The Effect of Visualizing Lesson Structures in a Teacher Education Program

Toshinobu KASAI[a*], Kazuo NAGANO[b] & Riichiro MIZOGUCHI[c]
[a]*Okayama University Graduate School of Education Master's Program, Japan*
[b]*Faculty of Liberal Arts, University of the Sacred Heart, Japan*
[c]*Research Center for Service Science, Japan Advanced Institute of Science and Technology, Japan*
*kasai@okayama-u.ac.jp

Abstract: We have built an instructional design support system called "FIMA-Light" which reasons about a teacher's intentions from his/her lesson plan and automatically produces I_L event decomposition trees. The decomposition tree expresses the ways of achieving a learner's state change that should be realized in a whole lesson in the form of a tree structure. In this paper, we discuss the difficulty of attaining the goals of university education without using our approach. We also report on practical use of FIMA-Light in teacher training at university in order to investigate changes in students' awareness of teaching strategies brought about by providing them with I_L event decomposition trees.

Keywords: Instructional Design, Ontology, Teacher Training, Teachers' Professional Ability

1. Introduction

Alignment between teaching practices in school and teacher education provided at university is an important aspect in improving teacher education programs (The Central Education Council, 2006). However, almost all universities provide only abstract descriptions in their policies, such as "Bridging Theory and Practice" (Department of Teaching & School Leadership, Okayama University, 2013; Fujimura & Sakanashi, 2010; Graduate School of Teacher Education, Waseda University, 2013) about the alignment between teaching practices and university education. One group (Mishima, Saito & Mori, 2009) analyzed the awareness of trainee teachers before and after their teaching practices in the classroom and found that they tend to notice the importance of their university education only after completing their teaching practices. This tendency suggests that alignment between teaching practices and university education is not necessarily successful. In this study, we examined the ability of teachers to instruct learners (the ability to properly design and practice instruction). We also clarified the respective roles of teaching practice and university education in teacher education programs, as well as the relationship between them (Kasai, Nagano & Mizoguchi, 2013). From this investigation, we identified the following two main goals that university students (trainee teachers) should aim to achieve in their university education before their teaching practices:

- To understand that there are various strategies (instructional/learning theories, teaching knowledge obtained from practices, etc.) for students to attain educational goals.
- To improve their skill at interpreting global and local strategies included in lessons designed by themselves or others
  - in order to learn skills from lessons designed by expert teachers, and
  - in order to improve their skills through discussion with peer students.

We considered that the I_L event decomposition tree (described in 3.1), which is defined based on the OMNIBUS ontology (Hayashi, Bourdeau, & Mizoguchi, 2009), might be suitable for such university education. We think that the goal of the university education should be to let university students learn the skills needed to produce not only lesson plans but also I_L event decomposition trees. Since university students cannot think in the structure of lessons, it is difficult

for them to produce I_L event decomposition trees. We have proposed the use of a system called "FIMA-Light" (Kasai, Nagano and Mizoguchi, 2011) which automatically produces I_L event decomposition trees. In that study, we showed that I_L event decomposition trees that FIMA-Light produces had effective information for university education in a teacher training course. In this paper, we report the results of practical use of FIMA-Light in university lectures in a teacher training course. The aim of this practical use was to investigate changes in students' consciousness about strategies brought about by providing them with I_L event decomposition trees.

The remainder of this paper is structured as follows: In Section 2, we explain the difficulties in attaining the goals of university education without using our approach. In Section 3, we describe the features of our study that can overcome these difficulties. In Section 4, we report the results of the practical use of FIMA-Light in lectures in a teacher training course. This is followed by a discussion of some related work and concluding remarks in Section 5.

2. Difficulties in Attaining the Goals of University Education

In this section, we explain the difficulties in achieving the goals of university education in the current situation (without using our approach). In order to achieve the goals, it is necessary to achieve the following four sub-goals for goal achievement. Below, we explain the difficulty in achieving each sub-goal.

- Professors who have the skills that university students should acquire and who can instruct them should exist in the teacher training course.

Since professors in various domains instruct university students, it is important to share various strategies (instructional/learning theories, teaching knowledge obtained from practices, etc.) among the professors so that university students do not become confused. However, it is often difficult to share strategies (especially teaching knowledge obtained from practices) among them, since their fields of specialty are different.

- Professors should teach university students various strategies.

What university students should learn is that various strategies exist to attain an educational goal. Therefore, it is important to teach them every strategy in the same representation format so that they can compare them. However, it is difficult to attain this sub-goal, since representation formats differ among different learning/instructional theories.

- Professors should teach strategies that are applied in expert lessons from global to local viewpoints.

