A Semantic Web system for supporting teachers using ontology alignment

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Abstract: In Japan, it is important to provide teachers of Information Technology Education (IT) with a powerful help system that can locate and provide access to a variety of useful information resources. To this end, we built an ontology of the goal of IT education and its applications based on Semantic Web technology. This application was based on the alignment of ontologies to reuse the results of other research. Furthermore, we propose a Goal Transition Model to show a skeleton of the transition of instructional goals based on ontologies. Finally, we propose support functions that are used in the model.

Keywords: semantic web; ontology; IT education; education support; lesson plan.

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Kazuo Nagano is a Professor at the University of the Sacred Heart, Tokyo, where he is doing research and developing the Information and Communication Technology (ICT) curriculum for schools and computer applications in education. He is also a member of the committee planning strategy for ICT education, one of the team responsible for drawing up ICT curriculum guidelines, on behalf of the Japanese Ministry of Education, Science and Technology. He won two awards for research activities in 1985 and research papers in 1995 on educational technology.

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1 Introduction

As a result of the widespread use of the internet and the development of numerous large information systems, Information Technology (IT) education has become increasingly important. However, there are very few specialist teachers with the specific skills needed for teaching IT (Ministry of Education, 2003). Furthermore, it is difficult for teachers to gain the necessary knowledge and skills, since the educational goals and techniques of IT instruction have not yet been clearly defined. For example, most teachers who are not specialists in IT education mistakenly believe that the use of the technology itself is the main goal of IT education, although the ability to use information systems is an indispensable aspect of IT education.

Many organisations provide web pages with useful resources for teachers of IT education such as digital content, lesson plans and Q&A (Okayama Prefectural Information Education Center, 2004; NICER, 2003). However, it is very difficult to collect the necessary resources for teachers because there are so many of these relevant web pages, and their formats and viewpoints are not unified, even when the resources have the same purpose.

One of the causes of these problems is that various concepts related to IT education and practical skills have not yet been clearly defined. Because most of the guidelines for IT education and commentaries about it present the concepts in a disorganised fashion, we believe that these concepts cannot be conveyed to teachers effectively. To solve this problem, it is necessary to clarify and articulate the fundamental concepts underlying the practical skills needed, and we believe that ontological engineering can assist in meeting this goal. The ontology we have developed provides a common vocabulary/concepts and fundamental conceptual structure for IT education, and its existence can promote the reuse and sharing of these concepts among teachers. However, because the ontology is quite abstract, we think that it would not be effective to instruct teachers in it. Therefore, in this study, we use the ontology as a basis and introduce educational goals for practical skills to define other useful information. If useful web resources for IT education are tagged on the basis of ontology, they can be accessed according to the various viewpoints they might have. This framework can be realised based on Semantic Web technology, which is an extension of the current web in which information is given well-defined meaning, better enabling computers and people to work in cooperation (Berners-Lee et al., 2001).

One of the authors has proposed (in Kayoo no Kai, 2001) a classification of the goals of IT education in terms that are familiar to teachers. Although the terms have been well accepted by teachers, they need quite a few modifications from the ontological engineering viewpoint. We made use of the results of this research by identifying the relations between this ontology and our ontologies. Our method is compliant with the openness of the Semantic Web, in that it allows the alignment of separate ontologies. By aligning our ontologies and the classification proposed by one of our authors (Kazuo Nagano), it will be possible to provide teachers with the integrated benefits of both classifications.

We also propose a Goal Transition Model that shows a skeleton of the transition of the instructional goals based on ontologies. If the skeleton of each provided lesson plan is expressed based on this model, teachers can judge whether the plan would be appropriate for their instructional objectives without reading it in detail. We also propose support functions that are realised using the Goal Transition Model. In this paper, we describe technical details of each part based on RDF, RDF-Schema and OWL technology for realisation of our application.

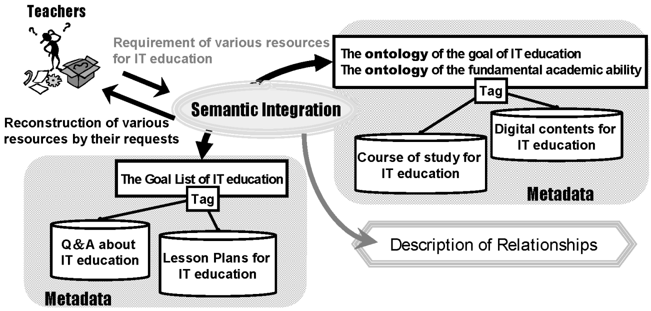
The remainder of this paper is structured as follows: in Section 2 we describe the outline of the framework for realising a system that provides teachers in IT education with useful resources. In Section 3, we explain each part of the framework that realises the alignment of ontologies. In Section 4, we describe in detail an example of the services of the Semantic Web application by the alignment of ontologies. In Section 5, we introduce some of the other projects related to our approach. Finally, in Section 6, we present the summary and future work.

