A Proposed Method to Support Awareness of Specialization for Interdisciplinary Communication Education

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***Abstract*—The more technologies are being developed and used, the more problems occur in many technical fields. Interdisciplinary communication is suitable to solve such problems. However, the education fostering this approach is still insufficient. The purpose of this study is to develop an interface to support the awareness of specialization so that we provide an effective interdisciplinary communication education for participants. Towards this goal, we utilize the transition of speakers' specializations following turn-taking and we define it as "patterns". To support awareness of specialization, this study focuses on the rate at which participants recognize other experts' specialization and specify the patterns when the awareness of specialization is easy to obtain. Experiments have been performed on 16 participants and were analyzed based on quantity and accuracy of the information to ascertain the effect of the proposed pattern. Our results show that the proposed pattern can give information at the rate of about 50% and support participants' recognition of other experts' specialization. From this result, the proposed pattern can support participants' recognition of other experts' specialization. Based on this, we propose an interface that shows when proposed patterns are likely to create chances to perceive specialization.**

Keywords–Interdisciplinary; Communication; Specialization.

I. INTRODUCTION

In recent years, experts' fields of science technology have become increasingly subdivided into many areas. By separating fields, we can encourage the growth of specific disciplines. However, some problems accompany the subdivision of learning fields; for example, we miss out on a holistic picture and it becomes more difficult to solve problems which span more than one technical field. To solve these problems, interdisciplinary communications are becoming more important [1]. For example, in the field of human / computer interaction, people are developing systems to improve interaction, not only between humans and computers, but also among humans. When we develop such systems, it requires the knowledge of psychology and sociology to perform practical interactions. In addition, there are various subjects such as medical science and economics to be considered. If we focus on such fields, we should not only investigate relevant studies, but also communicate with experts in those fields. However, there are few opportunities to communicate with other fields in a practical way in the Japanese educational environment. For that reason, it is thought that interdisciplinary communication education is insufficient [2].

In such a situation, interdisciplinary discussions are focused as a method of learning interdisciplinary communication [3], because interdisciplinary discussion may function as training for communication with people who have different specializations. In learning methods by using discussion, it is important to have interests in the differences between specializations and to recognize these features. By examining other expert's specialization, we better understand our own research position in academia; by acquiring different experts' knowledge and viewpoints, we have the opportunity to develop new technologies. However, it is difficult to fully comprehend other participants' specialization in actual interdisciplinary communication. These difficulties are due to the complexity of the contents of interdisciplinary communication that have diverse participants' specialization. Moreover, participants must voice their ideas in discussions; therefore, they cannot focus fully on paying attention to others' specialization. In the field of cognitive psychology, it is known that people cannot perceive anything which they do not understand [4]. This way, it is insufficient for people who are not familiar with interdisciplinary communication to learn it merely by discussion with experts who have different specialization.

The purpose of this research is supporting the awareness of specialization for effective learning of interdisciplinary communication. For that reason, we propose a method to support awareness of specialization. We utilize the transition of speakers' specialization following turn-taking as "patterns", and examine a method to determine the patterns that make it easier to comprehend other participants' specialization. We ascertain whether the patterns can help participants to recognize the specialization through experiments. Based on the result of an experiment, we propose an interface that shows the timing when specialization is apt to be recognized to help participants recognize the specialization. The rest of the paper is organized as follows. In Section II, a review of the literature on related work and the viewpoint of this study are given. In Section III, we define the elements utilized in this study and propose the information to support the awareness of specialization. In Section IV, we describe the experimental method and the result. In Section V, the proposal of interface idea is given. In Section VI, a conclusion and future works are given.

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II. RELATED WORKS

A. Related works

In recent years, many studies have investigated interdisciplinary communications. Fujigaki ascertained that multi specialized knowledge caused difficulties in understanding each other in interdisciplinary communication [5]. She defined the axis classifying scientific ideas, analyzed them and proposed a practical method of knowledge integration to remove the difficulties. Visualization methods are proposed by many studies to support interdisciplinary communication. Sumi et al. developed an interface denoting background knowledge that each participant's specialization had on a computer display [6]. They showed it could solve the problems caused by distance of knowledge. Huub et al. offered ontological knowledge base and Modeling Support Tools to support the multidisciplinary modeling process for water management that sometimes lacks mutual understanding between modeling team members [7]. They showed that tools can facilitate cooperation in teams. Lisa et al. visualized a cluster that showed studies' relationships in interdisciplinary fields [8]. This study suggested a system intended to reveal each study's position and its outline.