This sub-goal is to make university students understand the relations between various strategies and actual lessons. Here, in order to represent outlines of lessons, most universities (faculties) offering teacher education and school teachers utilize a format called a "lesson plan". Though there is no standardized format for a lesson plan, in general, teachers use a lesson plan to describe the learning activity, instructional activity, evaluation method, and points to consider while teaching in every scene of their lessons. However, since a lesson plan describes mainly superficial concrete activities, it is difficult to describe strategies that include the teachers' deep intentions. Therefore, in order to attain this sub-goal, professors have to extract global and local strategies that are included in each lesson by interpreting the lesson plan. Even if professors have sufficient skills, it is difficult for them to interpret teachers' intentions that are not described.

- Professors should make university students aware of the relations between various strategies and lesson plans designed by the university students.

In university education, university students should improve their skills in designing lessons that integrate a global strategy for attaining an overall goal in the whole lesson and local strategies for attaining sub-goals. However, before they attain this goal, they themselves cannot interpret relations between strategies and lessons that they design from global to local viewpoints. Therefore, professors have to interpret the lesson plans that university students design. Since

lesson plans designed by university students often include illogical and unnatural flows, it is more difficult for professors to interpret the lesson plans.

The purpose of this study is to solve the difficult problems explained in this section and to provide a method that supports the achievement of the goals of university education.

3. Features of this Study

In this section, we explain the I_L event decomposition tree and FIMA-Light which we propose for practical use in university education in order to solve the problems described above.

3.1 The I_L event decomposition tree and its features

In the format of a "lesson plan", teachers describe the learning activity, instructional activity, evaluation method, and points to consider while teaching in every scene of their lessons. This format is generally used also in teaching practices. Therefore, it is important for trainee teachers to learn how to describe their plans for their lessons in the format of a lesson plan before their teaching practices. However, since a lesson plan describes mainly superficial concrete activities, it is difficult for university students to consider strategies to be applied in the lesson from global to local viewpoints. Therefore, we think that effective instruction in university education cannot be realized using only the lesson plan as a format to represent lessons. Another representation format that will help university students to think from a more global viewpoint is required.

We considered that the I_L event decomposition tree, which is defined based on the OMNIBUS ontology (Hayashi, Bourdeau, & Mizoguchi, 2009), might be suitable for such university education. The OMNIBUS ontology has been constructed to organize a variety of learning/instructional theories and empirical knowledge extracted from best practices independently of learning paradigms. The core concepts of the OMNIBUS ontology are an I_L event and its decomposition structure. An I_L event is a basic unit of learning and instruction and is composed of a state change of a learner, an instructional action, and a learning action. A method for realizing the state change (macro I_L event) is expressed by a decomposition relation with multiple micro I_L events, called a WAY. In the OMNIBUS ontology, every piece of knowledge extracted from learning/instructional theories and practices can be described as a WAY. A macro I_L event is decomposed into several micro I_L events by applying a WAY. With this modeling framework, the flow of a lesson is modeled as a tree structure of I_L events that is called an I_L event decomposition tree. The root node of the decomposition tree is an I_L event that shows the intended learner's state change that should be realized in the whole lesson. In the decomposition tree, higher layers express instructional strategies of more global viewpoints. And by decomposing these into lower layers, this decomposition tree can express instructional strategies of more local viewpoints.

We think that these features of the OMNIBUS ontology and the I_L event decomposition tree can solve the problems caused by the lack of a unified representation format for various strategies.

3.2 Overview of FIMA-Light

FIMA-Light automatically produces relevant I_L event decomposition trees from the trainee teachers' lesson plans based on the OMNIBUS ontology. In order to input lesson plans to FIMA-Light, teachers select concepts prepared as instructional and learning activities for each step in the flow of their lesson plans. The current version of FIMA-Light produces I_L event decomposition trees based on 100 Ways that were extracted from learning/instructional theories

