Hirashima,T. et al. (Eds.) (2010). Workshop Proceedings of the 18th International Conference on Computers in Education. Putrajaya, Malaysia: Asia-Pacific Society for Computers in Education.

Question Generation to Prompt Internal Self-Conversation for Meta-Learning: Taking Presentation-Based Learning As an Example

Kazuhisa Seta[a], Hiroshi Maeno[a], Daijiro Noguchi[a*] & Mitsuru Ikeda[b]
[a]*Graduate School of Science, Osaka Prefecture University, Japan*
[b]*School of Knowledge Science, JAIST, Japan*
*seta@mi.as.osakafu-u.ac.jp, ikeda@jaist.ac.jp

Abstract: Meta-cognition plays an important role in acquiring and transferring expertise. Although we recognize the necessity of building a learning scheme for developing meta-cognitive skills, little knowledge for it has been acquired. We try to accumulate knowledge of meta-learning support system development in presentation based meta-learning scheme. Many researchers try to develop meta-learning support systems but their design principles are not necessarily described explicitly. Consequently, the know-how of developing meta-learning support system cannot be accumulated. Therefore, we adopt design model based approach to confront the problem. In our learning scheme, we provide a presentation task in specific learning area to a learner, who thinks he/she had already learned that specific topic. In this learning scheme, we intend to give the learner a chance to reflect his/her own learning processes. In this paper, we propose a question generation function to encourage learners' reflection for meta-learning based on a design model.

Keywords: Meta-Learning, Model Based Approach, Guidance Information, Presentation

1. Introduction

Many researchers in educational psychology field pointed out the importance of meta-cognition to enhance transferal to other learning domain [2][4], and research on computer supported system to enhance meta-cognitive skill is also investigated by many researchers based on the shared recognition [5][6][8].

On the other hand, design principles of meta-learning support systems developed are not necessarily clarified because of the lack of conceptualizations for characterizing them. Consequently, the know-how of developing meta-learning support system cannot be accumulated. Therefore, we adopt design model based development approach to confront the problem by conceptualizing the know-how to improve meta-cognitive skills clarified in educational psychology field. Therefore, the design model based on our conceptualization itself is meaningful as well as the concrete system development [5].

Furthermore, our research goal is to enhance learning of learning-method by stimulating learner's reflection on his/ her own learning processes. To achieve this goal, we give a task to make a presentation material on a specific topic [10].

It is pointed out in educational psychology field that an emphasis on meta-cognition needs to accompany domain-specific instruction in each of the disciplines, but not generic-instruction in general context because the type of monitoring required will vary [1]. In history, for example, the student might be asking himself as internal self-conversation, "who wrote this document, and how does that affect the interpretation of events," whereas in physics the student might be monitoring her understanding of the underlying physical principle at work [1].

In our research, we systematize such domain-specific learning methods as learning skill ontology. The learner in presentation task describes his/ her intention of presentation as a teaching plan based on it. Therefore, learner's learning-context is reified, and the learner can get the opportunity to analyze how the good learning processes should be performed in his/ her learning context.

Guidance (question generation) function that we consider in this paper is embodied computer based meta-cognitively aware instruction. The system intervenes to enhance learner's analysis on his/ her learning activity more actively, and plays a role of giving stimulation to facilitate learner's reflection on his/ her own learning processes. We confirmed the function could enhance meta-cognitively aware learning in our presentation based learning scheme [13].

In this paper, we'll mainly discuss two issues: (1) conceptualizations and design model based on them to build meta-cognition support systems and (2) learning scheme based on the model that embeds guidance function to prompt internal-self conversation for meta-learning. Concrete system and its experimental issues are described in [12].

2. Design Model Based on Conceptualizations

Design model that must be a basis of implemented support functions in each system is not always clarified. Thus, the targets that each implemented function intended to support are not clarified. This prevents us from accumulating and sharing the knowledge for building learning support systems. Therefore, we adopt the model-based approach in order to develop our system.

