Chen, W. et al. (Eds.) (2017). Proceedings of the 25th International Conference on Computers in Education.
New Zealand: Asia-Pacific Society for Computers in Education

Inquiry-based Support System to Improve Intention Sharing Skills

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Abstract: In order to achieve fruitful and creative discussions, it is important that the speakers verbalize and share their own intentions behind the utterance properly with the listeners. We call such essential skills for creative discussion "intention-sharing skills." The research objective is to propose a research activity support system for cultivating novice researchers' intention-sharing skills. To achieve this objective, we focus on the opportunities of research meeting. We, especially, take notice the researchers' internal self-conversation processes of organizing their own thoughts to improve their readiness for sharing intentions in a following research meeting. In this paper, we first structure inquiries for phase of organizing own thoughts. Then, we develop a research activity support system in which researchers focus on organizing the structure of their own thinking processes as a pyramidal structure consists of chains of inquiries and answers.

Keywords: Intention sharing skills, structured inquiries, inquiry-based support

1. Introduction

In a conversation, participants try to grasp not only superficial meaning of the speakers' utterance but also their implicit and tacit intentions behind their talks with the clue of the listeners' pre-existing knowledge, the speaker's nonverbal behaviors and the underlying contexts. To share intentions of each utterance is the key to a successful communication among participants (Tomasello et al., 2005). To make a conscious intention sharing is essentially required in the knowledge co-creative discussion: speakers themselves should try to clarify not only factual and episodic information but also their intentions behind the utterance (Enrici et al., 2011; Velleman, 1997). In this research, we call such tacit but essential skills of speakers as "*intention-sharing skills*" as a kind of metacognitive skills. If speakers cannot well display their intention-sharing skills, the discussion sometimes becomes confusing because of a discrepancy between the speakers' intentions and the listeners' understanding.

In this research, we focus on "research meetings." In a research meeting, discussion subjects are sometimes on ambiguous and unclear conceptual ones and only the presenters themselves know their own research progress from the last meeting. As mentioned above, sharing contexts of one's internal self-conversation processes with others is an essential activity for creative discussions. In order for presenters to explicitly share the contexts with other research collaborators, they need to understand their own thought processes comprehensively in advance, and display their intention-sharing skills expressing their thought processes. Since the research meetings have been carried out continuously to improve the research, it is reasonable and best-case opportunities whereby one practically cultivates own intention-sharing skills that require for a long-term period.

In this paper, we propose a research activity support system for cultivating learners' intention-sharing skills. We focus on learners' internal self-conversation processes to organize their own thoughts and intentions before a research meeting in order to improve their readiness for verbalization to share their intentions in the following meeting. First, we propose a learning activity model to cultivate intention-sharing skills, and discuss the concept of structured inquiries which prompt their internal self-conversations for organizing their thoughts. And we develop a research activity support system and show its functions.

2. Approach

2.1 Learning Model of Intention-Sharing Skills

Sharing skills of one's intentions with others play an important role to achieve fruitful and creative discussions. To cultivate such skills, it is important to conduct continuous performance of one's internal self-conversations which improves their readiness for sharing intentions in the following discussion and reflection of their discussion processes with referring to their internal self-conversations.

Figure 1 shows our learning model for cultivating intention-sharing skills through research activities. This model is composed of four phases: (a) organizing own thoughts, (b) systematization of thoughts, (c) sharing of intentions and (d) modification of thoughts. In the following, we describe the activities of learners performed in each phase. Intuitively, the first two phases (a) and (b) correspond to performing internal self-conversation processes, (c) does displaying intention-sharing skills at a research meeting and (d) does reflection of (a), (b) and (c).

- **Organizing own thoughts (Fig. 1(a))**: The phase at which learners try to clarify their unconscious thinking processes through activating their internal self-conversation before a research meeting. The thinking activity is essentially invisible and tacit processes. In the phase, learners explicitly express their thoughts as tree structure (Minto, 2006) which consists of the chain of inquiries and answers in a top-down fashion. Here, learners also need to express the relationships between respective structures of their research and the general structure of the target research domain.
- **Systematization of thoughts (Fig. 1(b))**: The phase at which learners try to specify purposes of the research meeting based on the organized thinking process in phase (a). In order to improve their readiness for sharing intentions in the following discussion, it is necessary to deeply think and choose the information should be shared among colleagues. Then, the documents need to be systematized which clearly describe the objectives in a logical manner.
- **Sharing of intentions (Fig. 1(c))**: The phase at which learners try to share their intentions at the meeting. It is required that they should not merely express the facts but verbalize their intentions.
- **Modification of thoughts (Fig. 1(d))**: The phase at which learners reflect on the discussion by modifying the tree structure of their thoughts created before the meeting. They are ready to criticize their thoughts objectively if elaborate internal self-conversations are performed in phases (a) and (b). The colleagues' opinions and questions in the discussion give an ideal opportunity to find a lack of their own thoughts in terms of intention sharing and internalize them for the next meeting.

