Learner Modeling to Capture Meta-Cognitive Activities through Presentation Design

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Abstract This paper describes a unique learning system that cultivates a positive attitude toward learning through presentation design activities. Learners are assigned two tasks: a declarative knowledge task and a presentation task that involves selecting slides from among a set of slides provided to create a presentation. The slides have been prepared so that some of them are relevant and support the theme of the presentation while others are redundant or may even contain wrong information. A learner model is presented that captures the meta-cognitive activities of learners toward learning as they perform these tasks. Once the various learning attitudes of the learners are known, it should be possible to create a system that offers learning guidance tailored to their different attitudes.

Keywords: meta-cognition, presentation design, learner attitudes, learner modeling

1. Introduction

The importance of meta-cognitive activities in learning is widely recognized. Reflecting back on learning activities is a kind of meta-cognitive activity that is very helpful for deriving learning strategies. Acquiring learning strategies for a particular domain on the basis of experience gained in a specific learning context is considered quite effective(1, 2).

Our previous study described an approach in which learners are given the task of preparing presentation materials about a particular topic that they have already learned(3, 4). We found that by providing stimulation from the system that prompts learners to reflect back on their own learning processes and to acquire domain-specific learning strategies, they achieved: (i) tightening of criteria for evaluating their own learning processes; (ii) collaborative meta-learning communication as a way of focusing not on the discussion about the attractive appearance of a presentation but on the ideal learning processes; and (iii) livelier reading-between-the-lines activities touching on things not explicitly mentioned in textbooks.

On the other hand, our previous study also suggests that there are some learners who cannot assign a large enough cognitive load to design well-organized learning processes but tend to assign enough to produce attractive presentation materials. Thus, their reflective activities on their own learning activities do not seem to stimulate them very much.

To raise the possibility of achieving the learning objectives, which are described in the next paragraph, with the results of the previous study, we recognized that it is necessary: (i) to give more sophisticated meta-cognitively aware instructions(1) than the previous study that can capture learners’ ‘invisible and implicit’ meta-cognitive activities on the basis of their presentation design activities; and (ii) to clarify a way of making learners concentrate on thinking about well-organized learning processes other than producing attractive presentation materials.

The learning objective we set in this study through presentation design activities is shared with the previous study: to make learners aware of the importance of deep understanding and to prompt them to reflect on their own learning processes rather than merely having a shallow understanding of a topic in order to produce superior presentation materials. However, we want to raise the possibility of achieving this goal by embedding a learner modeling function that can capture their meta-cognitive activities.

Our previously developed system can only use the information to provide feedback to learners if it is planned to explain pre-specified important learning topics defined as an ontology, because we do not have any means to capture an individual learner’s meta-cognitive activities dynamically. To achieve the learning objectives, we must clarify how we build a learner model that...
captures learners’ invisible meta-cognitive activities as the foundation of the system to give more sophisticated feedback on the basis of their presentation design activities. We think our original and meaningful contribution to this area is to clarify the way to build learner models that dynamically capture individual learners’ meta-cognitive activities.

On the basis of the model described in this paper, we may have developed a learning-support system that prompts the learners’ explicit awareness about their own meta-cognitive activities, which is prompted by their learning attitudes, by enhancing reflection upon learning activities in pursuing presentation design activity.

In this paper, we focus on the issues in our meta-model to capture learners’ meta-cognitive activities through their presentation design activities as the foundation of the system to realize more sophisticated meta-cognitively aware instructions (mentioned as (i)). We adopt a slide selection approach for (ii) as mentioned above, where all learners use the same set of slides to build a presentation. This selection approach also contributes to achieving a system that can build learner models proposed in this paper.

2. Related Work

Many researchers have proposed learning support systems that prompt learners’ meta-cognitive activities to deepen their understanding.

In terms of embedding a concept-map building environment to enhance learners’ meta-cognitive awareness on the basis of their concept maps, the KitBuild method(6) is a representative method that contributes to constructing their conceptual understanding.