By making the concepts as a basis of learning system design explicit and building learning systems based on them, we can accumulate the knowledge for building sophisticated learning support systems.

We propose five concepts that we specified from the viewpoint of system development.

We explain to avoid misunderstanding: we don't argue the know-how described in this section are new from the cognitive science viewpoint but we conceptualize from the viewpoint of system development as a basis of functional design for facilitating meta-cognitive learning. We explain the meaning of each concept in the following.

SHIFT means that stagger the time of developing learning skills after performing problem-solving processes. By introducing Okamoto's survey on reflection [9], we'll explain the meaning of SHIFT in detail.

He pointed out that there are two kinds of reflection, i.e., on-going monitoring and reflective monitoring.

- On-going monitoring means controlling cognitive processes IN a problem-solving.
- Reflective monitoring means modifying cognitive processes AFTER solving the problem.

The learner in on-going monitoring simultaneously performs three kinds of different level cognitive activities, e.g., solve a math problem expressed in words, monitor the problem-solving processes and generalize the knowledge to transfer other problems. The reasons why performing these processes simultaneously is difficult for most learners are two folds: first is that they tend to exhaust their limited cognitive capacity by performing these processes and second is that they cannot be aware of when and what meta-cognition they have to perform and how to perform it.

SHIFT means the strategy that enhances the reflective monitoring by staggering the time of performing the meta-cognitive activities AFTER problem-solving processes.

Furthermore, it is needed to give appropriate stimulation to encourage their meta-cognition. This stimulation can be interpreted that it gets the meta-cognitive task as easy as cognitive task by changing internal self-conversation task to usual conversation task. Thus, we conceptualize LIFT as making the learner be aware of learning skill acquisition as a principle for the system development in this research.

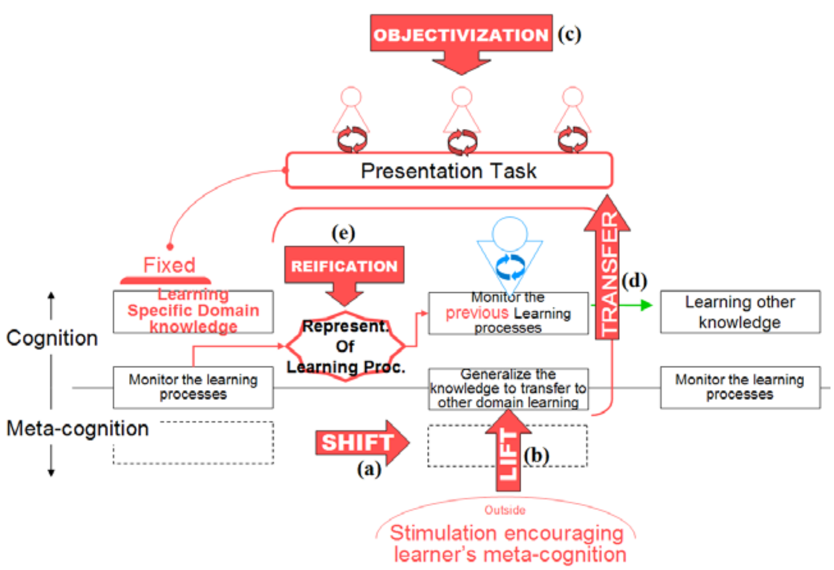
We think that how we can realize the SHIFT and LIFT is the key issue for developing meta-cognitive skills.

REIFICATION means that giving appropriate language for the subject of meta-cognition. By OBJECTIVIZATION, we intend making the internal self-conversation processes objective by discussing with others. TRANSLATE means changing the learning skill acquisition task to a problem-solving task that includes same task structure of learning skill acquisition task.

By introducing these conceptualizations, we can build a system design model shown as fig. 1 for the development of a learning system that facilitates meta-cognitive skill development. It contributes to clarifying why presentation task is suitable for facilitating meta-cognitive learning. In the figure, we are noncommittal about the boundary between cognition and meta-cognition since there are some opinions and not important for our discussion in this paper.