As described above, our model is designed to cultivate learners' intention-sharing skills step-by-step through the cyclic research activities.

In this paper, we focus on the phase of organizing own thoughts (Fig. 1(a)) out of the above four phases. In order to improve their readiness for sharing intentions in the following discussion, it is essentially important to organize their thinking deeply in their internal self-conversations in phase (a).

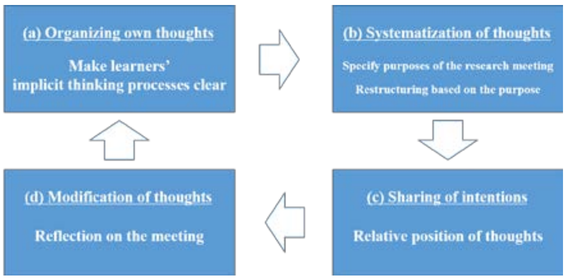

Figure 1. Learning Model for Intention-Sharing Skills

As a representation method of organize thoughts, we focus on a tool called mind map (MM) which has a predilection for the pyramid principle (Minto, 2006). The MM is a tool that adapts well to the structure of semantic memory of the human brain. By grace of making the best use of the structure, the tool contributes to organizing, understanding and memorizing information faster (Davies, 2011). While MM is designed for domain-independent general-purpose tool. But even if the target topic is learners' own research contents, it is difficult for learners to verbalize their intentions behind their thoughts into a pyramidal structure. In many cases, as Minto pointed out, this problem is caused by the reason that even writers themselves cannot be conscious of what they think without externalization.

Therefore, in order to prompt organizing learners' thoughts along with their thought contexts, we conceive the idea of providing inquiries (Ash & Clayton, 2009) which reflect the structure of target research domains as a stimulus. In the following section 2.2, we describe inquiries that should be considered in the phase of organizing thoughts (Fig. 1(a)) and structure a model of the inquiries.

2.2 Structuring Inquiries for the Phase of Organizing Own Thoughts

In the phase of organizing own thoughts (Fig. 1(a)), it is important for learners to overlook and situate their own thoughts about research so as to deeply understand their own research. This activity contributes to changing biased thoughts to fair and balanced ones. In accordance with the balanced thoughts, they can understand their thinking processes such as *why I need to think about this*, *what is unclear*, *what matter I need to think about first, and why I should discuss it in the meeting*, and they get ready for specifying the purposes of the research meeting. Followings are five necessary thinking activities that correspond to the policies of specifying inquiries to stimulate learners' internal self-conversations for their own research.

A. **Consideration both from macro- and micro- viewpoints**: In order for learners to delve into their own research deeply to verbalize their intentions, it is important that they should consider both the *domain-independent cross-sectional* research structures and the *domain-specific* structures in a balanced manner. To constantly consider their own research from these macro- and micro-viewpoints contributes to display well-balanced and critical thinking skills to improve their research and also to sharing their intentions among participants.
B. **Understanding of research structures**: Through the activity of verbalizing and structuring their own research, learners are aware of the irrational points of their own thoughts such as logical contradiction. It contributes to clarifying the purposes of the discussion and the points of sharing their intentions.
C. **Setting of criteria for decision-making**: In order to achieve a consensus-based decision-making among research collaborators, it is essentially required to verbalize the criteria of each decision-making. This activity requires learners to grasp and verbalize the logical paths of own thoughts leading to the decision-making.
D. **Clarification of reasons and purposes**: This activity requires learners to verbalize not only the results of thoughts (contents of leaf nods in the pyramidal structure) but also the causal and logical paths to them by considering their reasons and purposes.
E. **Critiquing rationality**: In order for learners to organize their thoughts in a rational manner, it is also important to critique the rationalities of each verbalized thought.

For promoting above thinking activities, we organized a set of both domain dependent and independent inquiries to stimulate them in their internal self-conversations. The inquiries prepared for promoting above activities *A*, *B* and *C* specify the requisite inquiries to promote research activities. They are organized to provide stimuli along their thought contexts. On the other hand, the inquiries prepared for the activities *D* and *E* play the role of reconsidering verbalized thoughts of the activities *A*, *B* and *C*.