In general, a concept map as an external representation of learners’ knowledge state prompts their meta-cognitive activities because they can monitor externalized representations instead of their own invisible internal knowledge state. Thus, it eliminates the ‘difficulty of invisibility’ and ‘difficulty of simultaneous processing with rehearsal’ in performing meta-cognitive activities. In addition to this general advantage of using a concept-map, the KitBuild method eliminates the ‘difficulty of segmentation’ by providing pre-defined ‘kits’ (nodes and links) as components of a concept map. Therefore, learners might be able to assign relatively large cognitive loads to perform their meta-cognitive activities. Furthermore, the system can provide a lot of meaningful information both for learners and teachers: the system can compare and analyze learners’ concept maps since they use the same set of standardized kits to construct their own concept maps.

Betty’s Brain(7) is also embedded with a concept map building environment: it is used as a means to realize ‘learning by teaching’ in the context of teaching a computer agent. Kashihara and Shiota(8) realized pseudo-haptic senses to utilize tablet media for the knowledge map composition, which allows touch operations to produce better cognitive awareness and retention of knowledge learned from the material.

In terms of supporting self-directed learning in hyperspace, Kashihara et al.(9) embedded a knowledge and learning process externalization environment to prompt their self-regulated skills, whereas Jouault and Seta(10) embedded a question generation function based on linked open data and concept maps to enhance meta-cognitive skills of learners performing their self-directed learning processes.

Externalized knowledge and learning processes in the above learning environments can be seen as learner models. They, however, are not modeled by computers but manually represented by learners. Furthermore, they do not capture meta-cognitive processes directly but represent base-level knowledge and/or processes.

Kayashima et al.(11) proposed a computational model of meta-cognitive activities that works as a reference model for system developers and researchers to design learning support functions to enhance meta-cognitive activities. The model clarifies the design intention of each function, i.e. which difficulties of performing meta-cognitive activities it attempts to eliminate.

We adopted their model and extended it to meet our purpose for designing our presentation-based meta-learning support system(3, 4). The extended model works well as a reference model for system design, but it does not have an operational method for systems to capture learners’ meta-cognitive activities during problem-solving and/or learning processes.

One of the characteristics of our new model in this paper is that it is an operational model for partially capturing learners’ meta-cognitive activities in their presentation-design processes. We clarify in which situations our learning support system can detect learners’ meta-cognitive activities in our presentation-based meta-learning support environment.
3. Meta-Learning Scheme through Presentation

3.1 Slide selection approach

Here we basically adopt the meta-learning scheme we previously proposed\(^3,4\), illustrated in Figure 1. As can be seen in the figure, (i) the learners study the domains they want to understand by attending lectures and doing self-study. (ii) Learners are then assigned the task of preparing materials to make a presentation on the topic and they work through this task using the proposed system. Finally, (iii) learners engage in collaborative learning to achieve the learning goal using the presentation materials.

A major difference between the approach we adopt here and that in another\(^3,4\) of our previous studies is that for the former, when learners deal with the task of compiling presentation materials, the instructor has pre-edited the slides and uploaded them to the system in advance. In other words, the presentation design task does not require the learners to actually produce the slides, but merely to select from among previously prepared slides and put them in proper sequence. This is our means of reducing the problem (ii) described in Section 1.

By eliminating the burden of producing slides, the task is basically a device for ensuring cognitive resources by focusing the learner’s attention not simply on the superficial appearance of the slides but rather on giving form to a better learning strategy (learning activity design). Moreover, we believe the task setting will work effectively, especially in collaborative learning toward the objective described in Section 1 of promoting meta-understanding, because the ability to make attractive looking slides has absolutely no effect on the communications among learners in this condition setting.

Learners are faced with three subtasks as they work through the slide design task in (ii) of Figure 1:

(2–1) Learners monitor and reveal their own knowledge of the topic described in each slide offered by the system and declare their own knowledge state by selecting from the following three categories: “understand,” “do not understand,” and “slide is wrong.”

(2–2) Learners formulate a learning plan, and organize their presentations as they proceed with the task by selecting (or not) the offered slides and putting them into order.

(2–3) Learners receive guidance messages provided by the system and reflect upon their learning, especially their meta-cognitive activities.

We note that slides loaded into the system include not only slides with correct information, but also slides that are plainly wrong and slides lacking any important content for learning about the target domain.

3.2 Theoretical background: meta-cognitive monitoring and understanding attitude

The Knowledge Monitoring Assessment (KMA), developed by Tobias and Everson\(^12\), is a well-known instrument for assessing metacognitive monitoring capabilities. The KMA has students perform two types of problems.

