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Presentation Based Learning Support System to Facilitate Meta-Learning Communications

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Abstract: As described in this paper, we propose a presentation-based meta-learning scheme. First, we introduce the design rationale of our meta-learning scheme by introducing our conceptualization, which clarifies the kind of support to facilitate meta-learning that is embedded into our learning scheme. Secondly, we present support functions that we embed into the system. Thirdly, we conduct experiments to verify the meaningfulness of our learning scheme, which suggests the system can stimulate learners' reflection on their learning processes. Furthermore, it can stimulate learners' meta-learning communications. Results show that users tightened their criteria to evaluate their own learning processes and understanding states. It is useful for learners to facilitate change in their learning processes.

Keywords: meta-learning, meta-learning communication, presentation-based learning

Introduction

Many researchers working in the educational psychology field have described the importance of meta-cognition to enhance transfer to other learning domains [2] [3]. Research into computer-supported systems to enhance meta-cognitive skill are also investigated by many researchers based on shared recognition [7] [8] [9]. Results show, particularly in the educational psychology field, that an emphasis on meta-cognition must accompany domain-specific instruction in each of the disciplines, but not generic instruction in a general context, because the type of monitoring that is required will vary [1]. In a history course, for example, a student might be asking herself in an internal self-conversation, "who wrote this document, and how does that knowledge affect the interpretation of events," whereas in a physics course, the student might be monitoring her understanding of the underlying physical principle at work [1]. In the software development field, in addition to learning program design methods at the theoretical level, it is important to combine concrete examples with theoretical issues for constructing deep understanding. Our research goal is the enhancement of meta-learning through stimulation of learners' reflections on their own learning processes. To achieve this goal, we assign a task to make a presentation material on a specific pre-learned topic for other learners whose academic abilities are similar to those of the learner [6].

Collaborative learners with no regulation, however, might stray in undesired directions: in the case of our presentation-based learning, for instance, they tend to discuss illustrations of the slides, the impact of the presentation, and so on. These topics are important in the business scene, but are not necessarily important for learning the lesson at hand.

We therefore propose a support system that facilitates meta-learning communication by providing learners with viewpoints to discuss their learning methods.

1. Design Rationale of the System

Meta-learning is the learning of learning processes: it requires learners to perform meta-cognitive monitoring and control of their own learning processes. However, it is not always performed spontaneously.

We encourage learners' awareness of meta-learning by setting a presentation task whereby the learners must be conscious of teaching methods to plan audiences' learning processes. Through the task, we aim (1) to facilitate learners' acquisition of domain-specific significant learning activities and (2) to tighten their criteria to evaluate their own learning processes and understanding states by reflecting on their own learning processes.

We herein explain the design rationale of our meta-learning scheme by introducing our conceptualizations: SHIFT, LIFT, REIFICATION, TRANSLATE, OBJECTIVIZATION.

- **SHIFT**: Stagger the time of developing learning skills after performing problem-solving processes. The learner cannot allocate sufficient cognitive capacity to perform meta-cognitive activities if the learner must perform both learning and production of presentation materials. By setting pre-learned subjects, we shift the time of meta-cognitive learning after domain-specific learning.
- **LIFT**: Make the learner aware of learning skill acquisition. In preparing presentation materials, the learner monitors prior personal learning processes and asks herself queries to validate them. This stimulation corresponds to LIFT.
- **REIFICATION**: Give appropriate language for the learner's self-conversation to acquire learning skills. It provides terms for representing learning processes and plays an important role in realizing appropriate LIFT and OBJECTIVIZATION.
- **TRANSLATE**: Translate the learning skill acquisition task (LSAT) to a problem-solving task that includes the same task structure of LSAT. The targets of meta-cognitive activities in learning are *learning* activities performed in her head, whereas, in our learning scheme, these are *teaching* activities performed in the outside world by translating learning skill acquisition task to presentation task.
- **OBJECTIVIZATION**: Objectify a learner's self-conversation processes by externalizing them for learning communications with other learners.

The difference between REIFICATION and OBJECTIVIZATION is that REIFICATION is giving a term to facilitate learner's internal self-conversation by eliminating a difficulty of segmentation of process, while OBJECTIVIZATION is objectifying effects of designed teaching processes through interaction with other learners to verify them.

These conceptualizations clarify what kind of support to facilitate meta-learning we embed into our learning scheme.