2 An outline of our approach

2.1 *Outline of the framework that complies with the openness of the Semantic Web*

The framework we employ is an example of the Semantic Web application system that is open to the decentralised world. An outline of this framework is shown in Figure 1.

Figure 1 The outline of our approach, which is compliant with the openness of the Semantic Web



This framework includes two sets of metadata, one of which is based on our ontologies, which are described later in detail. We authored the metadata of various resources about IT education in RDF using the ontology of the goal of IT education and the ontology of the fundamental academic ability as the tag. The other set of metadata is based on the Goal List of IT education (Kayoo no Kai, 2001), which was taken from research that has been conducted by one of the authors for the last several years.

The purpose of the Goal List is to provide teachers with viewpoints from which to evaluate the learner's activity during instruction in IT education. Because this Goal List was not generated based on the ontology theory, its quality is not as high as that of an ontology (Kasai et al., 2004). However, this Goal List has already been so widely used with the same purpose as an ontology that many information resources that support teachers for IT education in Japan are annotated using this list. Therefore, in this paper, we regard this Goal List as an ontology.

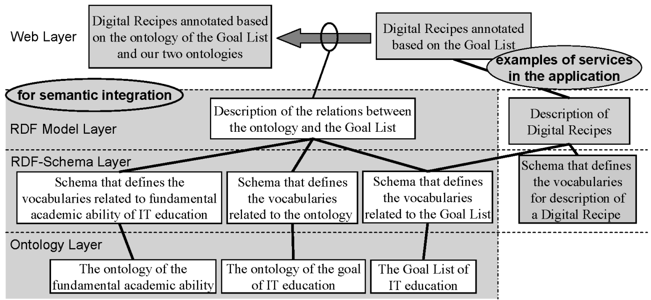
In this study, we realise semantic integration between the metadata based on separate ontologies by clearly describing relations between our ontologies and the Goal List. For example, in this framework, the system can reconstruct lesson plans that were tagged based on the Goal List from the viewpoint of our ontologies, and provide teachers with these plans. In addition, the system can integrate lesson plans based on the Goal List with digital contents based on our ontologies, which can be used in each step in the lesson plans. With this framework, it will become possible for teachers to make better use of the many resources available to them, for a wider range of purposes.

And, this framework provides teachers with benefits of both the Goal List and our ontologies. The benefit of the Goal List is that its expression is easy for teachers to understand, so teachers themselves can describe metadata from various resources. In fact, intensive activities had already been established to collect and store educational resources with metadata using 'Goal List'. This leads us to expect that the scalability of this framework will continue to improve. On the other hand, the benefits of our ontologies are that defined concepts show essential properties without confusion with other concepts and have high generalisability, which means that our ontologies can be applied in various situations and that specialised support in each situation becomes possible. An example is the support using the Goal Transition Model, which we will describe in detail in a later section. This model depends on the situation in which the learning objective is to cultivate the ability to solve various problems. And, in this model, roles of the concepts defined in our ontologies and relationships between them which exist in this situation are described. By using this model, the support system can search resources more effectively and provide teachers with resources more suitable under the assumption that learning happens during the problem-solving process.

2.2 The layered structure of our Semantic Web application

Here, we describe the outline of the alignment of ontologies of our Semantic Web Application. The layered structure of this part of the outline is shown in Figure 2.

Figure 2 The layered structure of the part of the outline concerned with the alignment of ontologies of the Semantic Web application



This application is constructed in four layers. The bottom layer is the ontology layer, in which we define all of the concepts related to our two ontologies and the Goal List of IT education. The second layer is the RDF-Schema Layer, in which the vocabularies of classes and properties used in the third layer, the RDF Model Layer, are defined. Regarding the alignment of ontologies, there are three schemata in this layer in which the vocabularies of classes and properties related to our ontologies and the Goal List defined in the bottom layer are defined. The third layer is the RDF Model Layer, in which, for the alignment of ontologies, we authored metadata of a resource that shows the relations between our two ontologies and the Goal List of IT education by using the vocabularies defined in the RDF-Schema Layer.