We presuppose a learner who has already learned a specific topic (UML). We give the learner the task of producing readily comprehensible presentation material for other learners whose academic ability is similar to that of the presenter. This task setting is important for the learner to focus on meta-cognitive learning: if the learner must perform both learning and making presentations, the learner cannot allocate sufficient cognitive capacity to perform the meta-cognitive activities. This task setting corresponds to the SHIFT (fig. 1(a)). It staggers the time of performing monitoring and generalizing processes AFTER performing learning. In preparing presentation materials, the learner monitors the previous own learning processes and asks herself queries to validate them. This stimulation corresponds to the LIFT (fig. 1(b)). It lifts monitoring and generalizing processes to the cognitive level. Then, she discusses with others whether the presentation material is easy to understand or not. This corresponds to OBJECTIVIZATION (fig. 1(c)). TRANSLATE means that it changes the learning skill acquisition task to the presentation task where the learner can be easy to be aware of learning skill acquisition (fig. 1(d)). REIFICATION (fig. 1(e)) provides terms for representing learning processes and plays an important role to realize appropriate LIFT and OBJECTIVIZATION.

Building the system design model based on the conceptualizations from the viewpoint of



system development contributes to deepening understanding of each learning scheme that aims to support meta-cognitive learning and to clarifying commonalities and/or differences among them.

3. Overview of the System

Based on the conceptualizations described in section 2, we can design support functions to enhance meta-learning. In this section, we'll explain the overview of our system based on these conceptualizations.

a. Structure of the System

Figure 2 shows a structure of our learning environment to support learner's meta-learning processes. The system is composed of three parts: Hozo (fig. 2(a)), which is an ontology building environment developed at Osaka University, meta-learning material authoring environment (fig. 2(b)) and presentation based meta-learning environment (fig. 2(c)). A scenario for using this environment is as follows.

(1) Building ontologies in Hozo

Ontology Engineer (OE) and educational psychologist build

- general level learning skill ontology.

OE and Domain Expert build,

- domain-specific learning skill ontology,
- domain ontology of learning target field and
- annotate hypertexts using ontologies built.

(2) Authoring a meta-learning material in authoring environment

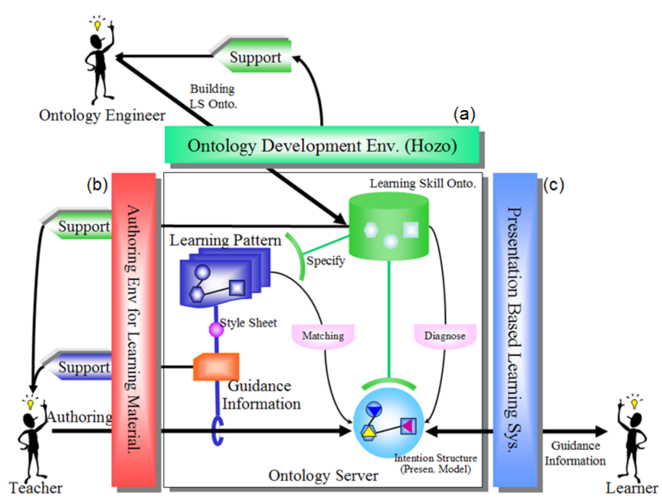
Teacher performs following activities:

- setting a presentation task for facilitating meta-learning activity,
- making a presentation material and its intention structure which plays a role of a teaching model, and
- identifying required teaching activities (learning topics) that must be embedded into presentation by a learner

(3) Presentation learning at presentation design phase

A learner, in our presentation based meta-learning support environment makes,

- intention structure of presentation (will be shown as Fig. 3) by referring domain-specific learning ontology, and
- presentation material according to the intention structure to satisfy requirements of given presentation subject.



Then the system provides

- guidance information (questions) to facilitate learner's reflection on his/ her own learning processes by referring learning skill ontology and the intention structure that the teacher made. The information is given by the learner's request to move to the following collaborative meta-learning phase. The learner's request is interpreted as a declaration that he/ she thought the presentation satisfies the presentation subject.

