Difficulties in Mastering Self-Regulation Skill and Supporting Method for It

Michiko KAYASHIMA[†] and Akiko INABA[‡]
[†]*Department of Human Science, Tamagawa University* [‡]*ISIR, Osaka University*
[†]*6-1-1 Tamagawagakuen, Machida, Tokyo, 194-8610, Japan*
[‡]*8-1 Mihogaoka, Ibaraki, Osaka, 567-0047 Japan*

Abstract. We consider hierarchical model of skills. Based on the model, we clarify difficulties in mastering each skill, consider which difficulties are reduced by existing supporting method, and then clarify which difficulties remain to master self-regulation skill. In this paper we propose a method of supporting learners' development of their self-regulation skills, which is designed to reduce the remaining difficulties. In the method, we are aiming to provide learners with opportunities to develop their self-regulation skill gradually: first, they learn the skill by observational learning, and then, they learn the skill by using it as a cognitive skill. Finally, they try to use the skill as a metacognitive skill with support of our plan externalization tool. This method is available in CSCL environment. Learners take turns to learn self-regulation skill gradually.

1. Introduction

The purpose of our study is to investigate how we facilitate development of learners' self-regulation skill with computer-based learning support environment. Self-regulation skill is one of metacognitive skills, and allows a learner to think about his/her own thinking process, and to control it for achieving his/her goal by him/herself [2].

There are already many computer-based learning support systems to help learners acquire domain knowledge. Self-regulation skill is not domain knowledge, but important for improvement of a learner's competence. Self-regulation skill is a skill which is independent of subject-domains, that is, once a learner masters the skill, he/she can apply it across domains and he/she can apply it even in domains where he/she has little prior background knowledge. Some learners develop the skill by themselves; but some learners do not. The former are intelligent novices who can plan how to solve a problem, apply their knowledge to authentic tasks, and monitor and regulate their problem solving process [3]; the latter may have difficulty in learning, especially it is difficult for them to apply their knowledge to authentic tasks, and to monitor and regulate their thinking process. So, it is necessary to consider what is difficult for the learners and help the learners to develop their self-regulation skill to allow them to become intelligent novices. However, many researchers had paid much attention to how to support acquisition of domain knowledge, but little attention to how to improve learners' self-regulation skills.

This paper is organized as follows; first, we consider why it is difficult to master self-regulation skill, and survey existing learning support systems and methods of helping learners develop their metacognitive skills. Then we describe which difficulties the systems and methods reduce. Finally, we propose a method of supporting learners' development of their self-regulation skill with computers.

2. The Difficulties in Mastering Self-Regulation Skill

2.1. Hierarchy of Skills and Difficulties in Mastering Them

There are many skills and every skill has its own difficulty in mastering it. As Figure 1 shows, we consider a hierarchy of the skills and classify the difficulties based on the

hierarchy.

Mastering a skill is difficult as compared with acquisition of specific (declarative) knowledge. It is difficult to explain how to use a skill explicitly even for a person who already masters the skill. This difficulty is inherited all types of skills.