Thanks to this framework, we can reuse resources that were annotated based on the Goal List in our application. In addition, the application can provide teachers with the integrated benefits of both ontologies. We used simple lesson plans on the Web (called Digital Recipes) provided by Okayama Prefectural Information Education Center (2002) as an example of resources for the purposes of this paper. These Digital Recipes are accessible to the public as resources based on the concepts proposed by the Goal List. In this example, for each step of instruction, the viewpoints of evaluation are provided in terms that are easy for teachers to understand (which is a benefit of the Goal List) and the goals of IT education based on our ontologies, which are easy to be hidden in its shadow are provided (which is a benefit of the ontology).

3 Details of each layer for realisation of our Semantic Web application

3.1 The Goal List and our ontologies in the ontology layer

Here, we will briefly describe the outline of the three ontologies used in our Semantic Web application.

The Goal List has three top-level categories, "Practical ability of using information", "Scientific understanding of information" and "Awareness towards participating in the information society", which the Ministry of Education authored. Furthermore, the Goal List classifies these categories in more detail. The classification of the Goal List of IT education is shown in Figure 3. For the purpose of this classification, examples of more concrete learning activities that are easy for teachers to understand are provided with a level that shows when learners should attain this goal. For example, "Level 1: A student can express his/her feeling" is provided for "a: Expression of information" as an example of concrete learning activities. We feel that if teachers are provided with information on activities related to concepts of learning, the goal will be easier for the teachers to understand. We also feel that it will be easier for teachers to understand each description when concepts of learning activities are included in the information provided. Furthermore, it is challenging to set the level of difficulty for a goal of IT education without presenting concepts of learning activities. Consequently, the Goal List has many advantages as information that is provided to teachers directly.

Figure 3 The classification of the Goal List of IT education

A : Practical Ability of using information
- (1) Expression and communicating information
  - a: Expression of information
  - b: Communication by a media
- (2) Using information in problem solving
  - c: Discovery and planning of a problem
  - d: Collection of information
  - e: Classification, analysis and judgment about information
  - f : Reporting and sending of information
- (3) Selecting the means of information (information media, computer, network)
  - g: Selecting the means of information

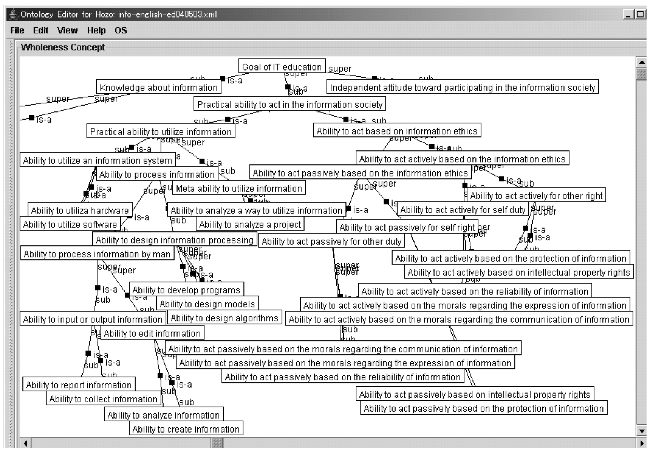
B: Scientific understanding of information
- (4) Understanding various means of information and its advantages and disadvantages
- (5) Basic theories and methods of information processing, information technology, and human's information recognition

C : Awareness toward participating in the information society
- (6) Awareness toward information
  - m: Awareness toward information
- (7) Information ethics and responsibility in sending out information
  - n: Information ethics

However, the Goal List has some faults from the viewpoint of classifying the goals of IT education. Although, essentially, the classification of educational goals should be performed by extracting the intrinsic goals that should be attained in education and systematising them, in many of the current classifications, we find concepts rather than goals; for example, the learning activities and learning environments related to the goals are sometimes incorrectly mixed up. Moreover, systematisation like that in this example, in which concepts are mixed up, sometimes causes another problem: the extracted concepts are not completely independent of each other.

