

# Development of a System that Provides Teachers with Useful Resources from Various Viewpoints Based on Ontology

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**Abstract:** In Japan, teaching of the subject "Information" was started in the high schools in April 2003, and interest in IT/information education has continued to grow since then. It is very difficult to design IT/information education materials, and there are very few specialist teachers of IT/information education. For this reason, it is necessary and important to provide teachers of IT/information education with a variety of useful resources. To that end, we are building a system that supports teachers in designing instructional materials for IT/information education. Here, we describe a part of this system that reconstructs resources according to the various viewpoints which teachers require. This function of the system is realized by tagging each resource with the ontology of IT/information education in the Resource Description Framework (RDF).

## Introduction

Because of the spread of use of the Internet and the development of numerous large information systems, the necessity and importance of information technology (IT)/information education have risen. In Japan, teaching of IT/information was started in the high schools in April 2003. However, most of the IT/information teachers are the incumbent teachers of general subjects, because there were very few specialist teachers of IT as of April 2003. As a result, it is likely that most of the teachers of IT courses lack the specific skills for teaching this topic. Furthermore, it is difficult to gain the necessary knowledge and skills, because the educational goals and situations have not been clearly defined for IT/information education. For example, most of the teachers who are not specialists mistakenly believe that the use of the technology itself is the main goal of IT/information education, though using information systems is indispensable to IT/information education.

Many instructors and researchers have published opinions about the various concepts of IT/information education and the relationships between these concepts. (Ministry of Education, 2000, The Meeting of Tuesday, 2003a, Ohiwa, 2001). Most of these opinions take into account factors that are useful during the usual instructional design process, such as situations and contents, in order to attain the educational goal. But it is also necessary, in IT/information education, to add educational goals that are related to the main goal of a unit, keeping in mind the contents and situations, because the main goal of IT/information education is an enhancement of the meta-ability to make use of information in various situations. This problem can be solved by teachers who have technical knowledge about information due to their prior learning and experiences. But for teachers who are not specialists in information technology, it is difficult to even understand this problem.

Many organizations provide webpages that show teachers of IT/information education various useful resources, e.g., digital contents, lesson plans, and Q&A (The Meeting of Tuesday, 2003b, Okayama Prefectural Information Education Center, 2003b, NICER, 2003). However, it is very difficult to collect the necessary resources for teachers, because there are too many webpages, and their formats and viewpoints are not unified, even when the resources have the same purpose.

One of the problems is that various concepts about information education have not been defined clearly. Because most of the guidelines and commentaries about the subject were provided by presenting the concepts in a disorganized fashion, we believe that these contents were not conveyed to the teachers effectively. To solve this problem, it is necessary to clarify and to tease apart the discrete concepts that compose IT/information education. We think that this can be done by applying ontology theory. The

ontology provides us with a common vocabulary and set of concepts about IT/information education and can promote reuse and sharing of these among teachers. If useful resources of IT/information education on webpages are tagged based on the ontology, they can be accessed according to the various viewpoints they represent.

In this study, we identified features of IT/information education and proposed an instructional design process model that is suitable for presenting IT/information education. And, we expressed the instructional concepts and the IT/information education concepts clearly and systematically based on ontology theory (Kasai, 2003). These ontologies show each concept for expression of the layered structure of our proposed process model and all concepts which are used in this model. Thanks to these ontologies, we can support teachers in designing the instruction of IT/information education in our proposed process model. We are currently building a system that supports teachers of IT/information education. This system has two parts. One is to provide teachers with useful resources for IT/information education, and the other is to support them in designing the instruction of IT/information education according to our proposed instructional design process model.

In this paper, first, we describe the outline of the work (the proposal of the instructional design process model and building of two ontologies) which we have done. Next, we show the outline of the whole system that supports teachers of IT/information education based on this work. And, we describe the one part of our support system in detail.