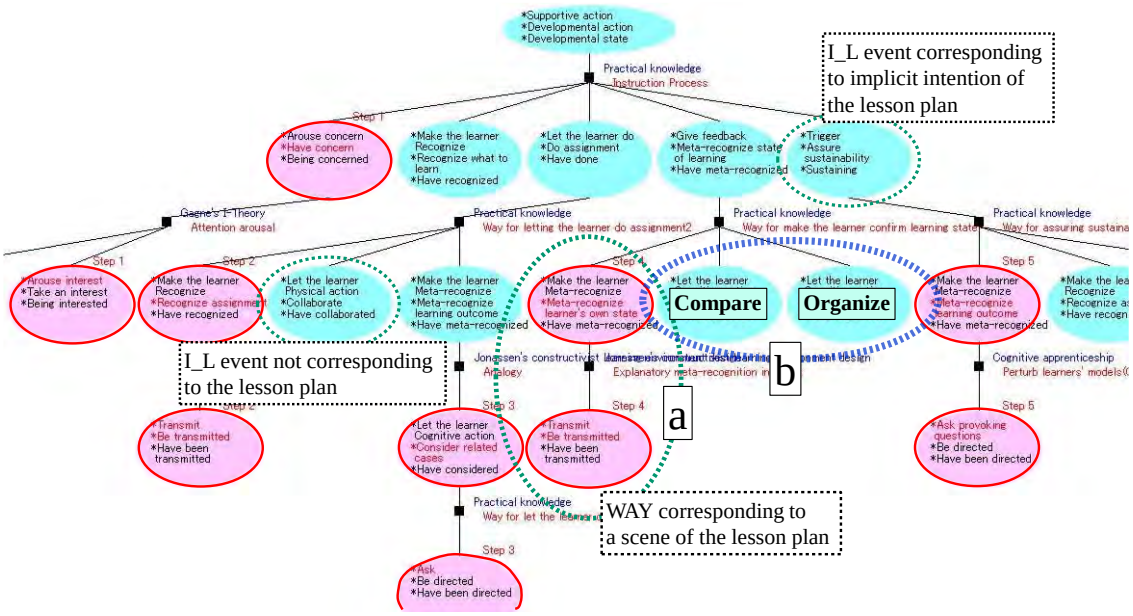

Figure 1. An example of an I_L event decomposition tree and its structure.

and 20 Ways that were extracted from practice lessons. An example I_L event decomposition tree that FIMA-Light produced by interpreting an actual lesson plan is shown in Figure 1. An I_L event decomposition tree includes two kinds of nodes. One includes pink nodes that show I_L events which FIMA-Light judged corresponding to the lesson plan. The other includes blue nodes that show I_L events that FIMA-Light judged not corresponding to any steps explicitly described in the lesson plan. The aim of FIMA-Light is to help teachers to deeply reflect on their lesson plans by providing them with the I_L event decomposition trees. By doing so, it is expected that they themselves will notice how to improve their lessons. We evaluated FIMA-Light in actual use. The results of the evaluation showed that FIMA-Light produced I_L event decomposition trees that were sufficiently relevant to the designed lessons (teachers answered that, on average, 89.2% of the nodes were relevant to the designed lessons). Thanks to the I_L event decomposition trees provided by FIMA-Light, teachers found 2.5 improvement points in each lesson plan, on average.

In university lectures of a teacher training course, FIMA-Light produced 30 I_L event decomposition trees by interpreting lesson plans that university students designed (refer to Section 4). We think that the interpretation of these 30 lesson plans could not have been be realized without this system.

4. Use of FIMA-Light in University Lectures

4.1 Purpose of the Use of FIMA-Light

The lectures in which we used FIMA-Light were “Studies on Information Study Method A” and “Studies on Educational Contents of Technology Education (Information)”, given at the Faculty of Education that one of the authors of this paper belongs to. Ten students attended these lectures in 2013. All students had learned how to write lesson plans in other lectures and had experience of teaching practice. The purpose of this investigation was to find answers to the following three questions:

- Can university students on teacher training courses be aware of the relations between the flow of instructions and the educational goals of instructions (whole goals and sub-goals of instructions) from descriptions of lesson plans?
- Can FIMA-Light produce I_L event decomposition trees that are sufficiently relevant to lessons designed by university students?

- Can I_L event decomposition trees improve university students' awareness of strategies from global to local viewpoints, whose aim is to let school students attain the educational goals?

In order for university students to efficiently attain the above goals in their university education, it is necessary to create suitable feedback based on I_L event decomposition trees according to the situation. As a preliminary stage to a discussion of suitable types of feedback, we focused on the changes in university students' awareness brought about by providing them with I_L event decomposition trees. The investigation was conducted via the following steps.

1. The instructor (the first author of this paper) directed the university students to create lesson plans and describe what teachers should consider in each scene of the lessons to attain the overall goal of the whole lesson or sub-goals, if they noticed something.
2. The instructor directed the university students to evaluate learning/instructional flows of lesson plans that other students created and to give their comments.
3. The instructor provided every university student with other students' comments and directed them to improve their lesson plans.
4. The instructor explained the I_L event decomposition tree.
5. The instructor inputted data of all lesson plans into FIMA-Light and provided every university student with two I_L event decomposition trees which FIMA-Light produced based on his/her lesson plans (two versions of the lesson plan before and after improvement).
6. The instructor asked every university student whether or not every node of his/her I_L decomposition tree was relevant to his/her designed lesson, independently of whether this was done explicitly or implicitly.
7. The instructor directed them to improve their lesson plans.
8. The instructor inputted data of improved lesson plans into FIMA-Light and provided the university students with the I_L event decomposition trees. The instructor asked them whether or not every node of the I_L event decomposition trees was relevant to his/her designed lesson.
9. The university students gave a score between one and five (with one being the lowest and five being the highest) in response to the question, "Did you think that your awareness of strategies from global to local viewpoints, whose aim was to let students attain the educational goals, was enhanced by the I_L event decomposition tree?".