We refer to studies about turn-taking. Turn-taking is a speakers' exchange system defined by Sacks et al [9]. There are many studies that use turn-taking to support discussion. Cao et al. showed that people could smoothly shift the right to speak by obtaining feedback on turn-taking [10]. Dimicco et al. created an application that visualizes information about turn-taking and speaking time [11]. From the investigation, visualization can help participants reconsider and better understand their interactions from social and behavioral viewpoints.

B. View point

In this research, we support recognition of specialization in the discussion for learning interdisciplinary communication. Therefore, we consider which elements of discussion we should use to support awareness. In discussion, specialization generally appears in participants' utterances. Moreover, how to represent each specialization and the contents thereof depends on the speakers' field of academic specialization. We define the learning domain that discussion participants specialize in as their "field." For these reasons, we focus on participants' utterances and fields.

In addition, we must also consider the discussion's features because we selected a learning method that uses dialog. Discussion consists of interactive utterances by participants. In this respect, it is the same as interdisciplinary communication. For that reason, we should study the features relevant to awareness of specialization from interaction with more than one participant. Therefore, we focus on turn-taking with regards to recognizing the characteristics of specialization.

We mentioned turn-taking and fields as elements to observe. We connect them and treat the transition of speakers' specialization following turn-taking. We defined the transition as a "pattern" and we use it to specify the timing that governs when participants are easily able to recognize the specialization. We describe an example of the pattern. By denoting humanities experts as "H" and science experts as "S", if H speaks just after S, we form the pattern "SH."

C. Difference from existing research

In existing research, many methods are proposed for supporting awareness of specialization. However, these studies do not refer to participants whose understanding of interdisciplinary communication is insufficient. There is some possibility that if those people used the proposed systems, they could not communicate smoothly and make a discovery through awareness of specialization. It is not until those people are educated that they can use the existing systems. With regard to studies that focused on turn-taking, those proposed methods are not for learning but rather for interaction support. This study treats turn-taking as one element to support the awareness of specialization in group discussions necessary for interdisciplinary communication within academia. That distinguishes our study from existing studies in focusing on basic learning and using it for interdisciplinary communication.

III. TOWARD THE SUPPORT OF THE SPECIALIZATION AWARENESS

A. Awareness of specialization and turn-taking

It is necessary to define what constitutes "awareness of specialization" for the purpose of interdisciplinary communication support. Specialization is composed of education and knowledge that participants have attained; therefore, the features of specialization are influenced by which disciplines the participants have learned. When participants attempt to recognize other experts' specializations, they compare their knowledge with other experts' utterances. Therefore, what participants can recognize is whether the utterance has specialization from the viewpoint of their own specialization. For that reason, this study treats "awareness of specialization" as "recognizing the features of other specializations,"

We are required to consider a relationship between fields and specialization because we are focusing on transition between fields. In Japan, academic fields are often classified into two types: "Humanities" and "Sciences" [12]. Generally, this classification is based on universities' departments or high schools' courses; however, it is difficult to delineate a clear division. Moreover, there are various specializations, and their classification and each participant's understanding of the classification is different. For that reason, each specialization should be labeled based on its field to avoid confusion.

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Sacks et al. defined turn-taking as consisting of five rules [9][12]. However, his rules did not stipulate that participants begin to speak simultaneously or while other people are speaking. Schegloff [13] and Jisun [14] defined how turns should be treated when such cases arise. Accordingly, this study combines Sacks' Schegloff's and Jisun's rules and defines turn-taking as having seven rules.

This study focuses on awareness of specialization and pattern; therefore, it is necessary to consider these relationships. It is expected that there are easily recognized patterns because specialization necessarily reflects participants' disciplines and their awareness is based on the comparison of their own paradigm to other experts' specializations.