(1) A question is presented, and the learners have to declare whether they can answer correctly or not.

(2) Candidate answers are presented, and learners choose the appropriate answer.

Task (1) is a comprehension monitoring task, while task (2) is a problem-solving task. Monitoring capability is then measured on the basis of the degree of agreement between the results of tasks (1) and (2).

Figure 1. Presentation Based Meta-Learning Scheme.
In analyzing the characteristics of learners on the basis of these results, it is apparent that students showing high agreement between the two types of tasks also tend to make a sustained effort to learn, while those exhibiting low agreement between the tasks tend to be less motivated with respect to learning and figure higher in the drop-out rate.

In this study, we assign learners subtask (2–1) in Section 3.1 inspired by KMA, we try to make the learners aware of the agreement or disparity between the results of tasks (1) and (2) by having them consciously carry out a monitoring task and an explanation task. Then, focusing on self-awareness of disparity between (1) and (2) as a trigger, the students should ideally relearn the subject matter to deepen their own understanding of the topic. Thus, the objective of our research is to develop a learning support system that comprehends this process, which it represents as a learner model, as much as possible.

3.3 Technical advantages: grasping the meaning of slide content

For a learning support system to make inferences about a learner’s meta-cognitive activities prompted by his attitudes toward learning as cognitive characteristics, it must be able to comprehend the learner’s actual understanding and the learner’s cognition and belief about that understanding.

In devising the tasks involving selection of slides that have been prepared in advance, we are able to attach metadata to each slide revealing its contents and its appropriateness or the desirability (whether it is desirable or not) for selection. Thus, by defining two tasks using the slides, the system can make a partial inference about the following learner characteristics:

(2–1) a declarative knowledge monitoring task reveals the state of the learner’s base-level understanding (correct or mistaken) and his meta-level cognition regarding that understanding (for example, whether the learner believes he understands correctly when, in fact, he understands incorrectly), and

(2–2) a presentation design task reveals the learner’s meta-level perception of importance on a subject in the target domain by referring to the slides he chooses to include (or not) in the presentation.

4. Meta-Model to Construct Learner Models

By assigning tasks using slides that are subject to semantic processing as instructional materials, we have been able to construct a learner model able to discern the attitude toward learning of individual learners. Here, let us consider the meta-model that forms the foundation for this individual learner model.

4.1 Interpretation model of the declarative knowledge monitoring task

Figure 2 illustrates the cognitive activity associated with the declarative knowledge monitoring task. In Section 3.1, we described a system to promote learning that basically offers the learner a set of slides, some of which are desirable for inclusion in a presentation and others that are not. The undesirable slides might include content that is just plain wrong or content that is repetitive and better covered in another slide.

Let us give some examples of this in the context of learning a software development method (UML) and design patterns. In these learning contexts, novice learners tend to focus on how to depict each diagram in UML and try to memorize the structure of each design pattern. However, it is quite important to learn ‘why UML was born’ (in the sense of learning about technology domains in general), ‘significance of design patterns in the software development cycle,’ ‘reusability and functional extendibility of a designed concrete class structure,’ ‘meaningfulness of pattern names in the software development cycle’, and so on, although these topics are not usually focused on by novice learners or not explicitly described in a textbook. Thus, learners must be made aware of the necessities to learn by prompting their meta-cognitive activities and then try to learn by themselves by reading-between-the-lines to deepen their understanding. In other words, they should not think they have learned without considering these topics.

On the other hand, being aware of the necessity to learn about these topics and find answers by themselves are not always easy for learners. Thus, we give presentation materials that deal with such topics, even topics which are not explicitly described in a textbook. We think giving slides to explain some topics that are not explicitly described in a textbook is really important to enhance learners’ awareness of the importance of read-
ing-between-the-lines to deepen their understanding. Learners who do not try to learn even when these slides are given must be given some sort of feedback in accordance with the meta-cognitive activities they have performed.

