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Analysis of Metacognitive Knowledge in the Process of Information Use

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The purpose of this study is to clarify what kind of metacoginitive knowledge students utilize when they examine and communicate information. For this, the authors developed 29 questionnaires based on literature review and free style description for 23 students. Concerning these 29 items, the authors asked another 193 students by 4 likert scales, how much they were aware of each item when they searched for information, put it together and communicated it for their questions. From the results of factor analysis, five components were abstracted: "Definiteness," "Awareness of Communicatively," "Examination of the Content of Information," "Awareness of Others," and "Selection of Information." Based on these factors, the authors discussed the trigger of metacognitive supports in information-problem solving.

Keywords: information education, information search, information problem solving, information literacy

BACKGROUND

The development of "information literacy" has been a challenge in the area of problem-solving learning in recent years (Mizukoshi, et al 2000). Information literacy mainly refers to the broad collection of information through the active use of the Internet, and the communication of the information to others through a variety of media (Lazonder 2003; Wopereis *et al*., 2008) (Figure 1.). This thought is implemented in the many theories of digital learning environment design (Hill & Hannafin 1997, 2001 ; CTGV, 1996).

Figure 1. *Information problem-solving process*

The development of information literacy requires the close examination of given information to select necessary information, just as has been indicated in the area of writing (Van der Hoeven 1999; Scardamaria & Bereiter, Steinbach 1984). In other words, it is important to work metacognition. In reality, however, it has often proved impossible to collect necessary information on the Internet (Walraven, et al 2008). Therefore, it is necessary to establish a framework to promote the metacognition in the learner's activities of collecting, arranging and communicating information (Miwa, 2003).

Meanwhile, in the field of education concerning expression, mainly expression in sentences, studies have been conducted from the viewpoint of how to improve the quality of output - studies that could lead to metacognition (Scardamaria & Bereiter, Steinbach 1984). Most of these studies, however, focus on the

type of learning that requires participants to put together their own thoughts from among given information, such as essay writing. These studies are not problem-solving types of studies in which participants decide on a theme and search for necessary information. Thus, these studies are not sufficient in terms of developing information literacy.

Therefore, it is essential to develop a specific method, such as providing worksheets and prompts, that analyzes the type of metacognitive knowledge that the learner needs to work and promote that knowledge. This is necessary from the viewpoint of how the metacognition of a learner should function in the activity of searching, selecting and putting together information for expression.

This study, based on the viewpoint of the former, aims to clarify what kind of metacoginitive knowledge students utilize when they examine and communicate information.

LITERATURE REVIEW

The importance of functioning matacognition has been pointed out in general studies. Metacognition signifies "cognition of cognition." The components are generally divided into the cognition of knowledge and the cognition of activities (Brown 1987; Sannomiya 2008). Metacognition helps to promote the introspection of the learner and takes him or her to a higher level of learning.

This research is target for the cognition of knowledge, the authors discuss on strategy of information use based on the importance of strategy (Scharaw & Moshman 1995). In this section, we discuss the research of learning environment design to nurse it.

How to Promote Metacognition

The designs of the learning environment to promote metacognition have been studied as components.

Conditions of production

This is a method that limits the learning condition by adjusting the situation of a task or how to impose the task, urging the learner to adjust his or her learning process. For example, Sugimoto (1991) clarifies that, in producing a text of opinions, the text indicating the relationship between the writer and the readers, their ideas and statuses, and what kind of writing it is and what it argues is more likely to create the learner's introspection. This idea is related to the learning conditions presented in the Situated Learning (Lave & Wenger 1991) and the Anchored instruction (CTGV 1996).

As for the method of producing a task, certain studies argue that applying conditions of limiting the number of words in a text appropriately or asking repetitive questions improves the quality of a product (Sakihama 2004; Sakihama 2005).

Awareness of others

Designing communication among learners in a learning environment can help improve the framework to promote metacognition. Reciprocal teaching (Palincsar & Brown, 1984) is one of those examples. Behind these studies is an experimental study that proves that assuming the characteristics and intellectual status of the reader can lead to the improvement of actual learning accomplishments (Kishi & Watai 1997). In recent years, effective knowledge has been provided in the practice of education through the CSCL environment and exchange learning (Kishi, 2008).