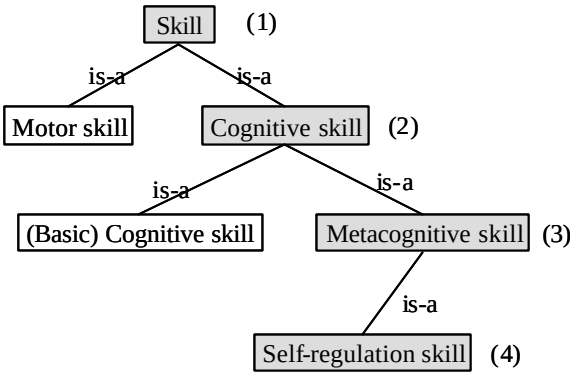


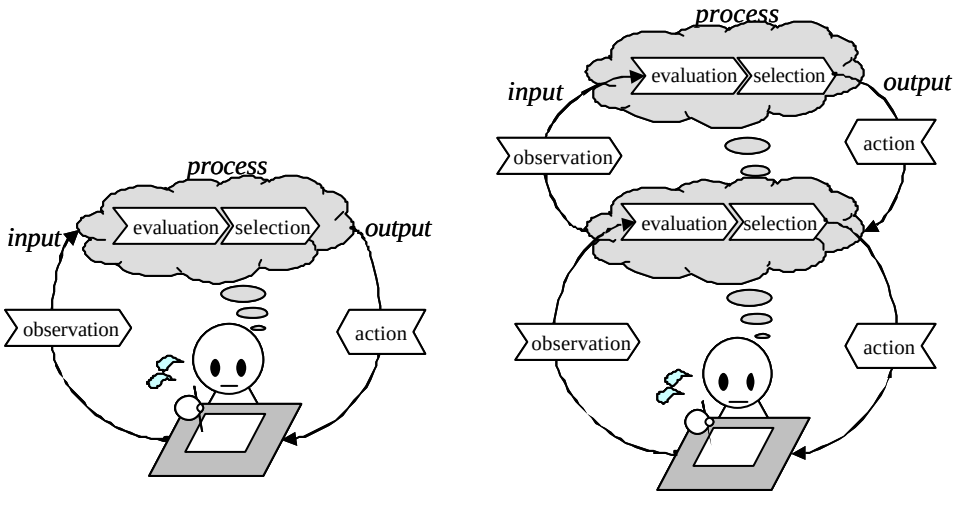
Figure 1. Hierarchy of skills

Motor skill is perceptual-motor skill such as driving a car, throwing, typewriting, playing musical instruments and so on. It is possible to observe initial state, information as input, process how a person uses the skill, and output of the skill (outcome). Cognitive skill is a skill performing in mind. It is ability to solve problems in intellectual tasks such as calculating, reasoning, problem-solving, and so on (Figure 2-a). Although both the input (initial state) and the output (outcome) of cognitive skills are visible for other persons, the process how a person uses the skill is usually covert and invisible. Thus, there is an additional difficulty in mastering Cognitive skill as compared with mastering Motor skill: the person who wants to master the skill cannot observe a process how to use it, thus, it is difficult to imitate the process.

As Figure 1 shows, there is Basic Cognitive skill in the same layer with Metacognitive skill. The simple distinction between Metacognitive skill and Basic Cognitive skill is what its controlling-target is. The target of Basic Cognitive skill is at the outside world of the person. The target of Metacognitive skill is at the inner world of the person who uses the skill (Figure 2 shows).

The reason why Basic Cognitive skill and Metacognitive skill are sometime confused is, we think, there are two types of metacognition: cognition at metalevel in specific domain, and cognition of cognition. A learner often encodes a given problem into more abstract problem and forms a representation of the problem. This abstract representation implies cognition at metalevel in specific domain. This type of cognition is at metalevel, but it is not cognition of cognition. So, the skill, which is used by this type of cognition, is classified into Basic Cognitive skill.

Metacognitive skill includes operating specific mental processes and there are several additional but essential difficulties in mastering the skill. (i) The input to Metacognitive skill, output, and the process how to use metacognitive skill are usually covert and invisible.



(a) Basic Cognitive skill (b) Metacognitive skill

Figure 2. Basic Cognitive skill and Metacognitive skill

(ii) Also, a learner has a difficulty in observing his/her own cognitive activity objectively (Figure 2-b). (iii) Since the input of metacognitive skill includes a track of cognitive activities during solving a problem, it has a difficulty in allocating mental resources: a learner has to allocate his/her mental resources to both cognitive activity and metacognitive activity which includes monitoring his/her own cognitive activity. (iv) Moreover, sometime a learner can solve problems even if the learner does not use metacognitive skill. So, it is difficult to understand how important to manage his/her own thinking process, and to be aware when he/she should do it.

