co-occurrences of codes in discourse based on the theory of "epistemic frames" (Shaffer, 2018). However, there is no previous research to show the improvement of collective cognitive responsibility using this analysis.

Coding-and-Counting Analysis. As previous research suggested, we can find characteristics of student-staff detailed developmental trajectories using coding-and-counting analysis especially if we analyze the discourse (Berkowitz & Gibbs, 1983; Miyake, 1986). In all coding-and-counting analysis, we first define a rubric along with an objective of the analysis. A rubric is a ruleset for the categorization of each dialogue. Some previous research defined its own rubric for its original purpose (Berkowitz & Gibbs, 1983; Miyake, 1986); however, other research used previous theories as the foundations of their rubrics (Ma et al. 2016; Shirouzu, Miyake, & Masukawa, 2002). The advantage of using previous theories as a rubric is that we can concentrate on our interpretation of the data. If we find cases which cannot be explained by the previous theories, we may expand these theories.

The concept of "adaptive experts" (Hatano 2001; Hatano & Inagaki, 1986) is interpreted as a summary of characteristics of organizations which was designed to improve participants' collective cognitive responsibility. Scardamalia & Bereiter (1994) demonstrated the importance of the attitude of being responsible for creating one's knowledge in social interaction, & Miyake (2008) suggested that students who were in such learning situations achieve adaptive experts. The following four points were proposed as conditions for the development of adaptive experts.

(1) Continuously encounter various novel challenges
(2) Engage in dialogical interactions
(3) Be relieved from urgent (imminent) external requirements
(4) Be in a community respecting understanding whole system

Adaptive experts were explained in contrast to "routine experts" as follows: "It is possible to invent new procedures from their specialized knowledge." Bransford, Brown, & Cocking (2000) argued about the importance of developing students' self-directive attitudes in learning from the viewpoint of adaptive expertise because students can transfer their knowledge or skill to the other domain's learning, not limited to a specific domain. Darling-Hammond & Baratz-Snowden (2005) also emphasized the importance of adaptive expertise in a teacher's development. Teachers, as experts, are expected to develop brand-new teaching methods when their routine work is inefficient.

Research context

Participants and environment

This section discusses the characteristics of classroom-M facilities and the required roles of student-staff. Student-staff working in an active learning classroom (called "classroom-M") in a Japanese technological university are participants of this study.

Classroom-M is a facility where group work can take place, using ICT equipment enabling a variety of classes, from the first year of undergraduate study through the post-graduate level, to be conducted in a flexible manner (Kondo & Narahara, 2011). Figure 1 presents the interior of classroom-M. Classroom-M has a floor area of 260m^2 and capacity of ninety students.

Figure 1. Interior of classroom-M

To conduct classes which use ICT, classroom-M is equipped with 100 laptop computers and 60 tablets which are centrally managed and can simultaneously work over wireless LAN. From its completion in 2011 to 2018, it has maintained an extremely high level of operation, with a maximum of 84% occupancy that never drops below 60%.

Classroom-M is staffed by one instructor, one support-staff member, and between five to 15 student-staff, who are the operational team. The instructor affiliated with classroom-M is stationed in the staff-room with the support-staff member and student-staff. The instructor supervises student-staff work; however, he refrains from providing direct instruction on how to solve and promote problem-solving through discussions between student-staff as far as possible.

Student-staff and their work

Student-staff provide general support for the use of facilities and for improving classroom-M. They work in shifts as part-time technical support staff. While it is possible to apply for a position from the first year of undergraduate study onwards, not all applicants are accepted. If they so desire, and there are no problems with their attitude towards their work, s/he can continue working until s/he graduates. There is, for example, a Teaching Assistant (TA) system for students working at the university, but student-staff who work in this classroom are not classified as TAs. Student-staff are officially affiliated with classroom-M management organization, not limited to each class.

There are two main types of work. One is user support, and the other is classroom and work improvement as follows. Student-staff are required to record his/her daily report of work in classroom-M to a SNS, review the other's posts in the SNS, and reply if needed.

(1) User support
During classroom operating hours, student-staff are stationed in the room in shifts. They proactively cooperate and consult with teachers for each class to support studying students in classroom-M. A prime example is the setup of the class environment and in-class support. Student-staff do not fixedly implement a predetermined work structure, and individual judgment is required. Rather than remembering a certain way of doing things, they are expected to understand and share the intentions of each teacher and to work independently.