Therefore, for a typical example in this context, we prepare a desirable presentation slide that explains ‘meaningfulness of pattern names in the software development cycle’ and an undesirable one that includes a wrong explanation. Furthermore, we can prepare other presentation slides, e.g., a desirable one explaining ‘why reusability and functional extendibility of the Abstract Factory Pattern are realized’ very well and an undesirable one that does not offer enough explanation. We call the latter type of slides as ‘correct-but-insufficient contents’ Slides. Thus, a ‘correct-but-insufficient contents’ slide cannot become a desirable slide but is an undesirable slide as shown in Table 1. Furthermore, it is notable that whether contents of a slide are sufficient or not is decided by teachers who prepare presentation slides in accordance with learning objectives.

Declarative knowledge monitoring expresses the learner’s ‘belief’ about his own understanding of something, yet of course it may or may not differ from the ‘actual state of his understanding’ about the matter. To implement a learner model that can accurately capture the learner’s meta-cognitive activities prompted by his/her attitude toward learning, which is one of the prime objectives of this research, it is exceedingly important to detect any disparity between a learner’s actual understanding state and his belief about that understanding. Learners in our system must declare their belief from ‘understand,’ ‘do not understand,’ or ‘wrong’ for each slide. Definitions of all terms are as follows:

(a) Understand: the learner thinks he has already understood the contents described in the slide.
(b) Do not understand: the learner thinks he has not understood some contents described in the slide.
(c) Wrong: the learner judges that the contents described in the slide include incorrect information. (Thus, he thinks his understanding regarding the matter is correct.)

The important thing is that learners express their ‘belief’, thus the results do not always represent their actual knowledge state properly. For example, in the case of (a), there are two patterns of a learner’s knowledge state on the topics described in the slide with an incorrect explanation. When a learner declares ‘understand’ concerning a slide that includes a somewhat incorrect explanation, he does not understand the contents very well and might have a misunderstanding. Furthermore, the learner could not recognize this even after performing meta-cognitive monitoring activities. Thus, detecting such kinds of disparities is quite important.

In our research, for example, the system can identify the following disparity: if a learner declares that one of the desirable slides contains wrong information, then the declarative knowledge monitoring task reveals a disparity between the learner’s belief that “my understanding is correct” (i.e., the learner is unaware that his understanding is wrong) even though his “understanding is

![Figure 2. Declarative Knowledge Monitoring Assessment Applied to Presentation Slides.](image-url)
Table 1. Meta-Model to Interpret Knowledge Monitoring Results.

| Slide attributes | Declarative Knowledge Monitoring Results | Semantic interpretation of declarative results | Domain knowledge determinability |
|------------------|----------------------------------------|-----------------------------------------------|--------------------------------|
| Desirable        | M: Learner thinks he understands        | B: Likely that he understands correctly        | Cannot determine if he understands correctly |
| Correct content  | M: Learner thinks he does not understand | B: Likely that he does not understand correctly | Cannot determine if he does not understand correctly |
| Undesirable      | M: Learner does not recognize he is wrong | B: Domain knowledge is wrong                    | Can determine his domain knowledge is wrong |
| Wrong content    | M: Not aware he is wrong                | B: Domain knowledge is wrong                    | Can determine if his domain knowledge is wrong |
| Wrong content    | M: Learner recognizes he does not understand | B: He does not understand correctly         | Can determine if he does not understand correctly |
| Wrong content    | M: Learner thinks he understands        | B: He understand correctly                    | Can determine he understands correctly |

Table 1 shows the meta-model that underlies the learner model based on declarative knowledge monitoring activities. We note in the “slide attributes” column on the left side of the table that each slide is associated with two types of metadata. The “desirable slides” contain correct information, while the “undesirable slides” contain information that either is wrong or correct but somehow incomplete.

The declarative knowledge monitoring results can thus be “understand,” “do not understand,” or slide content is “wrong.” Semantic interpretations of the declarative knowledge monitoring results are divided into meta-level (M) or base-level (B) interpretations corresponding to each slide attributes. For example, if a learner declares that a “desirable and correct” slide is (3) “wrong,” then this can be interpreted to mean that the learner’s “domain knowledge is wrong” at the base-level and that the learner is “unaware his knowledge is wrong” at the meta-level. Moreover, if a learner declares that he (7) “understands” a slide that is “undesirable and wrong,” we can make the same interpretations as noted above; but if he acknowledges that this slide is (9) “wrong,” this can be interpreted to mean that the learner “understands correctly” at the base-level and that the learner is “aware his knowledge is correct” at the meta-level.