Self-regulation skill is one of Metacognitive skill and there is additional difficulty in mastering self-regulation skill to ones in mastering general Metacognitive skills. The task of self-regulation skill is regulation including monitoring a person's thinking process, recognizing where he/she is in his/her plans, evaluating it with his/her goals, and adjusting his/her cognitive activity. The regulation task requires some specific knowledge and rules to evaluate and adjust a person's cognitive activity. We rarely have the opportunity to acquire the knowledge and rules in our usual experiences in schooling. So, it is one of the causes for making mastering self-regulation skill[1] difficult.

2.2. What Difficulties Do Existing Methods Reduce for Facilitating Development of Metacognitive Skill?

There are some methods for facilitating development of metacognitive skills: reciprocal teaching [9]; ASK to THINK – TEL WHY [8]; a "KITCHEN SINK" approach[2] [10] and so on. Here, we describe what difficulties these methods reduce based on the hierarchy model of difficulties in mastering skills we described in the previous section.

2.2.1. Providing just triggers to be aware self-regulation: two methods in the KITCHEN SINK approach

Here we take up the two methods in the KITCHEN SINK approach: using videotape and teachers as a role model for metacognitive behavior [10]. The former method provides a learner as an observer with an opportunity to observe another learner's problem solving process in which he/she uses only his/her cognitive skill. The latter method provides observers with an opportunity to observe an expert's problem solving process in which the expert's uses not only cognitive skill but also self-regulation skill. These two methods facilitate learners to learn metacognitive skill by observational learning. In observational learning, it is necessary what should be learned is visible [1]. However, it seems to be difficult to apply the method for learning a cognitive skill and self-regulation skill, because the processes of applying these skills are usually invisible. So, these methods provide trigger to be aware self-regulation skill itself for learners, however, the methods reduce no difficulties to develop learners' self-regulation skill and the methods provide no supports for learners' resource allocation, objective observing, and when and how the learner uses the skill.

2.2.2. Learning Self-regulation Skill in Cognitive Level: Others-regulation Skill

There are three methods which reduce two difficulties in mastering self-regulation; making input and output of self-regulation skill visible. There are Whole-Class Discussions of Problems with Teacher Serving as "Control", reciprocal teaching, and ASK to THINK – TEL WHY.

---

[1] Although Self-regulation skill is an instance of Metacognitive skill as we mentioned above, and there will be some Metacognitive skills in addition to Self-regulation skill, sometime the term 'Self-regulation skill' is used as the term which is synonymous with 'Metacognitive skill' and 'Executive Control'. So, let us use the term 'Self-regulation skill' as a synonym of 'metacognitive skill' in remain of the paper.

[2] There are four methods in the KITCHEN SINK approach. Each method is independent one.

(1) Learning others-regulation skill with Observational Learning

The method Whole-Class Discussions of Problems with Teacher Serving as "Control" is also proposed in the "KITCHEN SINK" approach. In this learning environment, the teacher monitors the learners' discussion process as input to regulate, and gives advice to the learners to regulate their thinking process. The skill that the teacher uses is to be called "others-regulation skill". The others-regulation skill is one of Basic Cognitive skill, because its controlling-target is in outside world of him/her; however, when and how the teacher uses the skill is very similar to ones of the self-regulation skill. Therefore, the learners can observe input and output of the teacher's others-regulation skill, and learn others-regulation skill by observational learning. So, we can say the method reduces the difficulties in mastering self-regulation skill: making input and output of self-regulation skill visible. But the process to use self-regulation skill is still invisible, and the difficulties that metacognitive skill has in itself are not reduced.