By setting the presentation task in which learners explain pre-learned topic to others, the support concepts of SHIFT and TRANSLATE are embedded into our meta-learning scheme.

Support concepts of LIFT, REIFICATION, and OBJECTIVIZATION are embedded into our design principle for developing our learning support system described in the next sub-section: Our system provides terms for describing teaching plans and visualization environment according to the REIFICATION concept. It also provides guidance information to stimulate a learner's internal self-conversation processes according to the LIFT concept. Furthermore, it provides a CSCL environment according to OBJECTIVIZATION concept.

2. Embedding Support Functions to Facilitate Meta-learning Communication

In our research, we developed a presentation-based meta-learning scheme whereby learners can specifically examine learning on their own learning processes. Learners in our learning scheme perform learning by following three steps.

i. Learning specific domain contents through self-study or attending lectures until they think they have understood them
ii. Making comprehensive presentation materials to teach other learners who have the same academic level
iii. Collaborative learning using presentation materials

In the following, we explain support functions embedded into the system at (ii) and (iii) phases to facilitate meta-learning, although phase (i) is beyond our support.

2.1 Intention Structure Reflecting Learning Contexts

To encourage meaningful meta-communication among learning partners, each learner must (A) become aware of performing meta-learning and (B) share individual learning contexts. In our learning system, providing a representation to describe their intention of the presentation (intention structure), intention structures and guidance function according to them play roles of enhancing their awareness at the presentation design phase.

At the presentation design phase, we make learners construct intention structures to be aware of learning skill acquisition. Giving appropriate instructions according to learners' learning contexts is significant to facilitate their learning skill acquisition processes.
In our task setting of making truly comprehensive presentation materials for use by those who have the same academic level with the presenter, we adopt an assumption that intention structures of presentation reflect learners' learning contexts in their learning.

In the intention structure (Fig. 1. (iii)), each node represents an educational goal. Educational goals connected vertically to each other represent that the learner intends to achieve upper goals by performing lower ones, e.g., the learning goal of "Make the learner understand the significance of building DP" is detailed as its sub-learning goals that "Make the learner understand considerable viewpoint of software design" and "Make the learner understand the meaningfulness of that each DP has its own name." Terms are provided from the system to represent the learners' educational goals.

2.2 Guidance Function to Enhance Meta-Cognitive Awareness

Guidance information to facilitate the learner's reflection on personal learning processes is provided when the learner intends to move to the subsequent collaborative learning phase. It represents queries on domain-specific learning activity based on the learner's intention structure. The teacher giving a presentation subjects also constructs an intention structures and indicates required learning (teaching) activities on them that should be embedded into learners' intention structures. The system cannot understand the contents of learners' presentation written in natural language. However, it can process intention structures by referring learning skill ontology. Therefore, if learners did not embed them, then the system provides queries by referring domain-specific learning skill ontology and the teacher's intention structure as follows:

(1) "Do the following learning activities need to be included in your presentation to achieve the learning goal "make the learners understand DP using Abstract Factory pattern as an example?" Choose "embed into presentation" by right-mouse clicking if you think you need to do so.

(2) "Do you have sufficient understanding of these teaching activities? Check the items you had already understood."

□ Make the learner understand the meaningfulness of the fact that each DP has its own name.

□ Make the learner understand the advantages of object-oriented programming by combining its general theories with concrete examples in the Design Patterns.

□ … (Required learning activities defined in learning skill ontology are listed)

The learner is required to examine the importance of each learning activity for constructing comprehensive presentation materials: the learner judges whether the learner's presentation is valid or not and whether each learning activity should be included in the learner's presentation. This guidance is a stimulation to facilitate the learner's reflection on personal learning processes.

The fact that the learner did not embed listed learning activities is interpreted as follows: (a) the learner has no learning activities as domain-specific learning operators in his own consciousness, (therefore the learner cannot perform them) or (b) the learner does not understand the importance of the learning activities even if they have and they had performed their learning processes. The learner's checking activity in query (2) is interpreted as a declaration of whether the learner has them as learning operators.

For (a), the learner must perform the learning activities spontaneously or must be taught from the learning partners at the collaborative learning phase. For (b), the learner must encourage internal self-conversation to consider the importance of each learning activity.

The guidance function is embedded based on the LIFT concept. It plays a role of building a foundation to encourage meta-learning communications among learning partners by stimulating their awareness in meta-learning before starting collaborative learning.