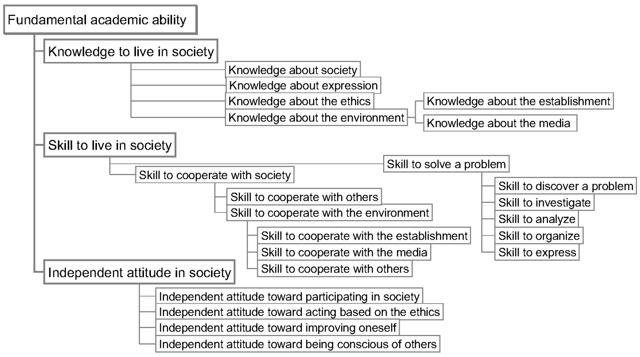
A portion of the *is-a* hierarchy as the ontology of the goal of IT education is shown in Figure 4. This ontology was built on the editor 'Hozo' (Kozaki et al., 2000), which is an environment for building ontologies. Because this Hozo outputs the ontology in OWL, we can use the concepts defined in the ontology in the RDF Model Layer and the RDF-Schema Layer based on Semantic Web technology. The ontology of the goal of IT education consists solely of the concepts of the goal of IT education. Stratification based on the *is-a* relation is the essential property of these concepts, and ensures that no confusion of various concepts occurs; such confusion can obstruct teachers' understanding of the concepts of IT education. To build this ontology, we first extracted three concepts that can be the goal of IT education. These are "Knowledge about information", "Practical ability to utilise information in the information society" and "Independent attitude towards participating in the information society". This classification is compliant with Bloom's taxonomy of instructional objectives (Bloom et al., 1971). Furthermore, we classified these three concepts into more specific ones. Kasai et al. (2004) described this ontology in more detail and showed its advantages by comparing it with the other classification from the viewpoint of the ontology theory.

Figure 4 A part of the ontology of the goal of IT education (*is-a* hierarchy)



For realisation of the alignment of the Goal List and our ontology, we describe the goal concepts of the ontology, which are contained in each example of the learning activity of the Goal List. To do this, another ontology that defines more general ability is necessary, because the Goal List contains more general ability than the goal of IT education defined in our ontology. Thus, we extracted and classified the goal of the "Period of Integrated Study" as the ontology of fundamental academic ability. The "Period of Integrated Study" was created to cultivate ways of learning and thinking, and an attitude of trying to solve or pursue problems independently and creatively. This ontology is shown in Figure 5. For this ontology, we classified three concepts: "Knowledge to live in society", "Skills to utilise information in society" and "Independent attitude towards participating in society", as well as the goal of IT education.

Figure 5 The ontology of fundamental academic ability



We can regard the "Ability to utilise information", which is the whole goal of IT education, as a specialised area of fundamental academic ability that is necessary in the information society. Here, we clarify the boundary between the goal of IT education and fundamental academic ability. We define all of the concepts involved in the ontology of the goal of IT education as 'academic ability', which is necessary to utilise digital information in an environment based on the information system and the information and telecommunications network. For example, 'Skill to investigate', which is one of the concepts of the ontology of fundamental academic ability, means the skill to obtain necessary information (including nondigital information). On the other hand, the skill to obtain necessary digital information using IT is "Skill to collect information through IT", which is one of the concepts of the ontology of the goal of IT education. Some pairs, as in this example, exist in two ontologies. The relation of these pairs is that the specialised concept of the ontology of the fundamental academic ability is the concept of the ontology of the goal of IT education. In addition, this specialisation means that an object of a concept of the ontology of fundamental academic ability is specialised to refer to digital information.

To the best of our knowledge, there is no goal classification that properly captures the intrinsic educational goals of IT education without any confusion regarding learning activities, the standards for evaluating education, etc. It is difficult to separate the various concepts related to IT education, because most goals of IT education are meta-abilities that are attained in the process of problem solving. Considering the fact that the purpose of the classification of the goal of IT education is to give teachers a clear understanding of the educational goals, our goal ontology is more suitable because it reveals the inherent conceptual structure of educational goals and thereby facilitates a teacher's understanding of those goals.

3.2 Definition of vocabularies of classes and properties in RDF-schema layer

Here, we describe the vocabularies defined in the RDF-Schema Layer for tags that are used in the RDF Model Layer. In this study, we define the vocabularies used to realise the alignment of ontologies in three namespaces.

The vocabularies defined in these three namespaces are shown in Table 1. The first schema, which is referred to by the prefix 'it_goal' in this study, defines the vocabularies of classes and properties related to the goal of IT education. The second schema, which is referred to by the prefix 'pre_goal' in this study, defines the vocabularies of classes and properties related to the fundamental academic ability. The third schema, which is referred to by the prefix 'goal_list' in this study, defines the vocabularies of classes and properties related to the Goal List of IT education. In Table 1, we omitted a description of the classes defined in these namespaces, because all of the classes show concepts of the three ontologies explained above.