(2) Learning others-regulation skill with a teacher's scaffolding: cognitive apprenticeship

Reciprocal Teaching [9] provides guided practice in the use of four strategies designed to promote understanding text. This method is a cooperative learning. The method allows learners to play the role discussion-leader and induces them to use others-regulation skill. The teacher plays an important role to support the discussion-leader as scaffolding. Similarly to the method mentioned in (1), first, the learner who plays the discussion-leader can observe the teacher's others-regulation. Then, the learner tries to practice others-regulation skill with help of the teacher. This method is like Cognitive Apprenticeship [4]. This method reduces the difficulties in mastering self-regulation skill: making input and output of the skill visible, and providing a teacher's support to learn the process to use the skill. But the difficulties that metacognitive skill has in itself are still not reduced.

(3) Learning others-regulation skill with a template of questions

ASK to THINK – TEL WHY [8] controls peer tutoring in a small group with a template for questions, such as review question, thinking question, and monitoring question. The learner who plays as a peer tutor teaches other learners to comprehend text. ASK to THINK – TEL WHY is also cooperative learning, and the learners take turns in playing as a tutor. In this learning environment, the input of other-regulation skill becomes to be visible by externalizing tutees' thinking process and cognitive activities through their answers. The output becomes to be visible by the tutor's regulation through asking questions. Similarly to the method mentioned in (2), the learner who plays the tutor tries to practice other-regulation skill with some supports that are the template of questions. This method reduces the difficulties in mastering self-regulation skill: making input and output of the skill visible, and providing some supports to learn the process to use the skill. But the difficulties that metacognitive skill has in itself are still not reduced.

2.2.3. Making the output of a self-regulation skill visible: Internalization

During the problem solving in a small group in the "KITCHEN SINK" approach, a teacher asks learners three questions at any time: What (exactly) are you doing? ; Why are you doing it? ; How does it help you? These three questions exactly evoke monitoring and evaluating functions in self-regulation skill. This method provides how to use self-regulation skill explicitly as the template of questions. This learning environment is like one inspired with socio-cultural theory [11]. Therefore, this method reduces the difficulty in mastering self-regulation skill: making learners aware how important to manage his/her own thinking process, and when they should do it, and providing some supports to learn the process to use the skill. But, there are still some difficulties in mastering the skill: it is difficult for learners to observe their cognitive activity objectively, and to allocate their mental resources to both cognitive activity and metacognitive activity.