4.2 Ability to identify disparities in knowledge monitoring results

The previous section described how we implement a meta-model that captures base-level data regarding construction of domain knowledge as well as meta-level data regarding cognition of the knowledge of the learner himself. Essentially, in this work we are trying to cap-
ture meta-cognitive activities prompted by the attitude learners have toward learning by focusing on how they transform the disparity between base-level and meta-level information (that is, by figuring out how the learners confront this disparity) through their presentation design activities.

Thus, taking it a step further, a key objective of this research is to ascertain to what extent a computer system can be used to autonomously grasp this disparity. Because we generally cannot externally observe a person’s perceptions and beliefs regarding his own knowledge, for a computer system to infer such information would seem to be quite difficult. While the results of a learner’s own monitoring and declaration of his own understanding may not be truly accurate, we assume that at least it accurately reflects the learner’s belief about his own knowledge. Based on this assumption, we should be able to determine meta-level cognition on the basis of the slide attributes and declarative knowledge monitoring results shown in Table 1. On the other hand, some of the domain knowledge shown in the right-hand column cannot be determined.

For example, consider the case where a learner declares that he (1) “understands” a “desirable and correct” slide. While he himself may be clearly aware that he does indeed understand (at the meta-level), there is no way that we can actually determine that this learner actually “understands correctly.” Examining the nine patterns shown in Table 1, we can only determine domain knowledge in five of them: numbers (3), (6), (7), (8), and (9). Yet we note that in three of these cases, a system would be perfectly able to detect the disparity between actual understanding and monitoring results:

Cases (3) and (6) where the learner declares a slide is wrong when it is actually correct, and Case (7) where the learner declares he understands a slide that is manifestly wrong.

4.3 Model for interpreting results of slide selection

Figure 3 illustrates the cognitive activity involved in the task of organizing a presentation. In designing a presentation through selection of slides, this reflects conscious decisions as to which slides are important in terms of content for achieving the learning objectives. Considering what is important to learn and the significance and meaningfulness of learning items in a target domain is an essential aspect of meta-learning activities for acquiring learning strategies. The slide selection process is intended to provide a task or impetus that stimulates this activity.

Table 2 shows our meta-model for constructing a learner model on the basis of the slide selection results. Again, slide attributes are shown on the left just as in Table 1. Corresponding slides listed under a semantic interpretation of selection results show the relationship between multiple slides explaining the same learning item.

Here, for example, when desired slides are not incorporated into the presentation (are not selected), we can determine that this reveals a lack of awareness regarding the importance of the content. For example, assuming that Slide S is chosen where Slide S shows “content that is not incorrect but somehow incomplete on a particular learning item” and Slide D shows “de-
tailed information about the learning item,” then we can
determine that this learner is not aware of the impor-
tance of the difference in content between Slides D and S.

4.4 Ability to determine a learner’s per-
ception of importance

In determining whether a learner understands the
importance of a slide’s content, we can assume that if
the learner fails to select slides with correct and desir-
able content, he is clearly unaware of the slide’s impor-
tance.

Yet on the other hand, we cannot jump to the con-
clusion that a learner is aware of a slide’s importance
just because he chooses a desirable slide. We can only
make that determination if the learner does not concur-
tently select a slide with incomplete content as the cor-
responding slide.

Furthermore, while we can certainly detect mistak-
en domain knowledge if a learner selects a slide with
wrong content, this in itself does not say anything about
the importance perception.

5. Meta-Model for Capturing Meta-
Cognitive Activities

By integrating the two meta-models discussed in
Section 4, we can build a meta-model able to infer
metacognitive activities through a presentation
design activity that also captures the learner’s attitude
towards learning.