It is desirable to systematize these inquiries in advance in terms of the commonality/differences among them in a context of a research domain rather than just listing them in a chaotic fashion. Therefore, we organize the inquiries based on the ontological engineering approach. Figures 2, 3 and 4 show a part of the systematized inquiries, each of them conceptualized along the "is-a," "part-of" and "attribute-of" relationships to provide the inquiries to prompt learners' thinking activities *A*, *B* and *C*, respectively. In these figures, the nodes marked red flags indicate the concepts and the unmarked ones correspond to the inquiries. As shown in Fig. 2(i), the inquiries about research (e.g., "*What is the objective?*") are connected with the concepts (e.g., "Objectives"). This systemization allows us to easily maintain the set of same/different meaning of inquiries under the concepts and thus easily grasp the structure of inquiries.

For *activity A*, it is desirable that learners constantly consider their research from both viewpoints of abstract and concrete, in other words, from *domain-independent cross-sectional* and *domain-specific* ones. We use "is-a" relationship to organize the concepts to represent these macro- and micro-viewpoints. The concept "Problems," for instance, has a child concept "Difficulties for learners" that should be considered in the research field of intelligent tutoring systems (Fig. 2(ii)).

In order to promote *activity B*, we systematize the concepts about research task structures based on "part-of" relationship as shown in Fig. 3; it is necessary for learners to think about "Problem-finding

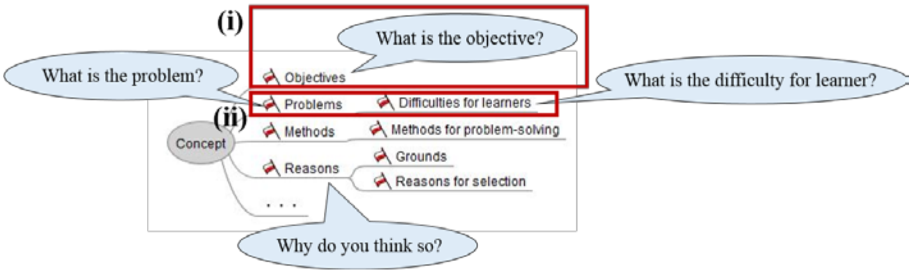

Figure 2. Class Hierarchy

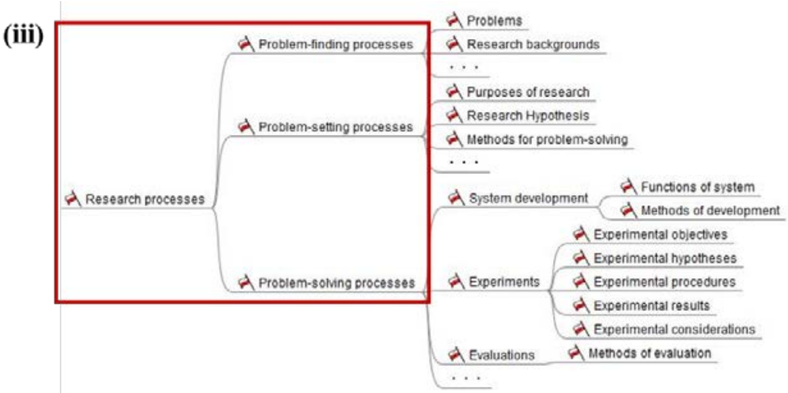

Figure 3. Part-of Relations of "Research Task Processes"

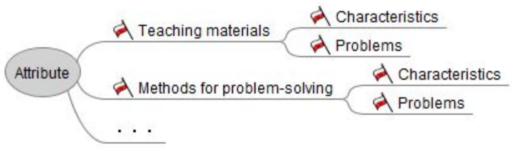

Figure 4. Attribute-of Relations of Educational System Research Domain

processes," "Task-setting processes" and "Task-solving processes" in "Problem-solving processes." Fig. 3(iii) shows the relations of these concepts. By organizing this way, the system could provide the inquiries that should be considered in their research task structures.

In *activity C*, it is necessary for learners to view the properties of a concept as the criteria for decision-making. In order to represent the concept properties, we apply "attribute-of" relationship. Figure 4 represents a part of the systematized concepts. The concepts, for instance, "Methods for problem-solving" and "Teaching materials," each of them requires to consider their properties to conduct educational system research such as "Characteristics" and "Problems," are defined by "attribute-of" relationship by referring to (Mizoguchi, 1995).