## **The Overview of the Work which We Have Done**

In this chapter, we describe the outline of the work which we have done for expression of the concepts necessary to support teachers of IT/information education (Kasai, 2003). First, we show our proposed instructional design process model, which is suitable for IT/information education. Next, we show two ontologies that define concepts used in our model. Before describing the model, we note that IT/information education has the following features by comparing it with other subject's education:

- The importance of meta-ability is higher than other education in the educational goal, and contents of education are decided for achieving it.
- The meta-ability (the ability which learners make use of information for) is a main goal, and an instructional form based on the constructivism is more important than other education.

The reason for these features is that most goals of IT/information education are to attain meta-ability, so it is difficult for children to attain this by the simple transmission of knowledge by teachers. An instructional format that calls for students to learn the necessary ability themselves in each given situation is effective.

## **The Instructional Design Process Model**

The instructional design process model by Gagne is typical of the models presented in this field to date (Gagne, 1979). Gagne's model is composed of four levels. We focused on the level comprised of the decision of the goal for a unit up to preparation of the lesson plan in the level of the instruction. The instructional design process of Gagne's model is interpreted to five steps based on our process model, as follows:

1. The decision regarding the goal of the instruction.
2. The decision regarding the contents of the instruction.
3. The decision concerning the situation of the instruction.
4. The choice of the media for the instruction.
5. The preparation of the lesson plan.

The Ministry of Education in Japan states that the delivery of contents from across units that relate to each other using the same teaching materials is also important (Ministry of Education, 2000). This means that in the instruction design process, it is not only necessary to decide the instructional situations to attain the goal of a unit but also to add the goal of the instruction that relates to its situations and the

teaching materials based on constructivism. To do this, we propose an instructional design process model in which two steps are added to the above model, as follows:

1. The decision regarding the goal of the instruction.
2. The decision regarding the contents of the instruction.
3. The decision concerning the situation of the instruction.
4. The choice of the media for the instruction.
5. The addition and choice of the goal of the instruction.
6. The reselection of contents of the instruction.
7. The preparation of the lesson plan.

We think that this process can provide for a more effective instruction design whereby students can not only gain the ability stipulated in a unit but also gain other necessary abilities in the situations given. This is a main goal of IT/information education, that is, to enhance the ability to use information according to each situation.

## **Two Ontologies for Supporting Teachers of IT/Information Education**

We have built two ontologies for supporting teachers according to our proposed process model. In this section, we explain the outline of these ontologies.

Here, an ontology clearly shows the concepts and the relationships that exist between them and gives their specific semantic definitions. In this way, an ontology promotes reuse and sharing of the concepts and the models described with these concepts.

The ontology of the structure of the instruction shows the contents comprising the instruction of one unit. This ontology shows the concepts for expression of the layered structure of this model. In this ontology, development of the instruction is described by listing the purpose of the learner's activities and the purpose of the teacher's activities. These are the main features of the ontology of the instruction. The development of the instruction has been described with regard to both the learner's and the teacher's activities in most instructional models, but here it is expressed with the goals of education. These mean what a teacher expects learners to attain. And, these can be described for each stage of the instruction in addition to the main goal of a unit. It is important for teachers to be clearly conscious of the goals of education underlying the learner's activities when they design the instruction based on constructivism. For this reason, this ontology of the structure of the instruction is focused on the goal of education.

The ontology of IT/information education is composed of a goal of IT/information education and the content of IT/information education. This ontology shows all contents used in our proposed process model. The "content of education" means the contents of the subject "Information" which the Ministry of Education has prescribed. It is the ontology of the goal of IT/information education to be used for a support system described in detail in this paper. So, we describe features of this ontology in detail here.