The learner reconsiders

- whether the presentation satisfies the requirements by referring guidance information that suggests the learning topics might be embedded.

(4) Presentation learning at collaborative meta-learning phase

A learner in collaborative meta-learning support environment performs,

- collaborative meta-learning with learning partners by referring interaction logs between the learner and the system.

Then the system provides

- information for the viewpoint to discuss their learning methods.

Ordinary learners tend to focus on the aspects on visual quality, impact of the presentation material and so on rather than validity of contents and their sequence structure (learning logic), when they discuss presentation material. Thus, we provide an environment that facilitates learning communication on learning logic, i.e., what should be learned and how to learn them, in the specific learning domain.

4. Question Generation Function Design

In this section, we explain what information the system should provide as questions to facilitate meta-learning activity.

a. Domain-Specific Learning Method

In our research, we focus on the meta-learning in technology domain, especially in software development domain as a concrete example.

In general, novice learners of object-oriented software development method tend to stop learning by memorizing only shallow knowledge such as how to depict diagrams or typical design patterns. Needless to say, memorizing how to depict diagrams is not essential in learning principles in software design.

We use DP which is a catalogue of software design model as a sophisticated learning material for enhancing learning of software design principles. Learners, however, cannot always understand them deeply even if they use DP as a learning material. They, therefore, cannot apply learned DPs to solve problems facing to them and build good design models by themselves even if they finished their learning.

The essential reason why they finish learning only by memorizing DPs is that they do not have domain-specific learning methods in the software design field.

In learning DP as well as software development methods, it is essential for the learner to ask himself to answer the important questions of designing software model: “Which functions might be extended?,” ”Which classes do we need to modify due to the respective functional extension?,” and “Which classes are not needed to modify even in a functional extension?,” and so on.

b. Intention Structure Reflects Learning Context

It is important for the system to understand learner’s learning context so that the system supports learners to acquire domain-specific learning methods in his learning context. In our learning scheme, we set an assumption that intention structure of presentation reflects learner’s learning context in his learning.

Let’s take a concrete example of this by referring to fig. 3.

In our system, it requires learners to describe intention (teaching) structures in making presentation materials. Figure 3(a) and 3(b) show intention structures of presentations that the teacher and the learner designed, respectively. Here, each node in the structure represents a learning (educational) goal, e.g., "make the learners understand the Iterator Pattern," and it is gradually detailed until feasible activities, e.g. "make the learners consider what functions might be extended."

Educational goals connected vertically represent that the learner intends relatively upper one is achieved by performing relatively lower ones.

Figure 3(a) is an intention structure that the teacher designed when he/ she sets the presentation task, i.e., "make the learners understand DP using the Iterator pattern as an example." In the figure, for example, the learning goal of "make the learners understand advantages of using Iterator pattern" is detailed as its sub-learning goals that "make the learner consider what functions might be extended," "make the learner consider which classes we need to modify due to each functional extension," and "explain advantages of using Iterator pattern."