(2) Maintenance and improvement of facility and equipment
The other aspect of their work is to maintain and improve the facility and equipment. Student-staff conduct their work under the principle of "Continuous creation of an improved learning environment."

- Maintenance of infrastructure and operation verification

Updating basic software, organizing replacements and exchanges of faulty equipment, and verification of operation relating to such things.

- Proposal and execution of improvements

As student-staff working collaboratively to solve problems, they are aware of the actual state of use. Based on their experience, they propose the introduction of new equipment, reviewing the way existing equipment is used.

As mentioned, such an organization was designed to improve the collective cognitive responsibility based on Hatano's theory. (1) Student-staff continuously encountered various novel challenges during their working time, and (2) they engaged in collaborative interactions in both face-to-face and the SNS. (3) They were relieved from urgent requirements, and the instructor could help them. Finally, (4) the organization respected each student-staff's understanding of systems.

Investigation of collective cognitive responsibility through social network analysis and visualization

Method

This study uses the discourse process visualization system KBDeX (Matsuzawa, Oshima, Oshima, Niihara, & Sakai, 2011), which is a system that uses networks to visualize time-based changes in aspects such as connections between members of a community or referential relationships between SNS threads. The focus point of this analysis is capturing student-staff collective cognitive responsibility through their interactions on the SNS.

In this context, this analysis works off previous studies to investigate changes in the collective cognitive responsibility of members in a group with changing membership by focusing on the content of postings to SNS threads by student-staff involved in the operation of classroom-M.

This analysis focuses on data of postings to an SNS, for information sharing, which was used by student-staff working collaboratively for the continuous improvement of classroom-M. The target data consisted of a total of 28,818 posts over four years between April 2014 and March 2018. The target period was selected in alignment with the amount of time a university student usually spends earning an undergraduate degree. There were changes in staff over the four years, with some working for the whole four years and some working for just six months, for example. The SNS users were the student and instructor staff of the active learning classroom. The data were used to analyze both the changes in the state of the network of the entire organization and changes in the behavior of instructor staff within the network.

To analyze the changes in the network over time, the four years' worth of data were divided into six-month periods, with the degree of centrality and betweenness centrality values (indices of evaluation in SNA) calculated for each period. A higher degree of centrality values indicates more nodal connections within the network. Higher betweenness centrality values correspond to higher levels of functionality in connecting nodes on the network.

In addition to the daily-work-reports (the "reports") by individual student-staff, the SNS, which is the focus of analysis here, also includes information to be shared between the student-staff, such as changes to scheduled classes, fault reports concerning ICT equipment in classroom-M, and discussions regarding how to fix such faults, for example. The posts are shared among all the student-staff and comments can be contributed to the posts. All comments are treated as child posts of the posts. It is also possible to construct a hierarchical relationship solely with child posts. This functionality can be used to create a grandchild post for commenting solely on a specific child post. In such a case, the new post, child post, and grandchild post have the same thread number.

The method for processing the SNS data involved the student-staff who had posted on the same arbitrary SNS thread regarded as being connected in the network to visualize the relationships between all the student-staff, including instructors. Specifically, a correspondence table of thread numbers and user names of contributors was inputted into KBDeX, with thread numbers which shared two or more posts extracted and inputted as keywords. The users with shared keywords are connected as nodes on KBDeX; the users who shared an arbitrary thread number were connected on the network. The effect of this process was that the users who had not directly exchanged opinions on the thread were connected in the network. Using the above data and method of analysis, it is possible, based on the thread numbers in the SNS data, to visualize the relationships between the student-staff in nodes on the network.

A previous study (Zhang et al., 2009) suggested that, through the process of increasing students' collective cognitive responsibility, students will engage in discussions with a variety of classmates on an SNS and the number of classmate entries that they cite will increase. In this study, it can be posited that increases in student-staff collective cognitive responsibility will lead to many connections with the student-staff on the SNS and increases in degree and betweenness centrality.

Specifically, the following three indices were investigated using SNA: (1) degree of centrality of the instructor, (2) degree of centrality of the entire organization, and (3) betweenness centrality of the instructor. After investigating the above three aspects, an examination was conducted using network diagrams for each period.