B. Proposed method

This study defines a "specialization rate" as the rate at which participants recognize other experts' specialization. We estimate the timing which participants will recognize the specialization and inform them about the timing to encourage awareness. For example, if a certain pattern appears x times and specializations emerge at y times just behind that pattern, then specialization rate " α " is defined as in the numerical expression below.

$$\alpha = y/x \quad (1)$$

It can be expected that we can recognize patterns more easily if the patterns are decided by specialization rate. We propose a method to obtain such patterns. Specifically, we classify patterns based on each speaker's field, derive each specialization rate, and form a pattern from fields that have the highest specialization rates. This study defines the pattern obtained by the above method as the "specialization pattern." Moreover, we define the patterns that are same as specialization pattern except one field as the "proximate patterns." This study calls for greater attention to awareness of specialization in subsequent utterances by presenting these patterns.

We illustrate this point with an example deriving a pattern composed of three utterances and two fields of Humanities and Sciences. Hereinafter, Humanities are referred to as "H" and Sciences are referred to as "S." If there are N utterances in the discussion, there are N-2 patterns in the same discussion. At first, we divide these patterns into two types based on first speaker's field whether H or S. Second, we calculate each case's specialization rate and select the field which has the higher specialization rate. In the same way, we compose the specialization pattern for the second and third field. Finally, we define proximate patterns from the decided pattern. For example, if we get pattern SSH, the proximate patterns are defined as HSH, SHH, and SSS.

IV. EXPERIMENT

A. Purpose

The purpose of the experiment is to gain information about turn-taking and awareness of specialization and examine the effect of specialization pattern. Specifically, we derive specialization pattern and proximate patterns and confirm the rate of the utterance just behind the patterns containing specialization. From the result, we propose an interface.

Figure 1. Experiment

B. Abbreviations and Acronyms

The purpose of this research is to support recognizing specialization for interdisciplinary communication learning; therefore, it is necessary to observe interdisciplinary discussions. Participants of the experiment should have a certain amount of knowledge and little experience of interdisciplinary communication because the candidates for support are unfamiliar with interdisciplinary discussion. The classification of specialization uses "Humanities" and "Sciences" which are referred to as "H" and "S" to prevent confusion. H and S are classified based on Universities' departments which are familiar in Japan because it is said that the factor which determines to which fields a person belongs to is the relevant university's departments [15][16]. We adopt current topics as the subject for the discussion because it seems more likely that participants know about the topics and they have original knowledge of their fields. It is necessary to obtain information about turn-taking and awareness of specialization while participants engage in discussion. However, participants are unfamiliar with interdisciplinary discussion; it is difficult for them to carry on a discussion and recognize the specialization at the same time. This study obtains information about turn-taking and awareness of specialization separately. Participants are able to focus on discussion while they speak and concentrate on awareness of specialization while they try to recognize it in order to get valid data.

C. Experimental method

This study carries out an experiment in accordance with the following conditions.

- Subject: Should we retain nuclear power plants in Japan?
- Participants: 16 University students (14 males, 2 females: early twenty years old)
- H fields: Human science, Letters, Economics, Law
- S fields: Engineering science

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- Member composition: 2 H students and 2 S students Equations

Our experimental procedure is shown below.

(I) Interdisciplinary discussion for consensus building (40 minutes)

(II) Recognizing specialization using the video of (I)

This study obtains turn-taking information in (I) because turn-taking occurs whenever speakers engage in dialog. Specifically, we record the order of turn shift in the discussion and obtain turn-taking information. Information about awareness of specialization is acquired in (II). This study gathers information about awareness of specialization from each participant's decision. If more than one participant judged that the utterance was professional, this study treats it as having specialization. The situation of the experiment is shown in Figure 1.