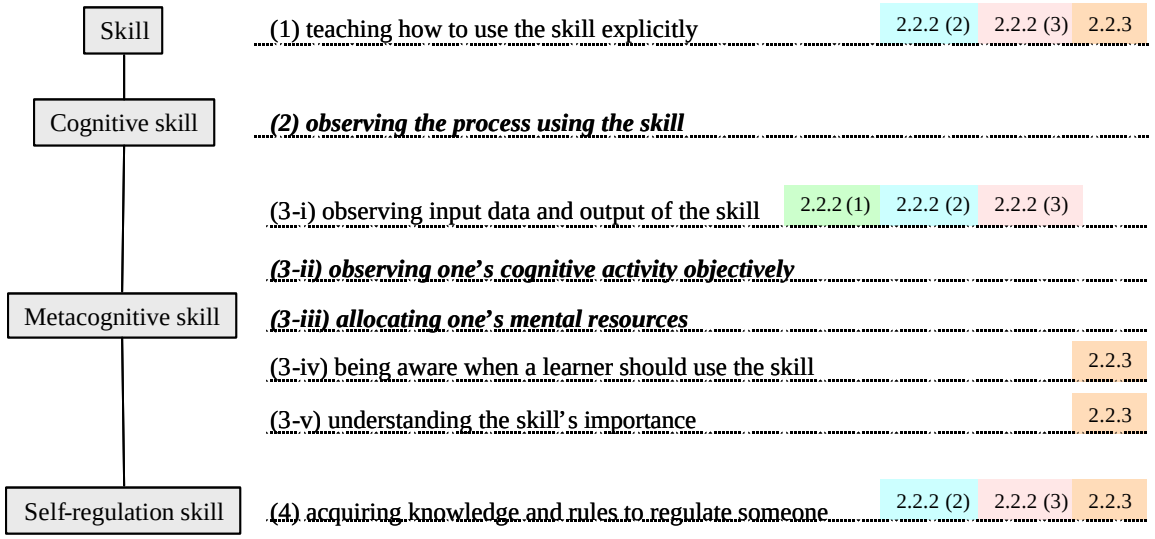


Figure 3. The difficulties reduced by existing methods and remains

3. A Method of Supporting Learners' Development of their Self-regulation Skill

We propose a method of supporting learners' development of their self-regulation skill. The method is designed in order to reduce the difficulties we described in the section 2 based on the hierarchical model of skills. In the method, we are aiming to provide learners with opportunities to develop their self-regulation skill gradually: first, they learn the skill by observational learning, and then, they learn the skill by using it as a cognitive skill. Finally, they try to use the skill as a metacognitive skill with computer system's support.

3.1. What Difficulties Are Still Remaining To Support Learners' Development Of Metacognitive Skill?

Figure 3 summarizes difficulties in mastering skills and reduced difficulties by existing methods based on the hierarchical model of skills. In the figure, from (1) to (4) mean the difficulties described in the section 2.1, and numerals, like 2.2.2 (1) or 2.2.2 (2), mean the existing methods described in the section 2.2. As the figure shows, reducing the difficulties (1), (3-i), and (4) are relatively considered well, and no method is designed to reduce the difficulties (2), (3-ii) and (3-iii). So, adopting the existing methods, we propose our supporting method to facilitate learners' development of their self-regulation skill gradually to help learners get over all those difficulties. We adopt the method which gradually increases cognitive (or metacognitive) loads for learners. For the difficulty (2), we design some learners use other-regulation skill through discussion. It makes the process how, when and why the learners regulate other learner's activity visible. For the difficulties (3-ii) and (3-iii), we design a plan externalization tool to support learners' resource allocation and observing their cognitive activity objectively.

3.2. Plan Externalization Tool to Reduce the Difficulty for Resource Allocation

In order to reduce the difficulty for resource allocation, we design and construct the prototype of a plan externalization tool. The plan externalization tool allows a learner to externalize his/her plan for problem solving, helps the learner confirm his/her execution process of the plan, and make the plan visible for other learners. Figure 4 shows the main window of the externalization tool. Its toolbar has six elements for externalizing the plan. The element "Goal" is put on the goal of the desired solution. The element "Given" is put on the starting point of the plan. It means given data of the problem. The "Process" has input and output. It represents the process to transform the given input into a desired output, and is written by a simple sentence. If the output of "Process-A" becomes the input of

"Process-B", a user can connect both "Process-A" and "Process-B" by putting the element "Unknown" between them. When a user has alternative plans, a user can leave both plans as they are and put the element "Decision" on it. It means if one of the plans is successful, another plan can be ignored. The element "Give Up!" can be put if it is impossible for the user to make any progress from there on. User can put "Unknown" on unknown input or unknown output. Usually, at the planning phase, input and output of the element "Process" is "Unknown" and the element "Unknown" is replaced by certain value at problem-solving phase.

3.3. The method for facilitating development of learners' self-regulation skill based on the hierarchical model of skills

The method for facilitating a learner's development of self-regulation skill is composed of three phases: first phase, a learner observes the process that other learners use other-regulation skill which is a Basic Cognitive skill and requires for the learners similar knowledge and rules with self-regulation skill; second phase, the learner tries to use the other-regulation skill through discussion and there is a template of question as a support for regulating the other; finally, the learner tries to use self-regulation skill as a metacognitive skill with supports by the externalization tool.