In addition, we defined the inquiries such as "*Why do you think so?*," "*What is the objective?*" for the *activities D* in order for learners to consider the reasons and purposes related to all the concepts. For the *activities E*, we currently defined an inquiry "*Why do you think these are rational?*" to examine the rationalities of relationships among each verbalized thought.

In this research, we embed the inquiries into a research activity support system in order for the system to intellectually provide useful inquiries by capturing learners' thought (see Section 3).

3. Inquiry-based Support System for Cultivating Intention-Sharing Skills

We have already confirmed that even simplified version of inquiries prompts learners' internal self-conversations and contributes to verbalizing their intentions (Mori, 2016). Based on the experimental results, we specified a structure of inquiries from the viewpoint of intention sharing as discussed in section 2.2, and developed a support system for learners to organize their own thoughts about own research using structured inquiries.

Figure 5 shows an interface of our system. In the area of thought expression map (TEM) (Fig. 5(I)), learners can organize their thoughts as sequences of chosen inquiries (blue-colored node) and respective their answers (orange-colored node) based on the concept of pyramid principle (Minto,

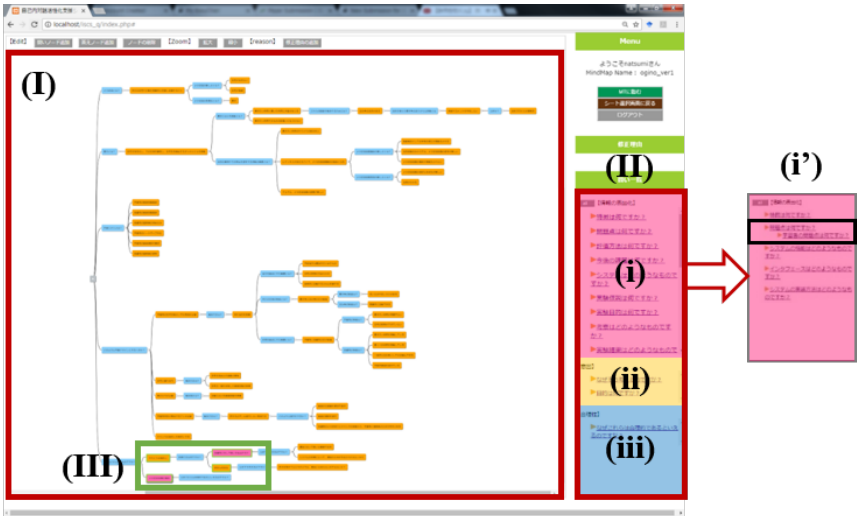

Figure 5. Support System for Organizing Thoughts

2006). In this area, thinking processes of learners are verbalized in a step-by-step manner by repeatedly verbalizing the chains of inquiries and answers in their internal self-conversations. The inquiry listing area (Fig. 5(II)) displays the systemized inquiries in a hierarchical list format. Learners can spontaneously choose the inquiries to construct their own thought contexts. While paying regards to the learner's own thinking, the displayed inquiries play a role of stimuli as a scaffolding along their thought contexts. In addition, based on the learners' selected inquiries from the listing area, the system detects an upper concept of the inquiries along 'is-a' relationship and displays the related inquiries of the concept based on the relationships among concepts (Fig. 3 and 4). In this way, by adaptively providing the inquiries related to the learners' thought contexts on the fly, it aims at activating their further internal self-conversations and improving the quality of the thought verbalization activity.

The inquiry listing area consists of three kinds of sub-areas for promoting five kinds of activities discussed in section 2.2. Each area is further divided from the viewpoint of timings to provide respective inquiries for learners. The inquiries classified in each area and their timings of display are explained bellow.