The ontology of the goal of IT/information education consists solely of concepts of the goal of IT/information education. A viewpoint for the stratification based on is-a relation is the essential attribute of the concepts of the goal of IT/information education. In other words, it means that no mixture of various concepts occurs, as such mixture can obstruct teachers' understanding of concepts about IT/information education. This is one of the characteristics of the ontology, and is one of the important reasons that we applied the ontology theory. In this study, for this ontology, we extracted three concepts that can be the goal of IT/information education. These are "knowledge about information", "practical ability in the information society" and "the independent attitude which takes part in the information society". This classification is based on Bloom's taxonomy of educational goals (Bloom, 1971). Furthermore, we classified these three concepts of the goal of IT/information education. In this paper, space does not allow us to explain these concepts in detail.

As far as the authors know, there is no goal classification which captures intrinsic educational goals of IT/information education without any confusion with learning activity, standard of evaluation for education, etc. Considering the fact that the purpose of the classification of the goal of IT/information education is to make teachers understand the educational goals clearly, our goal ontology is more suitable, since it reveals the inherent conceptual structure of educational goals which facilitates teacher's

understanding of the goals. Furthermore, thanks to the generality of our ontology, it enables to connect various resources by using these concepts defined in the ontology as tags in the RDF Model Layer.

Thanks to these ontologies, we can support teachers designing the instruction in our proposed process model, and promote reuse and sharing of these concepts of IT/information education and models described with these concepts among teachers.

## **A System to Provide Teachers with Resources from Various Viewpoints**

In this chapter, we describe the system that provides teachers of IT/information education with necessary resources according to the various viewpoints that they require. First, we show a whole support system, which we are building for teachers of IT/information education according to the work that we have done. And, we explain a part of this whole system in detail.

### **Outline of the Whole System that Supports Teachers of IT/Information Education**

The outline of the whole system that supports teachers of IT/information education is shown in Figure 1. This system has two parts. One part is for teachers of IT education. The system provides teachers with useful resources for IT/information education. We authored metadata of the Guideline of IT/information education published by the Authority in RDF: Resource Description Framework (Lassila, 1999) with the ontology of IT/information education as tags. Thanks to this framework, the system can reconstruct resources in the guideline according to the various viewpoints that teachers require.

The other part of this system is for teachers who are training for IT/information education. The system supports teachers who are designing instruction according to our proposed instructional design process model. When a teacher is in each step, the system can support them with the ontology of IT/information education and other metadata of the Guideline of IT/information education. By repeating the steps of the addition of the goal and the selection of the contents flexibly, a teacher can design his/her instruction according to this process model with these system supports. The lesson plan designed by a teacher in this process is changed automatically into the format defined by the ontology of the structure of the instruction, and is added to the database. Because this ontology provides common vocabularies and concepts with these lesson plans, the system can promote reuse and sharing of these among teachers.