D. Analysis

This study considers the rates at which specialization became apparently just after specialization pattern and proximate patterns. We define the rate as the "information giving rate." We can get information giving rate "P" as in the following expression when we define the number of specializations which participants recognized as Ra and the number of specializations which participants recognized and located just after specialization pattern or proximate patterns as Rs.

$$P = R_s / R_a \,. \qquad (2)$$

This study proposes two types of patterns to help participants recognize the specialization. Meanwhile, we can propose patterns that have high specialization rates. To compare proposed patterns and such patterns, we derive specialization rate for each pattern. We get the information about how many times each pattern appeared and participants recognized specialization after each pattern from our result. After that, we calculate the specialization rate of each pattern forms this information. We define such patterns as "higher patterns" and compare their information giving rate to analyze each pattern's feature.

The number of higher patterns is equal to the sum total of specialization pattern and proximate patterns. The number of utterance composing patterns is three or four. If the number of utterances is too few, the feature of interaction may be lost. On the other hand, if the number of utterances are too many, it may be difficult for participants to comprehend all of the patterns.

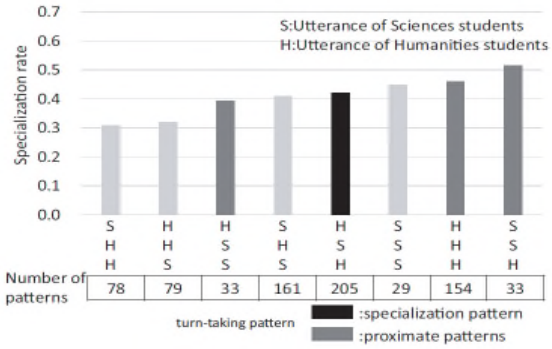

Figure 2. Specialization rate of each pattern (three utterances)

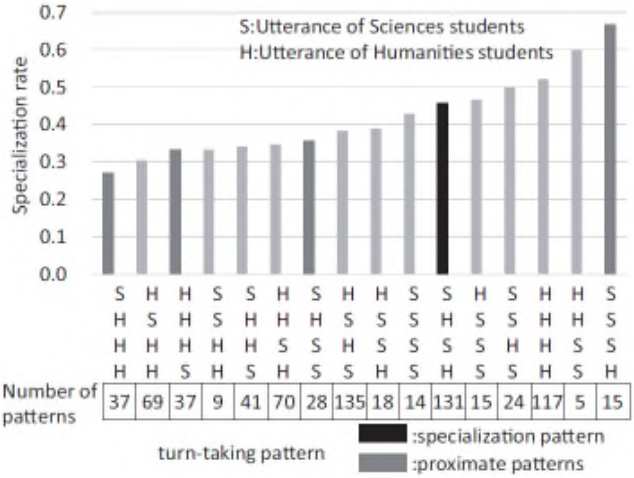

Figure 3. Specialization rate of each pattern (four utterances)

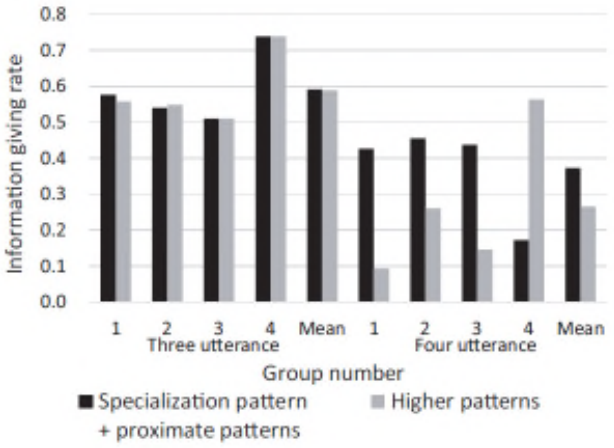

Figure 4. Information giving rate of each group

E. Result

Figure 2 shows specialization rates per patterns that are composed of three utterances. For example, item SSH shows the utterance just after the pattern contains the specialization at the rate of 50%. The number of each pattern's appearance is shown as "Number of patterns." Specialization pattern is indicated by a black bar and proximate patterns are depicted by gray bars. As a result, the utterance just after the specialization pattern contained specialization at the rate of nearly 40%. Some proximate patterns matched patterns whose specialization rates are higher.