- **Inquiry area for verbalizing own thoughts (Fig. 5(i))**: In this area, the inquiries for the thinking activities *A*, *B* and *C* described in section 2.2 are shown. In the following, we describe how to provide the inquiries for prompting each thinking activity. To answer them makes learners being conscious of their intentions.
  - ♦ Activity A: In order to enhance learners' fair and balanced thinking from both macro- and micro-viewpoints, the inquiries, which correspond to the instances of macro-/micro-viewpoints concepts, are hierarchically provided along the "is-a" relationship. For example, since the micro-level concept "Difficulties for learner" is connected with macro-level concept "Problems" via "is-a" relationship (Fig. 2(ii)), its corresponding inquiry "*What is the difficulty for learner? (micro-level)*" appears under the inquiry "*What is the problem? (macro-level)*" as shown the area surrounded by a black border in Fig. 5(i').
  - ♦ Activity B: For prompting learners' understanding of the research domain structures, the provided inquiries are dynamically narrowed down according to the selected inquiries by learners. Figure 5(i') shows an example in which a learner selects the inquiry of the concept "Experiments." In this case, the inquiries of the concepts that correspond to its parts (e.g., "Experimental objectives") or sibling relationships (e.g., "Evaluations") defined as "part-of" relationships (Fig. 3).
  - ♦ Activity C: In order to make learners be aware of the logical structures of own thoughts leading to a decision, the inquiries shown vary with the selected inquiries. The inquiries are narrowed down based on the concepts which have "attribute-of" relationships as shown in Fig. 4. When a learner selects the inquiry of the concept "Methods to approach," for instance, the inquiries about properties (e.g., "*What are its characteristics?*" and "*What are its problems?*") are appeared in inquiry listing area. These inquiries play a role of stimuli for rational decision making in a situation of having multiple options and to answer them makes learners being conscious of their own intentions of their decision making.

- **Inquiry area for verbalizing intentions (Fig. 5(ii))**: In this area, the inquiries for promoting the thinking activity D are displayed. The inquiries include "*Why do you think so?*" and "*What is the objective of it?*" to prompt verbalization of reasons and objectives of one's thought. Since these inquiries are essentially important and thus the learners should keep in mind at all the times, the inquiries are always shown statically in this area regardless of the learners' thoughts on the TEM.
- **Inquiry area for considering rationalities (Fig. 5(iii))**: In this area, the inquiries for the thinking activity E are displayed. For example, when a learner selected one of two inquiries of the concept types "experimental objectives" and "experimental procedures," their answers expressed in the TEM must hold a rational relationship, the frames of these two nodes (inquiries) on the TEM are highlighted with green color so as to let learners be aware of considering their rationalities. Learners can think the rationality by choosing green node(s) that they want to focus on. In the TEM, the selected nodes are highlighted with pink color as shown in Fig. 5(III) and the inquiry "*Why do you think they are rational?*" appears in this area.

The classification of inquiries into these areas aims to encourage learners' internal self-conversations from domain-level thinking activities (A, B and C) to meta-level thinking activities (D and E).

4. Concluding Remarks

In this research, we proposed a research activity support system for cultivating novice researchers' intention-sharing skills through their daily research activities in a laboratory. We focus attention on the activity of organizing own thoughts in the internal self-conversation processes in order to improve their readiness for sharing intentions in the following discussion. The proposed system allows learners to organize the structure of their thinking processes as a pyramidal structure consists of chain of inquiries and answers. The system also provides *inquiries* which play a role of stimuli for learners' comprehensive thinking activities. Since the inquiries are structured on the basis of the ontological engineering approach, the inquiries capturing their thought contexts on the TEM are dynamically provided.

Currently, we installed our support system into the learners' daily practical research activity. Still in a preliminary stage, we get a sense of possibility of sustainable use of the system in daily actual research activities in a laboratory. For future work, we improve the usability of the system and conduct a detailed analysis of learners' growing process of intention-sharing skills.

References

Ash, S. L., & Clayton, P. H. (2009). Generating, deepening, and documenting learning: The power of critical reflection in applied learning. *Journal of Applied Learning in Higher Education*, 1(1), 25-48.

Davies, M. (2011). Concept mapping, mind mapping and argument mapping: what are the differences and do they matter?. *Higher Education*, *62*(3), 279-301.

Enrici, I., Adenzato, M., Cappa, S., Bara, B. G., & Tettamanti, M. (2011). Intention processing in communication: a common brain network for language and gestures. *Journal of Cognitive Neuroscience*, *23*(9), 2415-2431.

Minto, B. (2006). The pyramid principle: Self-Study Course Workbook volume 1. Diamond Inc.

Mizoguchi, R. (1995). Intelligent Educational Systems. *Journal of Information Processing,* 36(2), 177-186. [in Japanese]

Mizoguchi, R., & Bourdeau, J. (2016). Using Ontological Engineering to Overcome AI-ED Problems: Contribution, Impact and Perspectives. *International Journal of Artificial Intelligence in Education,* 26(1), 91-106.

Mori, N., & Hayashi, Y., & Seta, K. (2016). Organizing Inquiries Prompting Learners' Readiness towards Creative Discussions. *IEICE Technical Report*, 116(314), 11-16. [in Japanese]

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and brain sciences*, *28*(05), 675-691.

Velleman, J. D. (1997). How to share an intention. *Philosophy and Phenomenological Research: A Quarterly Journal*, 29-50.