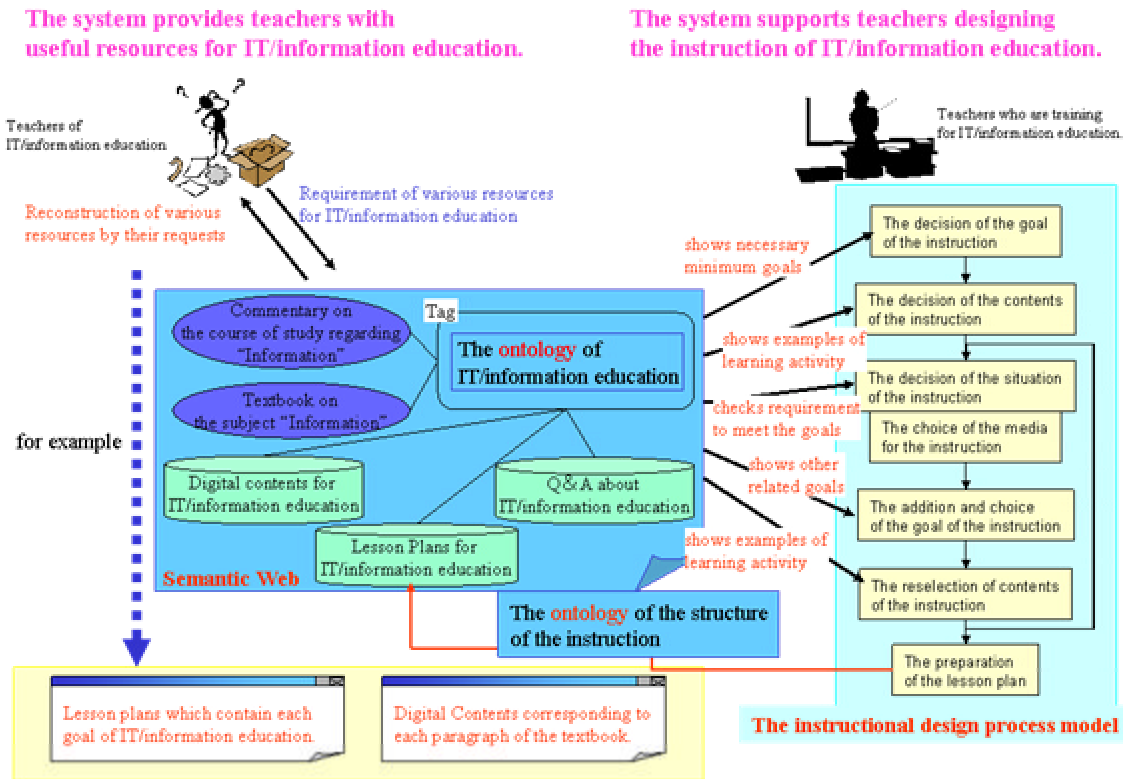
### **Explanation of the System that Provides Teachers with Useful Resources**

This system is an application of the 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, 2001). It is based on the Resource Description Framework (RDF), which integrates a variety of applications using XML as an interchange syntax.

The Semantic Web technology provides the web on which an agent can process automatically the metadata. The main purpose of the current web of HTML base is that "people can understand by reading", whereas the main purpose of the Semantic Web is that "machines can understand". The web can reach its full potential only if it becomes a place where data can be shared and processed by automated tools as well as by people. The Semantic Web technology is the vision for this web to scale. This technology aims for having data on the web defined and linked in a way that it can be used by machines not just for display purposes, but for automation, integration and reuse of data across various applications (The World Wide Web Consortium, 2001).

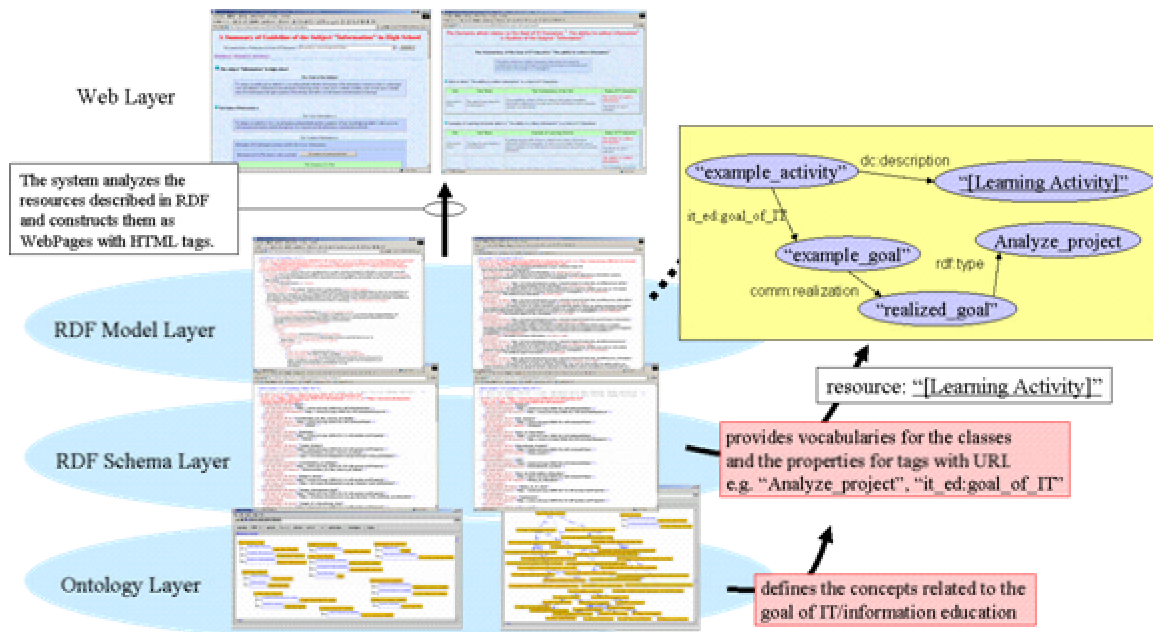
The structure of this system is shown in Figure 2. The system has four layers. The first layer is an Ontology Layer, on which we build ontologies on the ontology editor (Kozaki, 2000). These ontologies define all of the concepts used in this system and the relationships among them. They can also describe the relationships between the RDF schemas of the next layer. The second layer is the RDF Schema Layer. In this layer, the vocabularies of classes and properties used in the third layer, the RDF Model Layer, are defined. In the RDF Model Layer, we can author metadata of various resources by using the vocabularies defined in the two lower layers. The last layer is the Web Layer. In this layer, the system analyzes the