Prompt

Jonassen (1991) proposes comprehensive ID models that aim to promote metacognition. These models

emphasize not direct but indirect instruction methods, including modeling, coaching and scaffolding. In order to promote metacognitive, attempts have been made to promote metacognitive activities by providing prompts that can cause self-reflection while performing a task (Bannert et al, 2009; Veenman et al, 2005).

Applicability of the Learning that Promotes Metacognition

The applicability of the learning designed to promote metacognition from the above viewpoint is very wide. It can be applied, for example, in the areas of sentence comprehension or mathematics (Sannomiya, 2008). In the United States, it is also applied in library education. Curriculum guidelines encourage metacognition and the importance of the "development of information literacy".

However, basic studies on which the above applications depend are limited. Walraven *et al.* (2009) and others limit their studies to the online search, examining what metacognitive activities learners conduct, in terms of searching, scanning, processing and organizing. It has become known, however, that metacognition cannot be promoted in scanning and processing. Therefore, metacognition has been examined in each individual situation of utilizing information, such as those of searching information or presentation (Lorenzen 2002).

These studies do not examine prompts that generally promote metacognition in terms of "problem-solving through the media"; in other words, a series of activities that define problems, collect information through communication with the media and people, putting it together and expressing it. The studies do not investigate how to provide those prompts either. Furthermore, targeted activities are limited to those of writing, if they concern the expression of information.

Problematic Points

With respect to IPS (Information Problem Solving), there are two problematic points concerning research of the metacognition learners employ. First are the limits on activity methods used in the problem resolution process. Second is the lack of clarity regarding the concrete contents of metacognition within the overall problem resolution process. The present study clarifies the type of metacognition learners employ when they apply information in the problem resolution process, and discusses the learning environment design upon which this is based.

Various types of information are applied in the IPS process; it should not be limited to a single type of media. Originally, in IPS, learners experience the process seen in Figure 1, but this learning is not limited to web searches. Learners use not only the web, but also listen to others, gather information from books they have sought out, then compare the results. Further, they arrange the results and then give them expression in written reports, or via slides in a presentation. As it happens, owing to the necessity to place things in an experimental environment, previous studies have limited the activities to a single type: web searches followed by written forms of expression. We need to supersede such limitations and discuss how the employment of information in the problem resolution process conducted by diverse learners may be supported.

Then again, we are clear on the questions of the stage at which metacognition is activated in IPS, and of the type of metacognition involved, but the question of which types of metacognition are active at each particular stage remains uncertain. We need to elucidate the structural components of that sort of metacognition, and to consider education methods that will induce it.

To that purpose, the present study elucidates the type of metacognition learners employ when they apply information in the problem resolution process. Then, from the perspective of encouraging that, we discuss relations with educational methods and make a proposal regarding learning environment design.

METHODOLOGY

The survey in the present study was conducted in two stages: a pilot survey and a questionnaire survey. First, by means of the pilot survey, we sought to gather opinions via inquiry. This was prompted by the consideration that it was unclear what sort of metacognition was at work with respect to employment of information other than that obtained via web searches. Afterwards, lists were compiled on the basis of descriptions offered in this survey, following which a survey plan consolidated on the basis of factor analysis was drafted.

Pilot Study

The objective of this survey was to create items for the purpose of investigating the type of metacognition learners employ with respect to ordinary IPS. We made a list of 29 items that need consideration in utilizing information. Prior to that, we gave a questionnaire to 23 university students. The questionnaire consisted of three questions: what do you keep in mind when you search for information for your questions, what do you keep in mind when you put the information you have obtained together for papers or presentations, and what do you keep in mind when you communicate the information you have obtained in writing papers or designing presentations. Junior university students and older were studied. The idea was to obtain information from learners with a wealth of experience in IPS activities, namely, in searching for information and creating reports or presentations.The questionnaire encouraged the students to write whatever way they liked, and as much as they wanted. The authors organized and arranged the answers.

We took the items mentioned by the learners and, one by one, wrote them on cards and arranged them. We made a Japanese-language list from these, and repeatedly revised the wording of the contents transcribed.

When we turned the items for the survey into a list we allowed learners to respond freely. We compared certain deficiencies in contents and in expression with the information education's target list (Nagano, 2009), then supplemented them with written expressions. Concerning the learners' responses, the heart of these consisted of clarifying inquiries into the reliability of information and awareness of the goals of the investigation. Meanwhile, in arranging and presenting the data, the main focus of nine students' concerned skills (the layout of slides, the tone used in speaking) or other such matters; they touched on no items dealing with the treatment of advanced types of information.