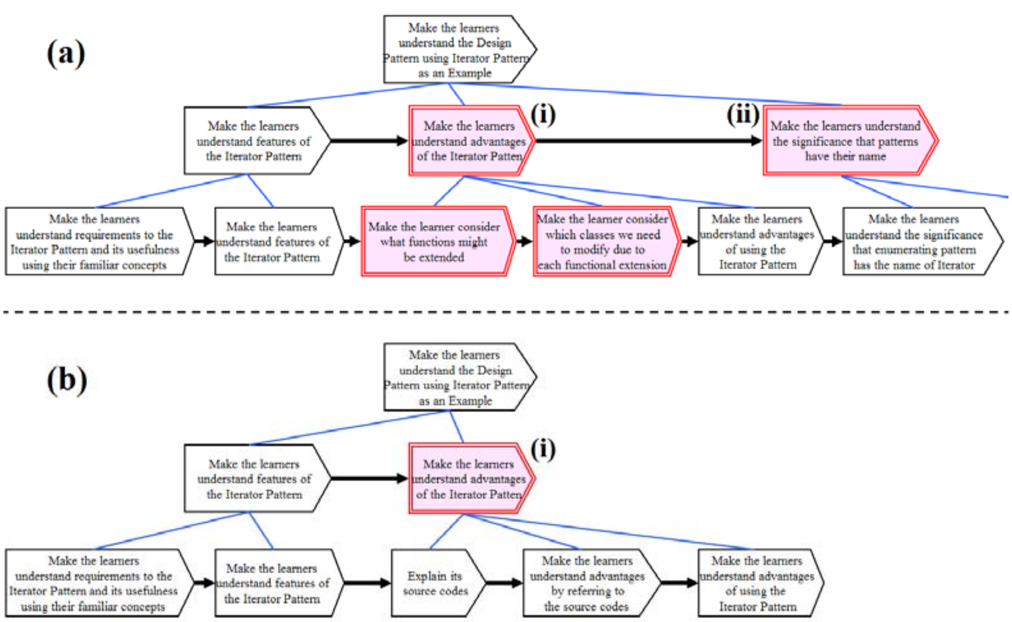
The educational activities double lined in fig. 3(i) are the ones that the teacher identified as required domain-specific educational activities.

The intention structure that the learner designed (fig. 3(b)) doesn't include the educational goals that the teacher identified. In our research, we interpret this meaning from the viewpoint of meta-cognitively aware instruction as "the learner does not recognize the important domain-specific learning activities (even if the learner had performed in learning)" or "the learner doesn't have the learning activities as learning-operators (thus, he/ she cannot perform them)."

c. Ontology Based Guidance Function

Guidance information is provided to the learner when she intends to move to the following collaborative learning phase. It gives queries on domain-specific learning activity based on the diagnosis of learner's intention structure by referring domain-specific learning skill ontology and the intention structure that the teacher constructed.

Below is an example guidance messages to prompt her reflection on her own learning



methods..
(1) Do following learning activities need to be embedded into your presentation to achieve the learning goal of “make the learners understand DP using Iterator pattern as an example?” If you think you need, choose “embed into the presentation” by right-mouse clicking.
(2) Do you have sufficient understanding of performing following teaching activities? Check items you had already understood.”

- Make the learners consider what functions might be extended
- Make the learners consider which classes we need to modify due to each functional extension
- Make the learners consider which classes we do not need to modify even in a functional extension
- Make the learners understand the significance that each pattern has its own name

All of these learning activities are the ones that are defined in domain-specific learning skill ontology. Learning activities that the teacher identified to perform in the presentation are preferentially-shown high in the list.

It requires the learner to examine importance of their learning activities whether she should embed into his/ her presentation.

This can be interpreted as a stimulation to facilitate the learner’s reflection on his/ her own learning processes. Furthermore, the checking activity is interpreted as declaration of (a) the change of the learner’s understanding on “the importance of performing learning activities that he/ she couldn’t be aware of in learning time” or (b) starting learning processes to understand it that the learner did not perform.

Therefore, the learner has to judge whether each query-item (teaching activity) should be embedded into his/ her presentation by referring these useful information capturing his/ her learning contexts. This encourages learner’s internal self-conversation on domain specific learning activities.

Declaration of (b) cannot be directly interpreted as the learner’s will for acquiring the learning operator (meta-learning), however, performing the learning activity is the necessary condition to acquire it as the learning operator.

The guidance information plays a meaningful role to enhance learner’s acquisition of learning operators and gives a precious opportunity to acquire them, since the learner performs based on the understanding of significance of each learning operator to achieve presentation subject.

For educational activities that the learners judged as less important but the teacher requires, the teacher’s presentation slide is shown in order to give an opportunity for the learner to reconsider the validity of his/ her judgment.

The interaction history in this phase will be shown as the learning material to facilitate learning communication in collaborative learning phase.