resources in RDF and outputs the necessary information as HTML files in the format required for use by teachers.



**Figure 1:** The outline of the whole system that supports teachers of IT/information education

A simple example in which vocabularies defined in the RDF Schema Layer and the Ontology Layer are used in the RDF Model Layer is shown on the right in Figure 2. In this example, the resource "[Learning Activity]" about IT/information education is tagged a goal of IT/information education that is related to its resource as metadata. We can use the vocabulary items "it\_ed:goal\_of\_IT" and "comm:realization" defined in the RDF Schema Layer for properties to express metadata in RDF. Here, "it\_ed" and "comm" are URI: Uniform Resource Identifiers. Moreover, the RDF schema provides a definition of a range for a value of the property. In this example, a value of this property "it\_ed:goal\_of\_IT" must belong to a class of a goal of IT/information education. And, we can use the vocabulary item "Analyze\_project" defined in the RDF schema Layer as the class which shows a concept of a goal of IT/information education "Ability to analyze project". In the Ontology Layer, concepts about a goal of IT/information education and relations between these are described in detail. The resource of this example is described in the RDF Model Layer by using these vocabulary items as follows.



**Figure 2:** The structure of the system that provides teachers with various resources

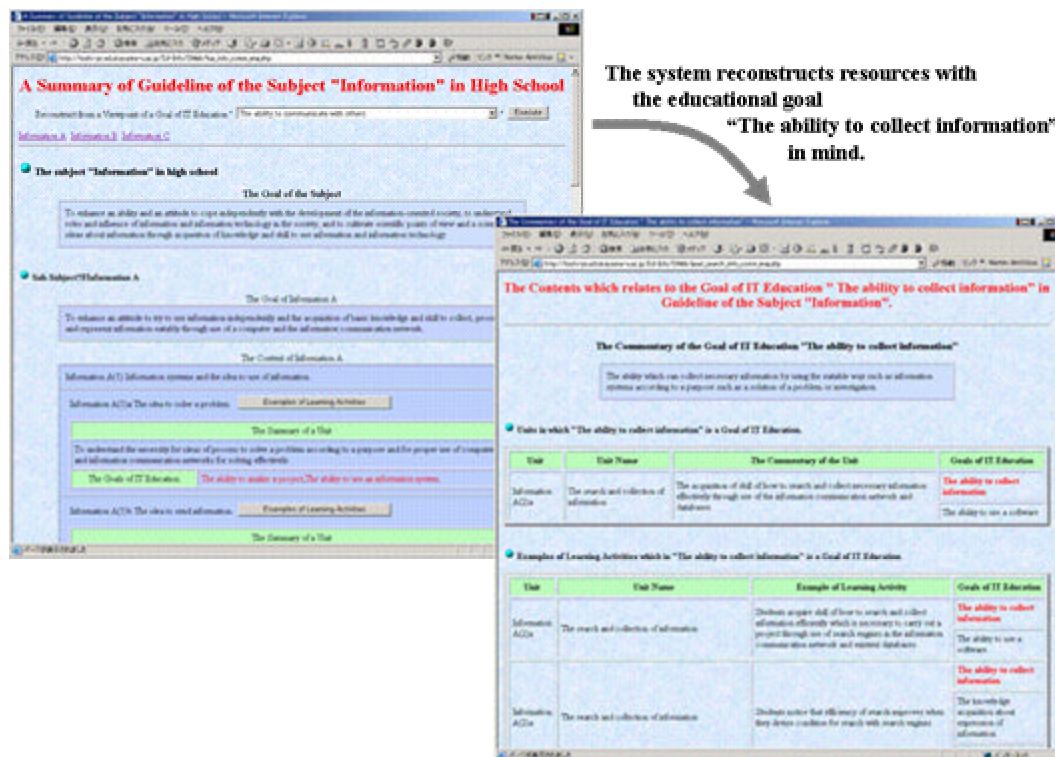
```

<rdf:Description rdf:ID="example_activity">
  <dc:description>
    "[Learning Activity]"
  </dc:description>
  <it_ed:goal_of_IT>
    <rdf:Description rdf:ID="example_goal">
      <comm:realization>
        <rdf:Description rdf:ID="realized_goal">
          <rdf:type>Analyze_project</rdf:type>
        </rdf:Description>
      </comm:realization>
    </rdf:Description>
  </it_ed:goal_of_IT>
</rdf:Description>

```

By using vocabularies and concepts defined clearly in the RDF Schema Layer and the Ontology Layer for description of metadata of all resource about IT/information education, the system can analyze the structure and meaning of these resources and can process these according to various purposes. An example of this is our system that provides teachers with useful resources from various viewpoints. An example of a screen produced by this system is shown in Figure 3.