2.3 Viewpoint Function to Stimulate Meaningful Learning Communications

Figure 1 portrays a screen image at the collaborative learning phase. The window comprises six panes: the presentation pane (Fig. 1 (i)), interaction history pane (Fig. 1 (ii)), intention structure pane (Fig. 1 (iii)), video chatting pane (Fig. 1 (iv)), text chatting pane (Fig. 1(v)) and discussion viewpoint pane (Fig. 1 (vi)). The system is implemented in Visual Basic (Microsoft Corp.) and Java, functioning cooperatively with Power Point (Microsoft Corp.).

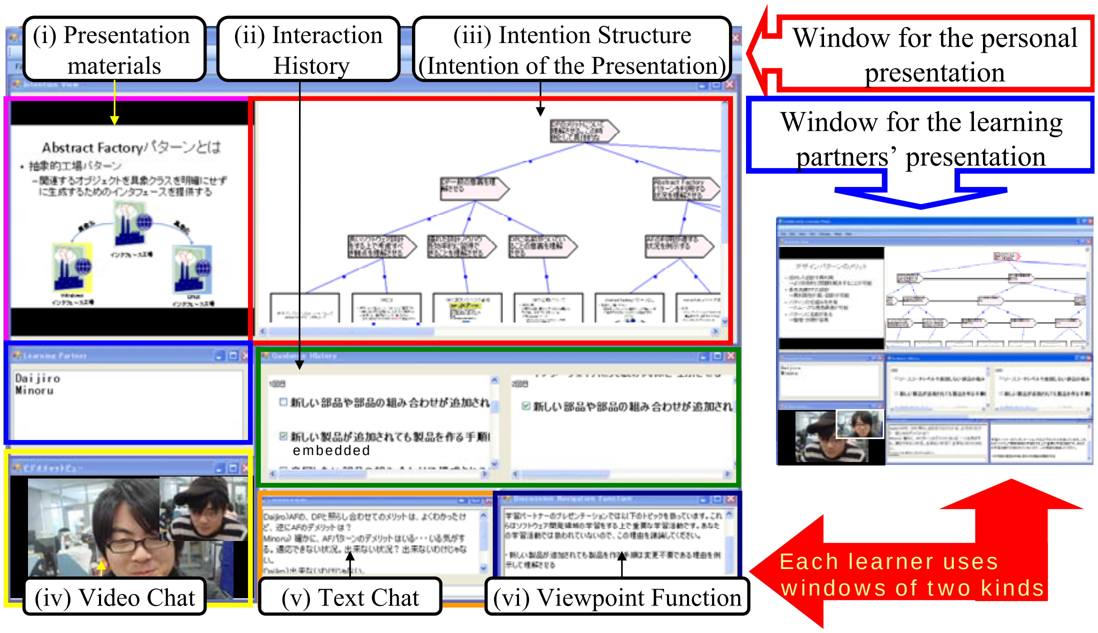

Figure 1. CSCL Environment to Facilitate Meta-Learning Communication.

The system in the collaborative learning phase provides support of two kinds to facilitate learners' learning skill acquisitions (acquiring learning operators and tightening evaluation criteria) as follows.

(1) Support to share learning (teaching) contexts of learning partners by referring to presentation materials with intention structures.

(2) Facilitate meaningful discussions to encourage their reflections on their own learning processes by providing discussion viewpoints.

As described in this paper, we particularly examine the topics on the viewpoint function. Thinking processes related to one's own learning processes are quite tacit. Therefore it is not easy to externalize and to discuss learners' thinking processes (while teaching processes reflecting their learning processes are externalized as intention structure). Ordinary learners with no support tend to discuss the appearance of illustrations, animations, and so on.

To eliminate the problem, our system provides viewpoints to discuss their teaching and learning methods based on the interaction history between the learner and the system at the presentation design phase. As shown in Fig. 1 (vi), the system provides each learner with respective viewpoints to discuss as follows: "You judged the learning activity "Make the learner understand the significance of the fact that an interface specifies the name of each method by taking an example." as important. It is an important learning activity in the software development domain and you embedded it into your presentation. On the other hand, your learning partner judged it as not important. Explain why you think this learning activity is important."

Collaborative learners can discuss their domain-specific teaching methods by referring to the viewpoints for meta-learning communication.