Results

Degree of centrality and betweenness centrality. The results of the analysis, as shown in Figure 3, show that (1) the instructor's degree of centrality (Figure 3, dotted line) was high and stable. This shows that the instructor

usually connected to most of the other student-staff. Next, (2) the degree of centrality of the entire organization (Figure 2, solid line) decreased over time. This implies that connections between student-staff decreased over time. Finally, (3) the instructor's betweenness centrality (Figure 2, dashed line) increased as the degree of centrality of the entire organization decreased. This implies that, as organizational linkages decrease, the instructor simultaneously worked to connect student-staff.

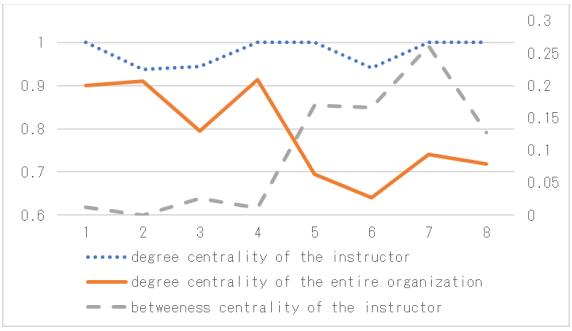

Figure 2. Degree of and betweenness centralities for the instructor and the entire organization

Network diagram. Figure 3 presents the network diagrams for the second period (when the average value of an instructor's betweenness centrality was at its lowest) and the seventh period (when it was at its highest). In the seventh period, the instructor was observed to be mediating the relationship of two independent student-staff.

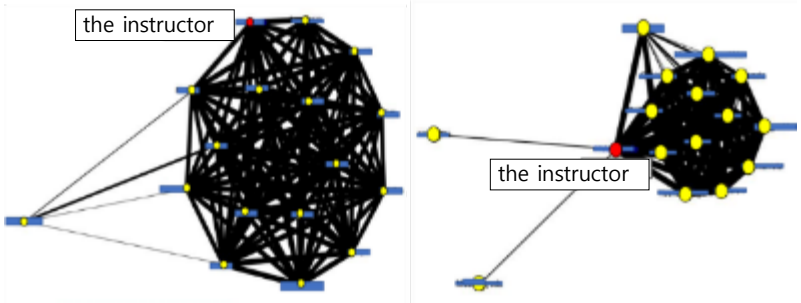

Figure 3. Network diagrams for lowest (Period 2, left) and highest (Period 7, right) values of the instructor's betweenness centrality.

Discussion

The results of this study suggest that the instructor made connections between student-staff over time, conducted more work on the SNS. It may be that the instructor could sense when information transmission between student-staff was not going well and thus worked in this way to remedy it. Due to circumstances like the fact that student-staff would leave their jobs when they graduated from university, there would be changes in staffing every six months. This may be the reason the instructor could be observed connecting student-staff. On the other hand, from the perspective of student-staff development, a better organization could emerge if this kind of mediating activity involved long-serving student-staff, not as an instructor, performing this function. In fact, in the third period, the betweenness centrality of student-staff was higher than the instructor's one. A previous study (Zhang et al., 2009) visualized an SNS-based discussion of learning in classrooms and found that a teacher moved away from the center. This was considered to mean that student-staff centered learning was occurring, and that students-staff collective cognitive responsibility had increased. For this study's target organization, it can be proposed that the environment for fostering the collective cognitive responsibility of student-staff requires investigation.

Investigation of collective cognitive responsibility through Coding-and-counting Analysis

Method

Overview. The trend analysis uses seven student-staff daily-work-reports from the SNS post where student-staff

activities were recorded in text form. On the other hand, in-depth analysis uses the daily-work-reports and focuses on student-staff with long work experience who had continuously posted to the SNS.

Participants. Target data for the analysis of general trends came from seven student-staff (A, B, C, D, E, F, G) with three or more years of service and two-and-a-half or more years of records on the SNS. The reason for choosing a period of employment of three or more years was that the average service providing the duration of student-staff was three years.

Student-staff A was selected from the above seven for an in-depth analysis into changes over a long period. The reason for selecting student-staff A was that she engaged in much more collaborative behavior, such as consulting with other student-staff than the other student-staff and, as such, it could be assumed that changes over the two-and-a-half-year analysis period would be easy to identify.

To grasp an overview of the changes in the seven student-staff which could be attributable to work experience, the half-year period between the start of employment and the six-month mark was labeled the "entry period" and the half-year period between 2 and 2.5 years was labeled the "proficiency period." A comparison of the SNS content in the two periods was conducted. Of these students, the 2.5-years' worth of posts of student-staff A were divided into five half-year periods and analyzed to uncover any changes.