Figure 3 shows specialization rates per patterns that are composed of four utterances. The graph composition is the same as in Figure 2. As shown in Figure 3, the utterance just after the specialization pattern contains the specialization at the rate of nearly 45%. One proximate pattern matched the pattern whose specialization rate is highest; however, the others show lower specialization rate patterns.

Figure 4 shows the information giving rates. Black bars show the rate at the time of presenting specialization pattern and proximate patterns and gray bars show the rates at the time of presenting higher patterns. As shown in Figure 4, in the case of three utterances, there is almost no difference between presenting specialization pattern and proximate patterns and presenting higher patterns. In the case of four utterances, Figure 4 shows presenting specialization pattern and proximate patterns can produce more information than presenting higher patterns except for group 4.

F. Considerlation

Figures 2 and 3 show there is some possibility that the proposed patterns can present good information from the perspective of the ease of recognition for every pattern because some specialization pattern and proximate patterns matched higher patterns. It appears that the reason some proximate patterns' specialization rates were low is the feature of specialization rates. Specialization rates become high not only when awareness of specialization transpired often but also when the patterns seldom appeared. This problem can be solved by providing more data for every pattern.

Figure 4 shows that information giving rates are influenced by the number of utterances that composes patterns. This result shows the possibility that we can change the amount of the information provided. It is necessary to provide a suitable quantity of information in accordance with the students' skill level. If the quantity of information is too high, participants may be confused. On the other hand, if the information is too scarce, the nature of the support system may be lost. We have confirmed that the proposed method can flexibly educate participants by changing the number of utterances that compose the relevant composing patterns. From this result, we can use the method proposing specialization pattern and proximate patterns for education support using awareness of specialization.

Moreover, Figure 4 shows specialization patterns and proximate patterns can transmit more information except in the case of group 2 of three utterances and group 4 of four utterances. This result shows that high specialization rate patterns cannot always give a great deal of information. One of the reasons for the result is same as the reason that proposed patterns did not match higher patterns. In other words, the cause is features of specialization rate. As in the other case, higher patterns that have been derived from all groups' data do not always match the patterns that have been derived from each group's data. This result shows that the proposed patterns can produce highly adaptable information.

In summary, these considerations show that if we can gather appropriate data, the proposed patterns can produce patterns that have a high specialization rate. Moreover, the proposed patterns can become a good support method under the same conditions. On the other hand, when the number of utterances which composes patterns is increased, proximate patterns' specialization rate and information giving rate decrease. This result shows that if we focus on more utterances, the number of patterns increases and awareness of specialization may diverge accordingly. In consequence, each pattern's specialization rate and information giving rate may be reduced. This phenomenon would occur when the number of fields is increased because this result is linked to an increase in the number of patterns. This study focuses on helping participants unfamiliar with interdisciplinary discussion recognize the specialization; therefore, this study presupposes that the case in which there are too many patterns is not in effect.

Meanwhile, there is a question of whether support interface is really necessary because participants recognized specialization in this experiment. This study gathers information about turn-taking and awareness of specialization separately; however, discussion and awareness should be performed at the same time. Participants who are unfamiliar with interdisciplinary communication do not always perform these tasks simultaneously. Moreover, even if one participant recognized specialization, the others might not be able to recognize the specialization. From these viewpoints, a support interface is needed.

V. TOWARD INTERFACE DESIGN AND DEVELOPMENT

A. Proposing interface design

This study shows that specialization pattern and proximate patterns can indicate patterns that have a high specialization rate with some accuracy. We propose an interface to help participants recognize the specialization based on the experiment result. Specifically, we propose the interface that calls participants attention to recognize the

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specialization when utterance that includes specialization appears. We describe a detailed method.

- Store the information about turn-taking and awareness of specialization that were gathered from this experiment and other discussions in a database.
- Derive specialization pattern by using stored data and information from the present discussion.
- Propose that the next utterance may have specialization to participants if the present pattern matches proposal patterns.

These methods give participants a stronger chance to recognize whether some utterances have specialization and make this awareness easier. Figure 5 shows our proposition for the design of such an interface.

Moreover, this interface can give information to not only participants but also facilitators. Participants can recognize the specialization from the information through the facilitators.