Table 1 Vocabularies defined in the RDF-Schema Layer

Prefix	*Type*	*Vocabulary*	*Explanation*
it_goal	Property	target_it_goal	Target goal as IT education
pre_goal	Property	target_pre_goal	Target fundamental academic ability as goal
goal_list	Property	target example	Target learning activity that includes same goal
goal_list	Property	example_activity	Example learning activity in the category of the goal list
goal_list	Property	level_of_difficulty	Level of difficulty
sch_ed	Class	Subject	Subject in school
sch_ed	Class	Unit	Unit for learning content of education
sch_ed	Class	Activity	Learning activity by students
sch_ed	Class	Grade	Grade in school
sch_ed	Property	realisation	Educational goal of an ideal to expect realisation
sch_ed	Property	goal_Description	Description about target educational goal
sch_ed	Property	grade	Target grade of Subject or Sub-subject in school

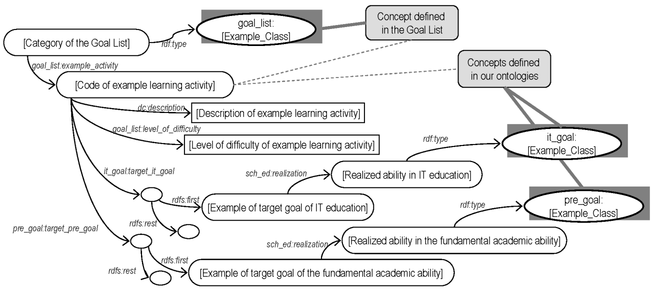
In the RDF-Schema Layer, we also define other vocabularies that we used in the RDF Model Layer to describe the other metadata used in our application. In Table 1, we show parts of vocabularies that are examples of services shown in Figure 2. These vocabularies are defined in a namespace referred to by the prefix 'she_ed'. This schema defines the vocabularies of classes and properties related to school education.

3.3 Description of relationships between our ontologies and the Goal List of IT education in the RDF Model Layer

Here, we explain the RDF Model for the description of resources, which shows the relationships between our ontologies and the Goal List of IT education. In this study, we describe the relationships by giving meaning to concrete learning activities that are provided in the classification of the Goal List based on our ontologies.

In the Goal List of IT education, for this purpose, examples of concrete learning activities that are easy for teachers to understand are provided with a level that shows when learners should attain each goal. Each example of these learning activities is a practical activity that contains educational goals explained by the concepts of our two ontologies. We authored metadata of these learning activities in RDF, which belong to the respective concepts of the Goal List, by using the vocabularies defined in the RDF-Schema about the concepts of the ontology of the goal of IT education and fundamental academic ability. A part of the RDF Model for describing the metadata is shown in Figure 6.

Figure 6 A part of an RDF Model for describing the relationships between ontologies



4 Details of an example of the services of the application by the alignment of ontologies

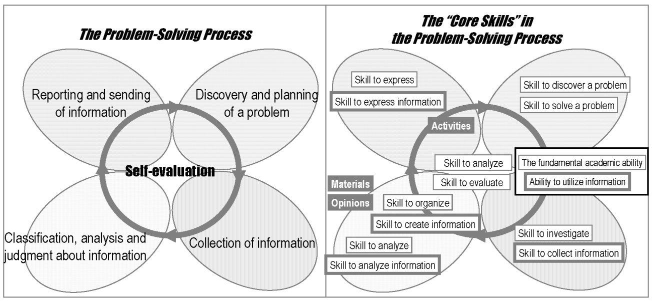
This example is a function that uses the Digital Recipes explained in Section 2. These Digital Recipes show the lesson plans of several classes for a unit. Each plan includes not only basic information (such as the target grade, target subject, aim in the whole classes and so on) but also the flow of concrete learning activities. First, we explain preparations for the example application using the Digital Recipes.

4.1 Preparations for the example application: the problem-solving process and the goal transition model

As mentioned above, the concepts in our two ontologies are those of high generality that can be applied in various situations. If a more concrete situation of activity is fixed, these concepts of educational goals are described with a role in the situation in detail according to the concreteness of the level of abstraction. The most concrete activities are actual learning activities in an actual class. Although there are various ways to make situations more concrete, in this paper we are mainly investigating situations where the purpose of learning activities is problem solving (parts of the problem-solving process), since the "Period of Integrated Study" program emphasises cultivating the ability to solve various problems in society. Next, we explain a general process for problem solving and describe the fundamental academic ability that is necessary at each step of this process as the educational goal.