Figure 5 shows the learning environment we propose here[3]. First, a learner plays the role of observer (learner-C in the figure) and learns self-regulation skill as other-regulation skill, which is regulation skill in cognitive level, by observational learning. Next the learner plays the role of monitor (learner-B). The learner monitors the problem-solver's behaviour and tries to regulate his/her cognitive activities. Finally the learner plays the role of problem-solver (learner-A) and tries to monitor his/her cognitive activities and regulate them by him/herself.

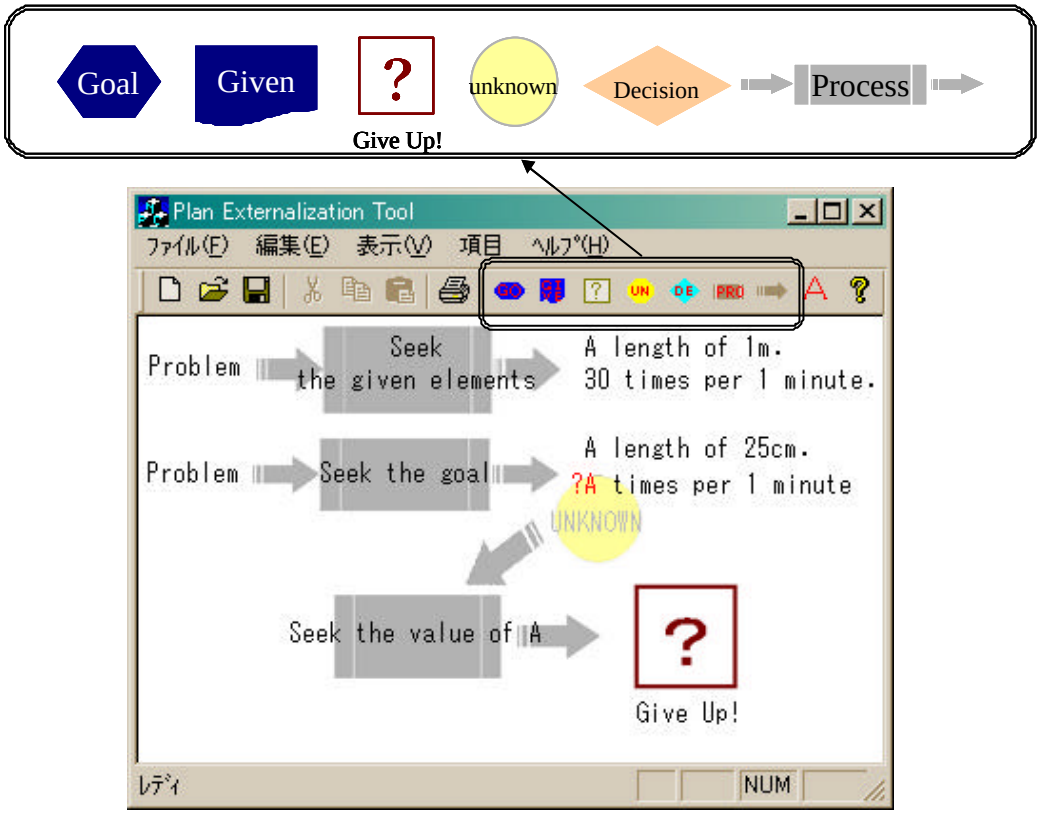


Figure 4. The plan externalization tool

[3] In this figure, we omit computers for each learner and network among them in order to avoid complicating the figure. Actually, each learner uses a computer and all computers are connected to network. Every learner can share the same screen information and use communication channel like a chat system.