The investigation was conducted by using the following five steps:

A) We analyzed a rate the number of comments that evaluated the flow of the lesson based on the relation with the overall goal of the whole lesson or the sub-goals.
B) We analyzed the 30 I_L event decomposition trees (FIMA-Light produced three I_L event decomposition trees for every university student).
C) We analyzed how the number of descriptions of what university teachers should consider in attaining the overall goal of the whole lesson or the sub-goals changed by improving the lesson plans.
D) We analyzed the results of the questionnaire conducted at the end.
E) We analyzed how the university students improved their lesson plans when provided with the I_L event decomposition trees.

4.2 Results of the Investigation and Discussion

Table 1 shows the results of step A). The flow of a lesson plan cannot be evaluated without considering the relations with its purpose, which is to attain the goal of the whole lesson or the sub-goals. Therefore, the relations with goals should be included in all comments. However, the relations with goals were included in only 21 out of 50 (42%) comments. In particular, the relations with sub-goals were included in only 2 out of 50 (4%) comments. This result shows that university

Table 1. The result of the analysis of a rate of comments related to goals

Total number of comments	The number of comments related to overall goals	The number of comments relate to sub-goals
50	19 (38%)	2 (4%)

students on teacher training courses are hardly aware of the strategies that are applied in order to attain the goals (especially sub-goals) of instructions from the descriptions of lesson plans.

Table 2 shows the results of step B). Some lesson plans designed by the university students included illogical and unnatural flows. However, FIMA-Light could produce I_L event decomposition trees that included all scenes in the flow of 30 lesson plans (every university student designed three versions of the lesson plan). The university students answered that on average about 90% of nodes were relevant to designed lessons. These results show that the current version of FIMA-Light can produce I_L event decomposition trees that are sufficiently relevant to the lesson plans that university students design.

Table 3 shows the results of step C). Every scene described in a lesson plan should have the role of attaining the overall goal of the whole lesson and the sub-goals. Therefore, one or more descriptions that include the relations with the goals of the instructions for every scene should exist. However, before providing the university students with I_L decomposition trees, there was on average only one description in each lesson plan, though the instructor directed them and provided them with examples. This result shows that the university students were hardly aware of strategies (especially local strategies) whose aim was to let school students attain the educational goals. After they referred to the I_L event decomposition trees, there were on average 5.1 such descriptions (including 1.6 descriptions related to sub-goals) in each lesson plan. The number of descriptions in the improved lesson plans is not enough either. We think that the increase in the number of descriptions related to goals in the instructions does not show that the skills which university students should learn in the university education improved, because global and local strategies in their lessons were provided explicitly by I_L event decomposition trees. However, from the results of the questionnaire (university students gave an average score of 4.6 in step D)), we judged that providing students with I_L event decomposition trees produced the following effects:

- improved the university students' awareness that there are various sub-goals according to strategies for attaining the overall goal of the whole lesson.
- improved the university students' awareness that there are various strategies for students to attain educational goals.
- improved the university students' awareness of strategies from global to local viewpoints, whose aim is to let school students attain the educational goals.

Table 2. The result of the analysis of 30 I_L event decomposition trees

Average of 10 I_L decomposition trees for each version	The number of scenes of a lesson plan	The number of scenes included in a tree	Total number of nodes in a tree	The number of nodes related to the lesson plan (judged by university students)
I_L event decomposition trees of the first versions of lesson plans	6.3	6.3 (100%)	28.9	24.6 (85.1%)
I_L event decomposition trees of the second versions of lesson plans	7.1	7.1 (100%)	32.4	28.1 (86.7%)
I_L event decomposition trees of the final versions of lesson plans	8.9	8.9 (100%)	37.6	34.0 (90.4%)

Table 3. The result of the analysis of descriptions in the lesson plans.