In this study, we referred to Geography Education Standards Project (1994) and defined the Problem-Solving Process, which is a more general process, as a cycle. This cycle is shown on the left side of Figure 7. The skills needed to carry out the essential processing in each step of this process are extracted from our two ontologies. These are shown on the right side of Figure 7.

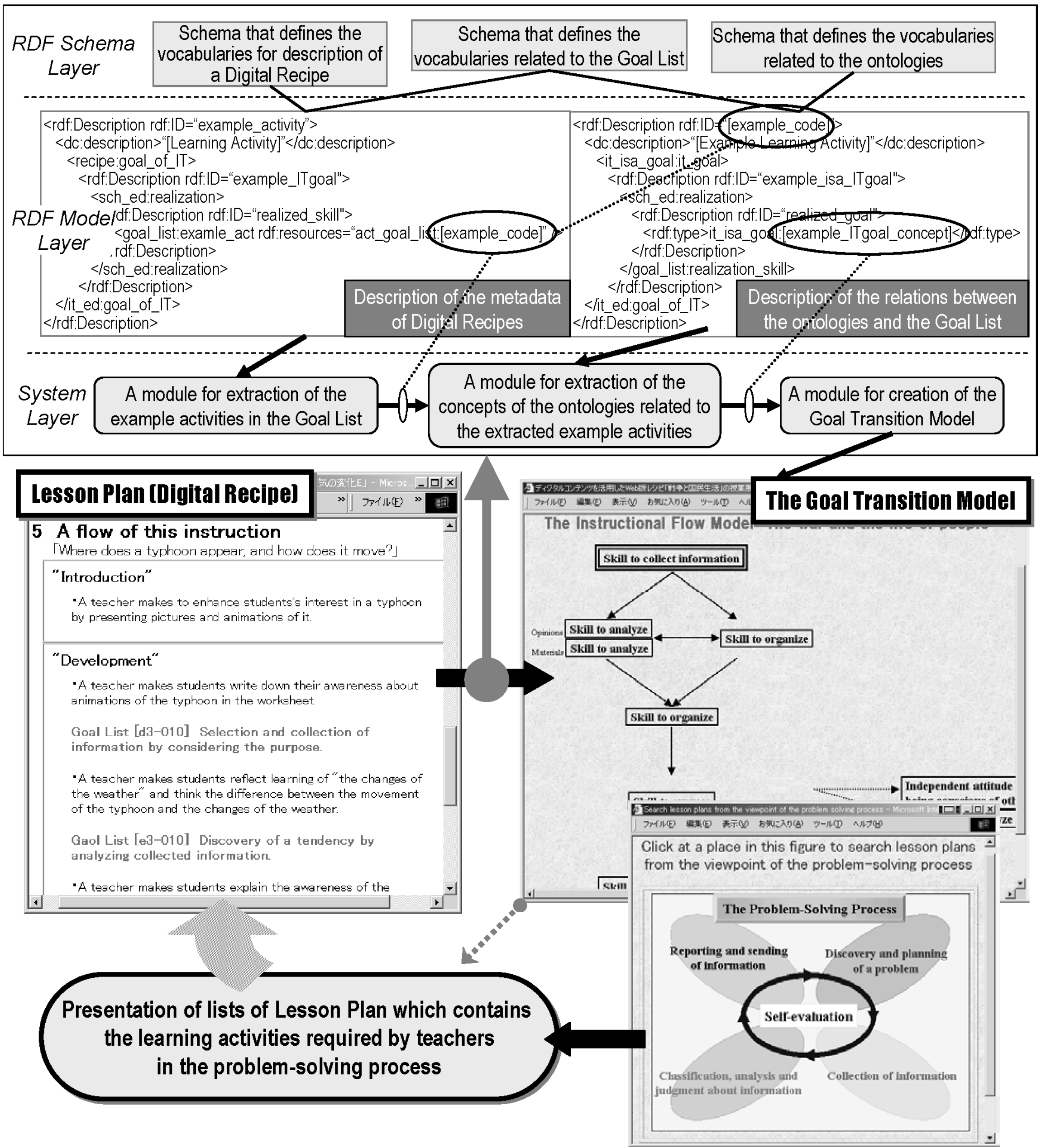
Figure 7 The Problem-solving process and the core skills in this process