3. Experimentation

3.1 Objectives and Methods

We conducted an experiment to verify the meaningfulness of our learning scheme and usefulness of support functions embedded into the system. We specifically examine the issues of whether the system can encourage meta-learning communications. The outline of the experimentation is described below.

- **Subjects:** 16 graduate students participated. They had completed software engineering (UML) and object-oriented (Java) programming courses when they were undergraduate students. They were divided into two groups at random: eight students were in the experimental group (ExpG) using the system; eight were in the control group (CtlG).
- **Presentation topic:** Make presentation materials explaining the merits of building design patterns by taking the abstract factory pattern as an example.
- **Flow of the experiments:** Continuous 7 days lecture (90 min lecture each day) without weekend:
  - ✓ **1st – 2nd day:** Self-study of software design patterns until they think they have understood them. (Questionnaire administered at the end.)
  - ✓ **3rd – 5th day:** Making presentation materials. Participants in ExpG used our system; those of CtlG used only Power Point (Microsoft Corp.). The system provides 109 domain-specific learning activities (including 16 required learning activities) to describe their intention structures. (Questionnaire administered at the end.)
  - ✓ **6th day:** Collaborative learning for meta-learning. Each participant in CtlG had provided guidance information before coming to collaborative learning. Four pairs in each group are constructed for collaborative learning. Participants in ExpG referred discussion viewpoint if they thought it is meaningful. In this experiment, we did not use chatting function but did adopt face-to-face communication specifically to

examine the evaluation of usefulness of viewpoint provides function. They performed CSCL by sitting next to each other. (Questionnaire administered at the end.)
- ✓ **7th day:** Examination to take a credit of the course. (Questionnaire administered at the end.)

- **Evaluation methods:** Administered four questionnaires (5-scale, 52 items for ExpG in total, 30 items for CtlG in total) and performed protocol analysis.

One of the authors conducted the experiment in his course: he explained the meaningfulness of meta-learning—what it is and the intentions of performing the presentation based learning for all students—at the beginning of the first day's lecture. He also explained that the learning goal of the lecture is to acquire software development domain-specific learning methods.

3.2 Experimental Results And Analysis

3.2.1 Time Ratio Analysis of Learners' Communication Topic

Table 1 presents a time-based ratio of their communications as a part of the protocol analysis. The average time ratio of meta-learning communication of four pairs in ExpG is drastically more than the ones in CtlG although the teacher had instructed to all participants to perform meta-learning communications for getting them be aware of meta-learning. Therefore, it suggests that the system was able to encourage learner's meta-learning communications. The average time ratios of communication for confirming their understanding of fundamental domain-concepts and for trivial things (how to depict the class diagram, illustration and animation of the slides, and so on) in CtlG are significantly higher than those in ExpG. These results also support the meaningfulness of the system.

Table 1. Time Ratio of Communication Topics in Collaborative Learning Phase

Topics	ExpG	CtlG
Percentage of meta-learning communication	31.75%	11.75%
Percentage of discussion on domain knowledge	1.5%	12.5%
Percentage of discussion on appearance of slides	0.5%	20.25%

3.2.2 Questionnaire Analysis

Table 2 presents results of questionnaires after their collaborative learning. Questionnaire items 1 and 6–10 are for participants in both ExpG and CtlG: item 1 is related to the usefulness of the presentation-based learning scheme and 6–7 are related to learning effects from the viewpoint of meta-learning. Items 2–5 only for participants in ExpG are on usefulness of support functions embedded into the system.

Regarding item 1, participants in both ExpG and CtlG gave quite high marks, which suggests the presentation based meta-learning stimulates learners' reflection on their learning processes. Regarding item 2, participants in ExpG gave high marks, which mean that descriptions of intention structures are useful to share their learning contexts. Regarding items 3–5, participants in ExpG almost all gave high marks, suggesting that embedded support according to the LIFT concept is useful to encourage learners' reflections on their learning processes and their meta-learning. Especially, we were able to verify the viewpoint providing function can trigger their meta-learning communications.