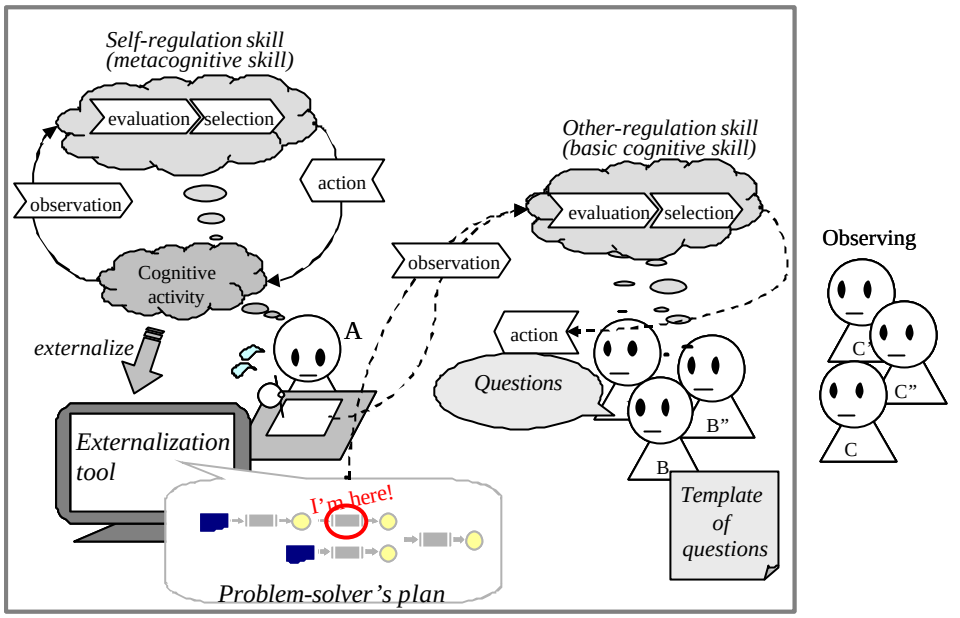


Figure 5. The learning environment gradually supports learners' development of self-regulation skill

3.3.1. Learning self-regulation skill by observational learning

In order to learn self-regulation skill by observational learning, it is ideal that input to the skill, process using the skill, and output of the skill are visible for the observer. In this learning environment, the observer (learner-C) learns it by observing the process in which the monitor (learner-B) uses other-regulation skill. Its input information is the problem-solver (learner-A)'s cognitive activity, and its outputs are questions that the monitor asks the problem-solver. The process using the skill is observed as discussion process among the monitors. It reduces the difficulty (2) in figure 3 which is not reduced by any existing methods. Both of the process and output are visible for the observer. Thanks to our externalization tool for the problem-solver, the input information is also visible. Therefore in this phase, the observer can observe all elements: input, process the monitors use the other-regulation skill, and output: observational learning is realized.

3.3.2. Learning self-regulation skill as other-regulation skill

The monitors observe, evaluate, and try to regulate the cognitive activities of the problem-solver through discussion among the monitors. The monitors have a checklist which has a template of some questions. These questions are intended to trigger off self-regulation skill of the problem-solver and it includes the questions that Schoenfeld proposed (see 2.2.3). The problem-solver designs a problem-solving plan and then executes the plan while he/she points where he/she is in his/her plan using our externalization tool. The monitors can observe the plan, where the problem-solver points in the plan, and what he/she actually does, because the screen is shared among the problem-solver, the monitors, and the observers via network. This means that the monitors can observe the problem-solver's cognitive activity. If the monitors evaluate the problem solver's behavior as wrong, for example, the behaviour is not suitable for the plan, or he/she does not point correctly where he/she is in the plan, the monitors select one of questions in the checklist and ask the problem-solver it. If this question would trigger the self-regulation of the problem-solver, the problem-solver's plan or/and behavior would be changed. In this phase, the monitors can practice to monitor another learner(learner-A)'s cognitive activity and to control it with the checklist. Repeating this allows the monitors to internalize the questions which provide some viewpoints how a learner checks and regulates his/her cognitive activity. The monitors learn how to use the other-regulation skill using the checklist as a practitioner.