Each concept of these skills plays a role in this process. For example, although 'Skill to analyse' appears in two different steps, the roles in these steps in the problem-solving process are different from each other. A role of the 'Skill to analyse' in the step of "Classification, analysis and judgement" involves the analysis of various kinds of information (including nondigital information) collected to solve the problem. While a role of the 'Skill to analyse' in the step of 'Self-evaluation' involves the analysis of the process of problem solving by oneself. The skills are necessary in steps of the problem-solving process, and these concepts play a core role in the process. In this paper, we call these concepts 'core skills' in the problem-solving process. In this process, if a more concrete activity is given in each step, other concepts of skills are given more detailed roles.

Most lesson plans of the "Period of Integrated Study" program provided via the internet aim to cultivate practical skills to be used in the problem-solving process. If all of the core skills of the problem-solving process are extracted in order from each lesson plan, it is possible to express a skeleton of the instruction from the perspective of the problem-solving process. The core skills are practical skills needed to carry out the essential activity in each step of the problem-solving process, and they express the true nature of this process in the context of problem-solving learning. In this study, we call this skeleton the "Goal Transition Model". All concepts that can be used in this model are defined in our two ontologies. An example of a Goal Transition Model extracted from an actual lesson plan is shown on the right at the centre of Figure 8.

Figure 8 Two functions that support teachers by using the goal transition model



Here, 'Skill to analyse', which exists in different steps of the problem-solving process, can be distinguished by considering its role. In this study, we classified and described objects of analysis clearly to judge which step 'Skill to analyse' is. The object of 'Skill to analyse' in the step of "Classification, analysis and judgement" is 'materials' or 'opinions', because a role of 'Skill to analyse' is the analysis of various kinds of information collected to solve the problem. The object of 'Skill to analyse' in the step of 'Self-evaluation' is 'activities', because a role of 'Skill to analyse' is the analysis of the process of problem solving performed by the learner himself or herself. In this study, we use 'problems', 'learner's self', 'others' and 'situation' as objects of analysis in addition to the three objects mentioned above, ‘materials’, ‘opinions’ and ‘activities’. However, ‘Skill to analyse’ is regarded as a core skill in the problem-solving process only when its object is one of these latter three objects. Otherwise, this concept is regarded as simply another goal concept. In the Goal Transition Model, the other concepts connect to the side of the ‘core skill’, which is contained in the same learning activities shown on the right at the centre of Figure 8.

4.2 The support system for teachers using the goal transition model

Here, we describe how to create this model from lesson plans and these two implemented functions. In the metadata of the Digital Recipes, each learning activity is tagged based on the Goal List. We show an example of web pages of Digital Recipes that are tagged with the Goal List on the left at the centre of Figure 8. A procedural flow to create the Goal Transition Model from the metadata of a Digital Recipe by the system is shown at the top of Figure 8.

The system analyses the metadata of a Digital Recipe we produced and extracts concepts of the Goal List tagged in this resource, and then the system extracts the concepts of the ontology of the goal of IT education and the ontology of the fundamental academic ability related to those concepts of the Goal List from the other resource (this describes the relations between our two ontologies and the Goal List). Next, the system connects and outputs the core skills in the order of the problem-solving process. Furthermore, the system outputs each other concept at the right side of the core skill contained in the same learning activity that contains the concept. Here, when the different concepts that are in the same step of the problem-solving process are repeated, the system outputs these concepts in parallel from the previous core skill. This is because concepts in the same step cannot be arranged.

One function builds the Goal Transition Model of a lesson plan (Digital Recipe) automatically and provides teachers with the model, as shown at the top of Figure 8. For this function, teachers can obtain the skeleton of this lesson from the viewpoint of educational goals without going through the lesson plan in detail. This skeleton provides teachers with a description of the true nature of the lesson, which can be difficult to uncover among superficial information such as learning activities, information systems, digital contents and the like. Therefore, we think that this function is useful for teachers who are not accustomed to cultivating practical skills in their students.

The other function searches necessary lesson plans from the viewpoint of the problem-solving process according to the requirement of teachers. By clicking on the place that shows each step in the problem-solving process, teachers can get lists of lesson plans containing the learning activities required, as shown at the bottom of Figure 8. In Japan, although IT education and the “Period of Integrated Study” program attach importance to cultivating the ability to solve problems, a function that can search the necessary lesson plans that are open to the public from the viewpoint of a step in the problem-solving process is nearly nonexistent. In this study, this function is realised by using the framework of the Semantic Web based on ontologies and the Goal Transition Model we have proposed.