Table 2. Meta-Model to Interpret Slide Selections.

| Slide attributes         | Selection results | Semantic interpretation of selection results | Importance recognition determinability |
|--------------------------|-------------------|---------------------------------------------|--------------------------------------|
| Desirable                |                   |                                             |                                      |
| Correct content          | Select            | M: Probably aware of importance              | Cannot determine if aware of importan ce |
|                          | Do not select     | M: Lack awareness of importance              | Can determine if unaware of impor tance |
| Undesirable              |                   |                                             |                                      |
| Correct but insufficient | Select            | M: Lack awareness of importance (of corre sponding slide) | Can determine if unaware of impor tance (of corresponding slide) |
| content                  | Do not select     | M: Aware of importance (of corresponding slid e when selecting corresponding slide) | Can determine if aware of import ance (of corresponding slide) |
| Wrong content            | Select            | B: Domain knowledge is wrong                 | (Can determine if domain knowledge is wrong) |
|                          | Do not select     | B: Probably understood correctly            | (Cannot determine if understood c orrectly) |

Table 3 shows a portion of a model able to infer
metacognitive activity on the basis of declarative
knowledge monitoring and slide selection results.

Because the declarative knowledge monitoring and
slide selection results reveal the state of a learner’s
knowledge at two different sequential points in time—
before and after the presentation design—this reveals
whether a learner with insufficient or mistaken knowl
edge at the beginning before starting the presentation
design project has reconstructed his own knowledge
through the presentation design task. In other words, the
model infers whether a learner performed metacognitive
control (which is triggered by taking note of his own
knowledge states in the process of designing the presen
tation) that modified or corrected his understanding as a
result.

In Table 3, for example, we can consider a learner
who declares that a desirable slide is “wrong” but then
chooses the slide for inclusion in his presentation. This
illustrates interpretation (3) where a learner “recognizes
his own misunderstanding through presentation design
activities, and modifies understanding through relearn ing.” On the other hand, if the learner does not incorpo rate the slide in his presentation, this likely suggests in terpretation (6) where the learner “remains unaware of
his own misunderstanding through the presentation pro cess (with an opportunity to explain the topic to another
person), and there is probably no relearning.”

On the basis of this model, we can distinguish four
basic types of learners in terms of metacognitive control
during the presentation design process using the results
of the declarative knowledge monitoring and slide se-
Table 3. Meta-Model to Infer Learners’ Meta-Cognitive Activities through Presentation Design Activities.

| Slide attribute | Declarative knowledge | Selection results | Semantic interpretation of declarative results | Semantic interpretation of selection results | Semantic interpretation of metacognitive control |
|------------------|-----------------------|-------------------|-----------------------------------------------|-------------------------------------------|-----------------------------------------------|
| Desirable        | Understand            | Select            | M\textsubscript{(A)}                           | (1) M: Probably aware of importance       | —                                            |
|                  | Do not understand     |                   | M\textsubscript{(B)}                           | (2) Based on recognition that understanding is lacking; understanding probably corrected by relearning. |
|                  | Wrong                 |                   | M\textsubscript{(C)}                           | (3) Recognized own misunderstanding through presentation design activities; understanding probably corrected by relearning. |
|                  | Understand            |                   | M\textsubscript{(A)}                           | (4) Probably not performing thinking activities on the importance of a learning topic. |
|                  | Do not understand     | Do not select     | M\textsubscript{(B)}                           | (5) Recognized understanding is lacking, but understanding probably not corrected by relearning. |
|                  | Wrong                 |                   | M\textsubscript{(C)}                           | (6) Not aware of own misunderstanding through presentation design activities, and probably no relearning. |
| Undesirable      | Understand            |                   | M\textsubscript{(C)}                           | (7) Not aware of own misunderstanding through presentation design activities, and probably no relearning. |
|                  | Do not understand     | Select            | M\textsubscript{(B)}                           | (8) Recognized understanding is lacking, but probably performed no relearning. |
|                  | Wrong                 |                   | M\textsubscript{(A)}                           | (9) Probably no appropriate efforts during declarative knowledge monitoring. |
|                  | Understand            | Do not select     | M\textsubscript{(D)}                           | (10) Recognized own misunderstanding through presentation design activities; probably corrected by relearning. |
|                  | Do not understand     | Do not select     | M\textsubscript{(B)}                           | (11) Relearning based on awareness of misunderstanding; probably corrected. |
|                  | Wrong                 |                   | M\textsubscript{(C)}                           | (12) —                                    |

B\textsubscript{(A)}: Likely that he understands correctly. B\textsubscript{(B)}: Likely that he does not understand correctly. B\textsubscript{(C)}: Domain knowledge is wrong. B\textsubscript{(D)}: Domain knowledge is correct. M\textsubscript{(A)}: Learner thinks he understands. M\textsubscript{(B)}: Learner thinks he does not understand. M\textsubscript{(C)}: Learner does not recognize he is wrong.
**MC Learners:** Learners who recognize through declarative knowledge monitoring tasks or presentation planning activities that “their knowledge is lacking, and correct their understanding by relearning.” Learner types (2), (3), (10), and (11) fall into this category, which represents diligent learners who are serious about learning.