Procedures.

We expected each student-staff had been changed gradually following these three trends based on Hatano's (2001) concept of adaptive expertise mentioned in the background section:

(a) identifying issues of classroom-M.
(b) doing one's work collaboratively with his/her colleagues.
(c) sharing an ideal image of classroom-M with his/her colleagues.

First, (a) suggests that student-staff gradually understand normal and problematic situations of classroom-M through their experience in first understanding a situation ((4) in conditions for the development of adaptive experts in the background section). Student-staff encounter a variety of problems during their work time because various users did diverse things (1 in adaptive experts' condition). Second, (b) is supported because student-staff do not work alone during shifts and do not work in fixed pairs to enhance dialogical interactions (2 in adaptive experts' condition). It could be easier to avoid urgent situations when two or more people are working simultaneously (3 in adaptive experts' condition). Finally, (c) suggested that avoiding a division of labor promotes conceptual understanding of the background of processes rather than simple rote learning.

In the following analysis it is sometimes the case that the total number of items counted exceeds the number of posts since the duplicates were permitted when counting the number of aspects corresponding to (a), (b), and (c) in a single post.

Seven student-staff were analyzed in trend analysis. As a baseline for the analysis, the total number of rows posted into the SNS by them over the 2.5 years was counted independently. Subsequently, considering the requirements, the analysis was performed as follows.

(a) Number of items where each student-staff was consulted about work
(b) Number of items where a work-related request to the other student-staffs was made
(c) Number of items where matters concerning learning/education-related theories, books, and similar were referenced

While the above analysis provided an overview of student-staff working in classroom-M, the fact that it was limited in providing an understanding of the details of each student-staff's development meant that a case study analysis of one student-staff had to be done.

In an in-depth analysis, (a), (b), and (c) were counted in the entries of student-staff A. Additionally, the item count in half-yearly subtotals was also calculated.

Results

To investigate the validity of the analysis, two of the researchers independently analyzed the data for the entry and proficiency periods of student-staff according to the same analysis standards. The degree of agreement between the two researchers was k=1 (Cohen's Kappa).

Trend analysis. The total number of the posts by the seven, from the first daily report to the last was 2,063 (with a total of 22,448 lines). Most of the content consisted of administrative communication such as daily work reports and shift changes.

Table 1 presents the results of a comparison of (a), (b), and (c) between the entry period and the proficiency period. The total for the seven members shows an increase between the entry and proficiency periods, with the student-staff having increased in the proficiency period by (a) approximately 2.3 times, (b) approximately 7.3 times, and (c) approximately 6.8 times.

The above results indicate that the seven student-staff consulted one another as they engaged in their work, regardless of the number of years they had been involved. Conversely, the number of requests made to the other student-staff and references to research knowledge tends to increase with the length of participation. In this context, the following case study analysis investigates changes in the number of entries over time.

Table 1
Number of lines in entries of seven student-staff about the entry period and proficiency period

	# of lines in the posted articles		(a) # of lines for consultation		(b) # of lines for request		(c) # of lines for references to the previous research	
	entry	proficiency	entry	proficiency	entry	proficiency	entry	proficiency
A	293	460	7	13	0	13	0	5
B	116	1519	5	11	0	18	0	10
C	359	812	5	9	2	9	1	2
D	66	509	0	9	0	11	0	0
E	258	383	3	4	5	6	1	2
F	393	457	2	4	1	4	2	6
G	149	569	3	7	1	5	1	8
subtotal	1677	4712	25	57	9	66	5	34

In-depth analysis.

・Changes in number of the references to consultation, requests, and research knowledge

Figure 4 presents the normalized numbers of entries relating to (a), (b), and (c) based on the number of lines entered in the proficiency period.

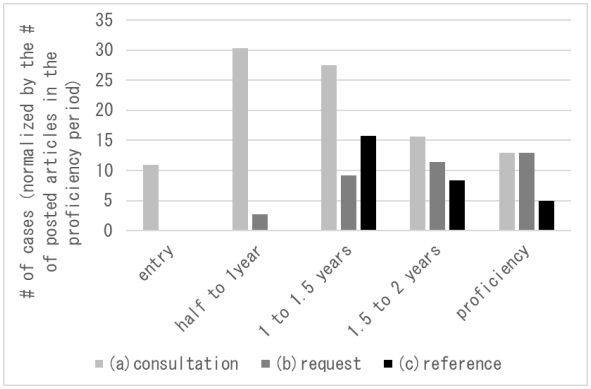

Figure 4. Breakdown of entries (a, b, c) by student-staff A

・Analysis of accounts of work improvement and reasons concerning one's work

From the above results, it can be presumed that student-staff A attained a certain degree of proficiency after 1-1.5 years. This suggested that student-staff A mastered the operations required for running classroom-M. Accordingly, she reached a level where she can recognize work-related improvements. Figure 5 supports the trend.