5 Related work

We would like to briefly introduce some of the other projects related to our approach.

First, we will consider the standardisation projects for describing the metadata of the education resources. The Learning Object Metadata (LOM) was provided by the IEEE Learning Technology Standards Committee (LTSC) (IEEE LTSC, 2002). The LOM specifies the syntax and semantics of LOM, defined as the attributes required to give a full/adequate description of a learning object. The IMS Learning Design project (IMS, 2002) aims at making a standard for describing the instruction/learning activities, the learning environment and the learning objectives that can be expressed in lesson plans. In compliance with this standard, we can express the contents of lesson plans in detail. However, it is difficult to share resources based on the nature of the contents, because these approaches focus on the minimal set of attributes that allow these LOs and Lessons to be managed, located and evaluated in total independence of their contents. Our approach aims at describing the metadata of the detailed contents based on the ontology to facilitate the sharing of information.

In the area of knowledge management, there is OntoShare (Davies et al., 2003), which annotates documents in a collaborative manner using shared ontologies in a large organisation. This system facilitates and encourages the sharing of information between communities of practice within organisations based on Semantic Web technology. However, the sharing of ontologies in this approach can only be realised in an organisation. It is difficult to share ontologies in the open environment. Our approach can be shared in an open environment, using research results from the past ten years.

Here, we discuss from the viewpoint of learning objects of e-learning. One of the important properties that evaluate usability in learning objects for e-learning is reusability (Miguel-Angel and Elena, 2003). By describing metadata of learning objects based on Semantic Web technology such as our approach, reusability is increased, because, thanks to the ontology which is the base, learning objects can be annotated in detail clearly and a system can infer relations between them. Recently, there has been a lot of research describing metadata of learning objects in e-learning based on Semantic Web technology (Christopher and Gord, 2006; Dicheva and Dichev, 2004; Faical and Cyrille, 2006). Christopher and Gord proposed an ecological approach, which sees metadata as the process of reasoning over observed interactions of users with a learning object. In this approach, by creating domain, educational, and learner characteristic ontologies, content can be dynamically linked to those competencies that are observed in a running e-learning system. The research (TM4L) of Dicheva and Dichev describes the metadata of digital learning resources based on ontology. TM4L describes the metadata of digital course libraries based on the ISO XTM standard (XML Topic Maps) to organise and retrieve information in a more efficient and meaningful way. Faical and Cyrille proposed a teacher annotation model that adapts to teachers' activities with regard to both their pedagogical and their domain expertise based on three ontologies: the pedagogy ontology, the domain ontology and the document ontology. They also built an annotation tool called 'MemoNote', which enables the user to annotate pedagogical documents using the teacher annotation model. The difference between our approach and these approaches is that we realise the alignment using other ontologies. It is difficult to focus on both the reusability and the scalability in the framework based on one kind of ontology. Our approach does, however, focus on both the reusability and the scalability because it uses one ontology that focuses on reusability and another that focuses on scalability.

There is a project on teacher education for ICT education by the Teacher Training Agency in England. This project provides a training curriculum for teachers to learn technical knowledge about Information and Communication Technology. Teachers can choose the courses from the curriculum that contain content they need. However, they cannot obtain a range of information from various viewpoints according to their situation as they can in our system, because the metadata of these contents were not described.

There is research using various ontologies (Aroyo et al., 2004; Bourdeau and Mizoguchi, 2002) to support teachers. The goal of Aroyo et al. (2004) was to specify an evolutional perspective on Intelligent Educational Systems (IES) authoring, and in this context to define the authoring framework EASE: powerful in its functionality, generic in its support of instructional strategies and user friendly in its interaction with authors. The study of Bourdeau and Mizoguchi (2002) proposes a theory-aware ITS-authoring system based on the domain and task ontologies of instructional design.

6 Summary

In this paper, we described two ontologies, the ontology of the goal of IT education and the ontology of the fundamental academic ability. In addition, we proposed a framework to make use of the results of other research (Kayoo no Kai, 2001) by aligning these ontologies based on Semantic Web technology. Furthermore, we proposed a Goal Transition Model that shows a skeleton of the transition instructional goals from a lesson plan, and a support system that has functions realised by this model.

In the future, we intend to build a system that supports teachers of IT education in planning lessons by systematically describing relations between the concepts of our ontologies.

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