B. The subject towards interface development

We describe the subject to develop the interface. At first, there is a problem with the data limitation. This study gets information from the discussion composed of 2 H participants and 2 S participants; however, the number of participant and participants' field ratio is not always the same. This interface can be applied to the case when these elements change though we need information about turn-taking and awareness of specialization from the other elements of discussions. We need more experiments to expand the useful range of our interface.

Second, there is a problem of how we determine the number of utterances that compose a specialization pattern. Figure 4 shows each case of information giving rate; however, the standard number of utterances that should be used remains indeterminate. This study focuses on three and four utterances; however, it is possible to increase the number of utterances unless the number of patterns increases too much. Therefore, it is necessary to consider the relationship between the standard of participants' skill level and the number of utterances that composes patterns to determine which information to give them.

C. Future works and subjects

The goal of this study is to develop an interface that is able to give all requisite information about awareness of specialization and help participants to be aware of and recognize it more readily. It seems that participants can get knowledge about the diversity of other participants' way of thinking and field and learn interdisciplinary communication through awareness of specialization by using such a system.

There are some obstacles to achieving this goal at present.

(i) Not all participants can recognize the specialization when information is presented.

(ii) Fields' classification and definition are very limited.

(iii) Classification is not applicable to all discussions. This section considers how to solve these problems. First, we focus on (i). This study leaves the decision of whether utterances have specialization to participants; no matter how well developed the system becomes, not all participant will be able to recognize the specialization when information is given. It is possible to make participants recognize the specialization by analyzing the contents of utterances to show more exactly timing. However, if this system provides more detailed information, there is a possibility that

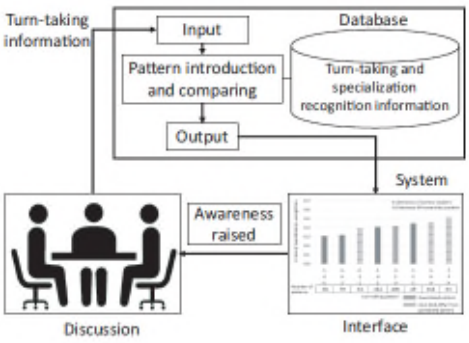

Figure 5. Interface image

participants cannot learn spontaneous awareness. It is necessary to consider how far we should provide support.

Second, we focus on (ii). As mentioned in Section III-A, the standards of fields' classification are based on Japanese universities' departments; therefore, it is unclear whether the proposed method can perform in foreign countries' educational environments. Moreover, this study presumes participants have only one specialization; however many experts have more than one specialization. It is necessary to examine the effect of this method based on field classifications considered common in the pertinent country and consider what happens when participants have multi specialization. We forecast that the effect of this method does not change when the fields' classification changes unless the number of classification is increase. In addition, it is expected that multi-specialized experts recognize more specialization than other participants and their specialization is easy to recognize.

Finally, we focus on (iii). Not all interdisciplinary discussion can separated in H and S. For example, discussions between Engineering experts and medical experts is considered as interdisciplinary discussion; however, these fields both belong S in this study's classification of fields. In that case, this method is not able to support participants; therefore, it is necessary to confirm whether the method can support participants in other systems of classifying fields. Moreover, if this method will be usable, we need new training data with a new classification to derive the proposed pattern.

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VI. CONCLUSION

This study was aimed to support awareness of specialization in group discussion for learning interdisciplinary communication. Toward the goal, we proposed providing information based on transition of speakers' specialization following turn-taking as "pattern". We focused on when the pattern by which participants tend to recognize the specialization appears. We defined such patterns as "specialization pattern" and "proximate patterns" and examined whether these patterns can help participants to recognize the specialization. The result showed that, if we choose an appropriate number of utterances and have suitable data, specialization pattern and proximate patterns can help participants recognize the specialization in interdisciplinary discussion. We proposed an interface that indicates when specialization might appear in the next utterance when specialization pattern or proximate patterns appeared.

The proposed interface can be adapted to specific groups at the present. Further discussion is needed to gather information about turn-taking and awareness of specialization. Moreover, it is necessary to develop the interface to examine the effect of interdisciplinary communication learning through recognition of specialization.

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