5. Related Works

In this section, based on our design model proposed in this paper, we can clearly address our research by comparing with other related works that focus on facilitating meta-cognitive skill development.

In the research on problem posing [7][8], they transfer learning skill acquisition task to problem posing task: it includes SHIFT and TRANSLATE principles. In performing problem posing task, learner has to remind his own problem solving processes: it includes LIFT principle. Furthermore, secondary effects occur since posed problem has to be solved by other learners: it includes OBJECTIVIZATION principle. It doesn’t include REIFICATION principle. In this learning scheme, it is a problem that learners might not be able to follow this task transfer.

Consequently, the system design model based on the conceptualizations plays a role of clarifying commonalities and/ or differences among related learning schemes.

6. Concluding Remarks

We aim to build a novel learning scheme to encourage meta-learning through presentation task. In this paper, we mainly address two issues: (1) conceptualizations and design model based on them to develop meta-cognition support systems and (2) and (2) learning scheme based on the model that embeds guidance function to prompt internal-self conversation for meta-learning. We'll carefully address the empirical issues [12] and our model-based approach for the system development in othe paper.

References

[1] Bransford, John, Ann Brown, and Rodney Cocking, eds., Brain, Mind, Experience, and School., in How People Learn, National Academy Press, Washington, DC, 2000

[2] Brown, A.L., Bransford, J.D., Ferrara, R.A., and Campione, J.C.: Learning, Remembering, and Understanding', In: E. M. Markman & J. H. Flavell. (Eds.), Handbook of child psychology (4th ed.) Cognitive Development, Vol. 3, Wiley: New York, pp. 515–529, 1983

[3] Erich Gamma, Richard Helm, Ralph Johnson, John M. Vlissides, Design Patterns: Elements of Reusable Object-Oriented Software, Addison-Wesley Professional; illustrated edition, 1994

[4] Flavell, J. H.: Metacognitive aspects of problem solving, In L. Resnick (Ed.): The Nature of Intelligence, Lawrence Erlbaum Associates: Hillsdale, NJ, pp. 231-235, 1976

[5] T. Hirashima and K. Horiguchi, ``Error-Visualization for Learning from Mistakes," Trans. of Japanese Society for Information and Systems in Education, Vol. 21, No.3, pp. 178-185, 2004 (in Japanese)

[6] Kayashima, M., Inaba, A. and Mizoguchi, R.: What Do You Mean by to Help Learning of Metacognition?, Proc. of the 12th Artificial Intelligence in Education (AIED2005), pp. 346-353, Amsterdam, The Netherlands, July 18-22, 2005.

[7] Kojima, K., & Miwa, K.. A Case Retrieval System for Mathematical Learning from Analogical Instances. Proc. of the International Conference on Computers in Education (ICCE), pp. 1124-1128, (2003)

[8] Nakano, A., Hirashima, T., Takeuchi, A., Developing and evaluation of a computer-based problem posing in the case of arithmetical word problems, The Fourth International Conference on Computer Applications, ICCA2006, (2006)

[9] Okamoto, N., Review of Metacognitive Research – from educational implications to teaching methods -, Journal of Japanese Society for Information and Systems in Education, Vol.19, No.3, pp. 178-187, (2002)

[10] Seta, K. & Ikeda, M., "Conceptualizations for Designing a Learning System to Facilitate Meta-Cognitive Learning", In Proceedings of World Conference on Educational Multimedia, Hypermedia and Telecommunications (ED-MEDIA), pp.2134-2143, Vienna, Austria, 2008

[11] Seta, K., and Ikeda, M.: Design of an Environment for Developing Presentation Skills, Proc. of the International Conference on Computers in Education (ICCE-06), Beijing, China, pp. 29-36, 2006

[12] Noguchi, D., Seta, K., Fujiwara, M., and Ikeda, M. "Presentation Based Learning Environment to Facilitate Meta-Cognitive Aware Communication", in Proc. of International Conference in Computers in Education, (2010, to appear)