It is expected that learners will execute better learning processes using the acquired domain-specific learning activities and tightened evaluation criteria if the learners' meta-learning processes are performed successfully. Items 6–10 inquired the about learners' consciousness of them. Both groups gave high marks to each item. However, CtlG gave higher marks than ExpG for the acquisition of domain-specific learning activities (items 7

Table 2. Results of Questionnaire after the Collaborative Learning Phase

Questionnaire Items		ExpG		CtlG	
		Mean	SD	Mean	SD
1	Do you think the collaborative learning after making your presentation materials enhanced your reflection on your own learning processes?	4.375	0.267	4.375	1.982
2	Do you think the intention structures facilitated your analysis on your learning partner's presentation structures (his teaching methods to construct audience's understanding)?	3.375	0.553		
3	Do you think the viewpoint providing function enhanced your consciousness of your learning methods?	3.625	0.839		
4	Do you think the viewpoint providing function facilitates your analysis of your learning processes?	3.625	0.839		
5	Do you think the viewpoint providing function facilitated your discussion?	4	1.142		
6	Do you think collaborative learning changed your criteria to evaluate your understanding of DP?	2.875	1.553	3.375	1.982
7	Do you think you could acquire learning methods using collaborative learning?	3.375	0.839	3.625	1.41
8	Do you think your learning processes for other DPs will change after performing this presentation-based learning?	3.75	1.071	3.5	1.428
9	Do you think you could acquire learning methods by performing this presentation-based learning?	3.625	0.553	4.125	0.982
10	Do you think your consciousness of learning will change by performing this presentation-based learning?	4.1	0.238	3.875	0.982

and 9), whereas ExpG gave higher marks than CtlG for items related to the consciousness of changes of their own future learning processes (items 8 and 10). Those responses seem to be mutually contradictory. However, they are not so by the following interpretation: learners in ExpG had tightened their learning criteria to evaluate their learning processes and understanding states; thereby, they also strictly evaluated their meta-learning processes. The results of the average time ratio of meta-learning communication support this. However, the fact that participants in ExpG gave low marks related to item 6 suggests that they were unable to perform all meta-learning processes by themselves even though they were able to understand the importance of meta-learning. They might be conscious of the functions. Actually, we do not embed the functions that support performance of learning activities acquired by meta-learning processes even when the system triggers learning activities. On the other hand, participants in CtlG spent less time for meta-learning communications, suggesting that the learners' evaluation criteria had not been tightened through their communications. Consequently, their evaluation results for these items were more tolerant.

4. Related Works

Through interaction with computer agents, Betty's Brain supports learners as they acquire domain knowledge and self-regulated skills [8]. Learners in their system and our system perform teaching activities. Betty's Brain supports learners' teaching processes on domain knowledge by externalizing the changes of Betty's understanding. It realizes SHIFT, LIFT, and TRANSLATE concepts. In contrast, we embed support functions to stimulate their judgment of the importance of domain-specific learning activities and facilitate their communication on them.

Learning support systems for self-directed exploratory learning embed a function to lighten a learner's cognitive loads of performing meta-cognition [7]. This embedding of functions does not always include the SHIFT principle. Furthermore, self-setting of learning goals and acquisition of experience of self-exploratory are important points in this approach. This emphasis differs from our goal because we fix the target domain knowledge for domain-specific meta-learning and seek to encourage learning skill acquisition by the production of presentation materials.

An interaction analysis system for collaborative learning was proposed by Inaba et al. [4]. The teacher can characterize learning interactions among learners using systemized concepts; then the system can understand the situation of the learners' interaction. Therefore, the system can show information related to each learner's state as well as the situation of the group discussion. Consequently, the teacher can instruct the group discussion based on that information. We also would like to develop an interaction analysis system for our presentation-based meta-learning scheme. It is also helpful for both learners and teachers to analyze their interactions.

Azevedo et al. [9] classified monitoring processes into 8 categories used by learners during self-regulated learning (SRL) with hypermedia and analyzed learners SRL processes in detail. We also would like to classify meta-learning processes by analyzing learners' learning communications.

5. Concluding Remarks

As described in this paper, we present discussion of a presentation-based meta-learning scheme. We introduced the design rationale of our meta-learning scheme by introducing our conceptualization. It clarifies what kinds of support to facilitate meta-learning are embedded into our learning scheme. Furthermore, we conducted an experiment to verify the meaningfulness of our learning scheme and usefulness of support functions embedded into the system, which suggests that the system was able to stimulate learners' reflection on their learning processes. It stimulates learners' meta-learning communications. Consequently, they tightened their criteria to evaluate their own learning processes and understanding states. It is meaningful for the learner to change their learning processes. We also evaluated their learning outcomes of domain dependent knowledge: it suggests participants in ExpG could get higher mark than ones in CtlG. We will carefully address the issues of this in future works.

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