As Figure 5 shows, the number of reasons increased greatly. Furthermore, descriptions relating to work improvements appeared in the same period and continued to increase from this period through to proficiency.

The results of the above case study suggests that, from the beginning of student-staff A's employment to the first

year mark is the period where they were able to conduct the work, up to the 1-1.5-year mark is the period where they grasped the meaning of their work and made requests to others and began to make improvements on their initiative, and from the 1.5-year onwards is the period where they expanded what they could do as part of their regular work.

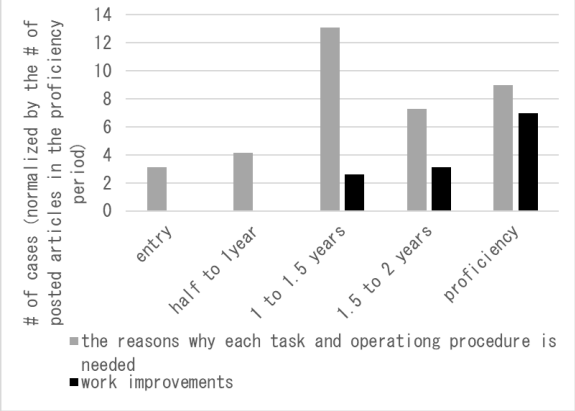

Figure 5. Breakdown of student-staff A's entries

Discussion

These results showed that underlying student-staff ability to independently engage in the improvement of their work and classroom-M facilities, there was deeper understanding of why one's work was necessary and the reasons for work procedures and that such an understanding may be influenced by (a) the interactions with colleagues and discovering issues, (b) engaging in one's work as a member of the community, and (c) learning about the theoretical background of the direction the community is pursuing. The above results provide suggestions relating to the necessary conditions in environments for improvement of student-staff collective cognitive responsibility and their contribution to the development of the organization.

Conclusion

To examine analytical methods for collective cognitive responsibility, we applied SNA and its visualization and coding-and-counting analysis. SNA and its visualization indicated that the instructor actively mediated communication between student-staff when the communication in their organization seemed to be non-ideal. Conversely, the coding-and-counting method revealed that the occurrence of trend changes in each student-staff discourse was based on time-series. The result from SNA and the coding-and-counting method externalized different dimensions of student-staff improvement of collective cognitive responsibility.

The implication of this research supports Ma et al. (2016) and Zhang et al. (2009). However, this research is impressive because we show such characteristics based on a real, longer-term dataset than Ma et al. and Zhang et al. Ma et al. focused on three months of a grade 4 class, and Zhang used data collected at yearly intervals from a fixed class. This study scaled-up to a situation which more closely resembles actual society as suggested by Nonaka & Takeuchi (1995), with both annual changes in the composition of members and long-term staff members and where investigations were conducted from a variety of perspectives.

According to our results, SNA is appropriate for drawing the agent who works for making relationships within an organization. However, the coding-and-counting analysis revealed detailed developmental trajectories of each student-staff. We can find both macro- and micro-level changes when we use SNA and coding-and-counting analysis even though the dataset was almost the same. There are possibilities to adapt the analytical method which is used in the coding-and-counting analysis to SNA and then compare SNA and coding-and-counting analysis; however, it is not easy because SNA requires describing the counting method. To fulfill the requirement, we should choose keywords for each category; however, this is not easy because each person uses different keywords to describe the same situation. Thus, we used coding-and-counting analysis without deciding strict keyword lists and interpreted contexts of each article.

These implications suggest that using SNA for grasping each participant's position to find some problems with less effort than coding-and-counting analysis and checking the contents of each relationship to suggest how to improve the quality of interaction between the participants simultaneously is efficient for organizational development. The advantage of SNA is that it is a costless method, so we will develop automated feedback systems for results of SNA to each participant to improve their self-directive activities with their peers for the future.

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