Questionnaires

The list of 29 items was compiled in the following method. Concerning these 29 items, we asked 193 subjects, university students who were separate from those who answered the prior questionnaire, how much they were aware of each item when they searched for information, put it together and communicated it for their questions. We asked them to answer in four grades (4 meaning "very applicable" to 1 meaning "not applicable at all"), and conducted factor analysis on the results.

RESULTS

We carried out factor analysis (principal factor method, determination of factors based on screeplot, Varimax Rotation) employing 29 questions. Three with a factor loading of less than 0.35 were subsequently eliminated and the factor analysis re-performed. As shown in Table 1, 5 factors were identified. The α-coefficients demonstrating the internal validity of each factor ranged from 0.85 to 0.61.

Five components were abstracted: "Definiteness," "Awareness of Communicatively," "Examination of the Content of Information," "Awareness of Others," and "Selection of Information."

Table 1. *The Results of Factor Analysis*

	Factors				
	1	2	3	4	5
(22) Clarify the purpose of your research.	0.70	0.21	0.14	0.09	-0.04
(11) Clarify what content you need to examine.	0.62	0.39	0.03	0.04	0.16
(21) Communicate facts accurately.	0.60	0.33	0.23	0.16	-0.06
(20) Clarify your point.	0.58	0.42	0.08	0.16	0.10
(1) Clarify the key words for research.	0.53	0.08	0.02	0.07	0.19
(6) Make it clear to others what you want to communicate.	0.48	0.34	0.17	0.30	0.20
(25) Make sure that the information you have obtained is based on facts.	0.46	0.34	0.09	0.25	0.22
(3) Search various sources of information, such as the media and people.	0.40	-0.05	0.27	0.01	0.22
(15) Use words and expressions that are easy for others to understand.	0.24	0.66	0.02	0.17	0.25
(23) Think of the means of expression that is easy for others to understand.	0.31	0.57	0.08	0.32	0.06
(19) Be conscious of those you communicate information to and proofread it until you find it sufficient enough.	0.13	0.54	0.16	0.36	0.03
(10) Make sure all your words are clear enough for others to understand.	0.18	0.49	0.28	0.10	0.08
(12) Think of the order of your arguments that are easier for others to follow.	0.33	0.46	0.08	0.06	0.09
(24) Make sure that the findings you are trying to communicate serve the purpose of your research.	0.13	0.19	0.60	0.24	0.08
(4) Make sure that the information you have obtained is reliable.	0.15	0.08	0.59	0.12	-0.11
(9) Ascertain the source of information.	-0.02	0.01	0.58	0.09	0.12
(18)Try to obtain information from reliable sources.	0.26	0.22	0.54	0.07	0.10
(26) Emphasize where you find necessary.	0.01	0.05	0.21	0.59	0.12
(2) Think of the content that can stimulate the interest of those to whom you communicate it.	0.34	0.26	-0.02	0.51	0.21
(7) Consider the content according to the level of knowledge of those to whom you communicate it.	0.05	0.26	0.31	0.45	0.04
(27)Predict the reaction of those you communicate information to.	0.22	0.19	0.12	0.39	0.11
(16) Insert photographs and diagrams, among other visual aids.	0.22	0.09	-0.09	0.19	0.55
(17) Analyze the information you have collected to find tendencies or regularities.	-0.02	0.11	0.37	0.20	0.47
(13) Compare more than one piece of information to obtain the necessary information.	0.21	0.31	0.31	-0.09	0.37
(14) Decide if the information you have obtained needs to be made public.	0.20	0.27	0.20	0.24	0.36
α-coefficient	0.85	0.83	0.71	0.7	0.61
Factor Contribution Rates (%)	12.73	23.47	31.61	38.10	42.72

Factor 1 is named "Definiteness" because of high factor loading in the items of "Clarify the purpose of your research" and "Clarify what content you need to examine". Factor 2 is named "Awareness of Communicatively" because of high factor loading in the items of "Use words and expressions that are easy for others to understand" and "Think of the means of expression that is easy for others to understand". Factor 3 is named "Examination of the Content of Information "because of high factor loading in the items of "Make sure that the findings you are trying to communicate serve the purpose of your research" and "Make sure that the information you have obtained is reliable".