Average of 10 Lesson plans	The number of scenes of a lesson plan	The number of descriptions related to goals of the whole lesson	The number of descriptions related to sub-goals in a lesson plan
The first versions of lesson plans	6.3	1.2	0.1
The second versions of lesson plans	7.1	1.3	0.1
The final versions of lesson plans	8.9	3.5	1.6

Finally, we discuss concrete ways in which the university students improved their lesson plans when provided with the I_L event decomposition trees (step E)). Most of the improvements were achieved by adding scenes in which "I_L events not corresponding to the lesson plan", as judged by FIMA-Light, were embodied. Figure 1 shows an I_L event decomposition tree that FIMA-Light actually produced from a lesson plan on information technology for high schools, designed by one of the university students participating in the investigation. The educational goal of the lesson was that students should understand "the characteristics of digitization of still pictures". In the original lesson plan before it was improved, there was a flow containing a scene, "the teacher has students answer some questions" ("a" in Figure 1). The description for this scene was "have students confirm their understanding of knowledge that they learned in the instruction". This description shows the relation between this scene and the goal of the whole instruction. However, we could not interpret the university students' awareness that they regard "students confirm their understanding of knowledge" as a sub-goal. In the I_L event decomposition tree that FIMA-Light produced from the lesson plan, there were I_L events ("b" in Figure 1) aimed at letting students "compare" and "organize" after the above scenes. The university students added a scene "students discuss in groups" based on these nodes. Furthermore, they added a description "have students discuss in order to deepen their understanding of knowledge" for the added scene. In the I_L event decomposition tree before the lesson plan was improved, there was no node which can be interpreted as "students deepen their understanding of knowledge". Therefore, we thought that the university students themselves could become aware of the existence of such a sub-goal and the strategy for attaining it.

Although our investigation was preliminary, the results suggest the possibility that using I_L event decomposition trees in university education can contribute to enhancing the quality of teacher education programs.

5. Related Work and Concluding Remarks

We have built an instructional design support system called FIMA-Light based on the OMNIBUS ontology. FIMA-Light can automatically produce I_L event decomposition trees from teachers' lesson plans. We have previously evaluated FIMA-Light in practical use by incumbent teachers. In the present study, first, we considered effective alignment between university education and teaching practice in teacher education programs, and we reported the results of an investigation into the possibility that FIMA-Light can be utilized effectively for university education.

Here, we would like to discuss some related work on a system known as SMARTIES (Hayashi, Bourdeau, & Mizoguchi, 2009) to contrast it with FIMA-Light. SMARTIES is an authoring system that aims to support teachers in designing learning/instructional scenarios based on the OMNIBUS ontology and that is compliant with the standard technology of IMS Learning Design. By using SMARTIES, teachers can make I_L event decomposition trees that are compliant with learning/instructional theories through deeply reflecting on the design intentions of their lessons. In addition, SMARTIES can suggest WAYs, described in the OMNIBUS ontology as strategies for achieving state changes in learners. In this approach, in which teachers employ a so-called top-down method, when they design scenarios, they have to think about deep intentions that they may not usually be explicitly aware of. For such instructional design, it is necessary for teachers to think deeply about the lessons from global to local viewpoints. Therefore, though this approach is effective for expert teachers, it is very difficult for novice teachers and university students (trainee teachers) to employ.

On the other hand, our approach employs a bottom-up method and can automatically produce I_L event decomposition trees through reasoning about teachers' design intentions from given lesson plans that they usually design. With our approach, therefore, even novice (trainee) teachers can participate in this process. This is one of the features of our approach. To support

incumbent teachers, FIMA-Light does not directly improve, or tell them how to improve, their lesson plans by itself, because such support would prevent teachers from improving their professional skills. Therefore, by providing teachers with the I_L event decomposition trees that is produces, FIMA-Light aims at letting them themselves think about how to improve their lessons and in what respects. However, to support university students (trainee teachers), even though FIMA-Light provides them with I_L event decomposition trees, we cannot expect that they will recognize their underlying intentions. In order to support university students' learning, it is necessary to create suitable feedback based on I_L event decomposition trees according to their learning situation. To the best of our knowledge, there is no system that can automatically reason teachers' deep-level intentions from their designed lesson plans, and can support them based on the results of such interpretation.

The purpose of the university education that we proposed in this study is to provide university students with the ability to make I_L event decomposition trees themselves through thinking deeply about their lessons. Therefore, we think that, in the final stages of their university education, SMARTIES rather than FIMA-Light can support them more effectively. In future work, we intend to clarify how FIMA-Light should be utilized in university education in order to let university students efficiently attain the educational goals for teacher education. In particular, we intend to examine the following two topics: 1) the generation of suitable feedback based on I_L event decomposition trees produced by FIMA-Light, and 2) effective alignment between FIMA-Light and SMARTIES for university education in teacher education programs.

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