3.3.3. Learning self-regulation skill as a metacognitive skill

To reduce one of the difficulties, resource allocation, we propose to use computer as a part of a learner's working memory. It means that we provide the externalization tool for the learner's problem-solving planning. This externalization also allows him/her to concentrate on observing his/her own thinking process objectively. Because it makes his/her thinking process visible and it reduces his/her cognitive load. So, in this phase, we aim to reduce the difficulties (3-ii) and (3-iii) in figure 3. In this learning environment, the problem-solver draws his/her problem-solving plan using the plan externalization tool. After planning, the problem-solver executes his/her plan while he/she points where he/she is in the plan. This behavior allows the problem-solver to be conscious of his/her cognitive activities: what (exactly) am I doing? Also, the monitor's questions cause the problem-solver to be conscious of his/her cognitive activities. If the problem-solver becomes to be not able to point where he/she is in the plan, he/she may need to re-plan and execute the new plan.

This method is based on the socio-cultural theory which comes from Vygotsky [11]. He argued that the development appears on two planes: first on the inter-psychological, then on the intra-psychological. This theory means inter-psychological processes are themselves internalized by the individuals. At first, the monitor's questions act as a trigger the problem-solver's self-regulation skill. Then the problem-solver would internalize the monitor's questions that are based on the checklist. The monitor's questions are internalized by the problem-solver, and could act as a trigger to cause his/her own self-regulation skill.

4. Conclusion

There are many skills and every skill has its own difficulties in mastering it. We consider hierarchical model of the skills and clarify the difficulties based on the model. In this paper we propose the method of supporting learners' development of their self-regulation skills, which is designed in order to reduce each difficulty we clarified. In the method, we are aiming to provide learners with opportunities to develop their self-regulation skill gradually: first, they learn the skill by observational learning, and then, they learn the skill by using it as a cognitive skill. Finally, they try to use the skill as a metacognitive skill with support of our plan externalization tool. This method is available in CSCL environment. Learners take turns to learn self-regulation skill gradually.

References

[1]Bandura, A. (1971) Social Learning Theory, General Learning Press.

[2]Brown, A. (1987). Metacognition, Executive Control, Self-regulation, and Other More Mysterious Mechanisms. In F.E. Weinert & R. H. Kluwe, (Eds.) Metacognition, Motivation, and Understanding. (pp.65-116). Lawrence Erlbaum Associates.

[3]Bruer, J. T (1993) Schools For Thought, The MIT Press.

[4]Collins,A. (1991) Cognitive apprenticeship and instructional technology, In L. Idol & B.F. Jones, (Eds.) Educational values and cognitive instruction, Lawrence Erlbaum Associates.

[5]Inaba, A., Ohkubo, R., Ikeda, M., Mizoguchi, R. & Toyoda, J. (2001) Design and Analysis of Learners' Interaction based on Collaborative Learning Ontology, Proceedings of EuroCSCL01, pp.308-315.

[6]Kayashima, M. & Okamoto, T. (1999) Awareness of other's metacognition is the Discerning Factor by which Reflection turns into Monitoring, Proceedings of AIED99, pp.717-719.

[7]Kayashima, M. & Inaba, A.(2003) How do we facilitate development of learners' self-regulation skills? http://www.ai.sanken.osaka-u.ac.jp/~inaba/Doc/SR-Skill/ (submitting to CSCL03)

[8]King, A. (1999) Discourse Patterns for Mediating Peer Learning. In O'Donnell A.M. & King, A. (Eds.) Cognitive Perspectives on Peer Learning, (pp.87-115). Lawrence Erlbaum Associates.

[9]Palincsar, A. S. & A. Brown (1984). Reciprocal Teaching of Comprehension Fostering and Comprehension Monitoring Activities. Cognitive and Instruction. 1(2): pp.117-175.

[10]Schoenfeld, A. H. (1987). What's all the fuss about metacognition? In A. H. Shoenfeld (Ed.) Cognitive Science and Mathematics Education, (pp.189-215). Lawrence Erlbaum Associates.

[11]Vygotsky, L. A. (1930 re-published 1978) Mind in Society, Harvard University Press.