Factor 4 is named "Awareness of Others" because of high factor loading in the items of "Emphasize where you find necessary" and "Think of the content that can stimulate the interest of those to whom you communicate it". And factor 5 is named "Selection of Information" because of high factor loading in the items of "Insert photographs and diagrams, among other visual aids" and "Analyze the information you have collected to find tendencies or regularities".

Based on these factors, the authors discussed the trigger of metacognitive supports in information-problem solving.

DISCUSSION & CONCLUSION

From the standpoint of encouraging metacognitive recognition of information representation, previous studies considered the postulation of conditions, other-consciousness, and prompts. We wish to present a plan for a learning environment design based on these educational methods, and in which the 5 factors extracted in the present study are borne in mind.

Previous studies involved learning environment design based on encouraging factors 1, 2, and 4. From the standpoint of factor 1, it is customary to monitor for clarity with respect to what an individual is doing at a given time. Beyond that, we may say that consideration is given to the individual transmitting the information (factor 1) and the method of transmission (factor 2). Concerning factors 3 and 5, more can be expected indirectly rather than directly. It is necessary to design with these elements in mind, and to incorporate them. For example, in line with factor 3, there is a need to perform repeated, careful investigations with respect to the question of whether or not the accuracy of the information sought and the contents sent match the objective. Further, in line with factor 5, careful selection of information is required.

To promote metacognitive knowledge with respect to IPS, and with respect to the particular methods best to adopt, we made it our goal to think from the perspective of the metacognitive knowledge we wish to urge upon learners. We can represent this relation as seen in Figure 2. It is possible for lesson designers to employ this data as a guideline in creating lessons.

It is desirable that the chart be put to use so as to design learning that does not favor one form or a single type of metacognition. Among the five factors, it is necessary to induce many varieties of metacognitive knowledge suited to the objective of the particular learning situation. However, it is not good to simplify that method. For example, if there is a basis toward a direct “prompt” method, learners tend to pay too much attention to this and experience a great deal of emotional pressure. From the perspective of motivation, this exerts a negative influence on the learning process. What is required is a learning design that naturally and occasionally induces metacognitive knowledge. On the other hand, exclusive use of a learning process that is an indirect method, incorporating agenda setting and awareness of others, will end up producing individual differences between learners in whom metacognitive knowledge can be induced and those in whom it cannot.

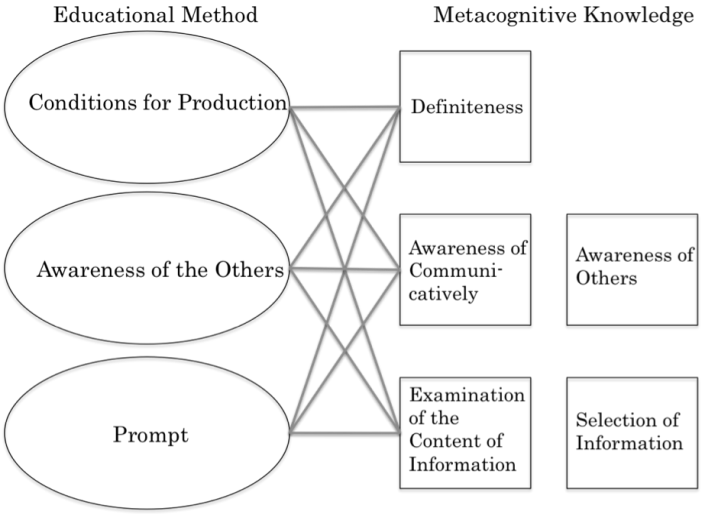

Figure 2. *The selection model of educational method and metacognitive knowledge*

There are two issues in the present study. The first is that, because this study merely extracted factors, the interrelations between factors are unclear. For that reason, it is necessary to reveal these relations and to clarify the learner's model. The second issue concerns the development of a learning environment that encourages accuracy in information content as well as care in selection of information. Third, it might be noted that this study does not take into account individual differences among learners. Learners themselves adjust for the motives and objectives of their study（Bandura 2001;Metcalfe & Greene 2007）.As the present study is one that did not take place in an authentic environment, it is necessary to clarify this by designing an experimental learning environment, following which assessments may be made.

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