**NonMC Learners:** Learners who recognize through declarative knowledge monitoring tasks that their knowledge is mistaken or lacking, yet do not address the lack of knowledge in the presentation design activities or make any effort to relearn. Learner types (5) and (8) fit into this category, which represents unmotivated or indolent learners.

**NonExpLStG Learners:** Learners who, even after explaining the topic to another person, do not become aware that their own knowledge is wrong or pursue relearning. Learner types (6) and (7) fall into this category. For this type of learners, explanation as a way of exercising self-monitoring and self-control simply does not work as a learning strategy.

**NonReflective Learners:** Learners who correctly understand learning items, yet have never considered the significance or placed the learning items in the target domain. Type (4) learners fall into this category. These are learners with only modest understanding of how to acquire transferable learning strategies.

Reflecting on these different types of learners, we should be able to generate appropriate advice tailored to each type. Although this falls outside the theme of the present paper, here we briefly touch on the types of advice and guidance that the system offers.

**Advice and guidance for MC Learners:** The system infers that relearning (metacognitive control) by explaining to another person would be appropriate for this type of learner, so after verifying this is the case, the utility of explanatory activities should be recognized as an explicit learning strategy.

**Advice and guidance for NonMC Learners:** The system infers that this type of learners remains unaware of gaps in their knowledge even after explaining to another person and the opportunity does not encourage their internal self-conversation. By encouraging these learners to actually deliver their presentations in a collaborative learning setting, this could provide the motivation they need.

**Advice and guidance for NonExpLStG Learners:** While these learners form some understanding of the learning items, they nevertheless poorly understand the significance or the context of the items. They might improve most by setting learning goals that help them understand the significance of the topic and then engaging in discussions through collaborative learning.

**6. Conclusion**

Research focusing on presentations has attracted a great deal of interest in recent years. Saito et al. (13) have devoted attention to improving the skills needed to organize and create presentation documents. These authors highlight the importance of understanding the underlying semantic structure when preparing documents and they have devised an interactive learning system that helps learners understand semantic structures.

The work of Kojiri and Iwashita (14) stresses improvement of speaking skills. These authors make a compelling case that supplemental comments between fragmentary slides play a critically important role in accurately conveying the speaker’s intent to the audience, for it is these comments that provide the theoretical structure and theoretical connectivity that integrates the overall slide presentation. Following up on this approach, these authors have developed a system that generates supplemental speech between slides.

In this study, we adopted a different approach. Our objective was not to improve presentation delivery skills, but rather to elevate the learner’s meta-learning skills to better understand the context and reflect upon learning the presentation materials.

We described a learner model that captures a learner’s meta-cognitive activities on the basis of presentation design activities. In this work we adopted a novel approach from a technological standpoint using a slide selection scheme and a computer system that understands the meaning of the slides. Through a declarative
knowledge monitoring task, we were thus able to partially detect the disparity between the state of the learner’s knowledge and the state of the learner’s belief, while also capturing the transformation that can be observed through presentation planning activities. In this study we have come up with a novel approach for inferring metacognitive activity of learners by focusing on the transformation of this disparity and then leveraging that information to capture the attitude of subjects toward learning. The proposed model is not limited to learning about domains, although we intend to verify its usefulness in the domain of learning about technology as a first step.

Building on this approach, we have already confirmed the feasibility of the learner model described in this paper. Specifically, we confirmed that the system can build a learner model on the basis of the learner’s declaration of knowledge monitoring results and slide selection results. Furthermore, we have developed a scheme for generating advice and guidance on the basis of the learner model that captures a learner’s meta-cognitive activities and natural language templates prepared in accordance with each learner type. In the future we want to implement the system to give feedback on the basis of the model proposed in this paper. Furthermore, we will need to evaluate the usefulness of the feedback by conducting experimental studies.

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