The screen on the left in Figure 3 is a webpage constructed with HTML tags by the system by analyzing the metadata of a summary of guidelines on the subject "Information" in high school in RDF. The contents of these guidelines are commentary about the educational goal of the subject "Information", commentary about the educational goal of each sub-subject ("Information A", "Information B", "Information C"), and commentary about contents and the educational goal of each unit and examples of learning activities. We describe the metadata of this resource with goals of IT/information education in RDF in the method illustrated in Figure 2.



**Figure 3:** An example of how the system reconstructs resources and provides them as an HTML file

The screen on the right in Figure 3 is a webpage the system provides a teacher when he/she requires information related to the goal of IT/information education, "The ability to collect information". The system analyzes metadata of this guideline and extracts contents (units that contain this goal, commentary about these units, and learning activities that contain this goal) that relate to this goal. Because this example is processed in one RDF file, this function is realized by the description of metadata even if the vocabularies defined in the RDF Schema Layer and the Ontology Layer are not used in RDF. But, if metadata of other resources about IT/information education are authored using the same vocabularies and concepts defined in the RDF Schema Layer and the Ontology Layer, the system can extract the necessary information from more than one RDF file according to a goal of IT/information education defined by the ontology and can provide teachers with this information. Thanks to this framework, the system can process all resources from unified viewpoints, even if they use different formats. The system can select and reconstruct necessary information from all resources according to teachers' requests and provide the information in the form of webpages.

## Summary

Here we described the development of a two-part system that supports teachers of IT/information education by providing them with various resources from various viewpoints and by supporting them in designing the instruction according to our proposed instructional design process model, which is suitable for IT/information education. In this paper, we explained in detail the first part of the system.

As of Dec. 2003, many organizations provide teachers of IT/information education with useful resources as webpages, but it is very difficult to get the necessary information to access these pages, because there are so many of them, and because the formats and viewpoints are not unified, even when the resources are meant to serve the same purpose. To solve this problem, we proposed a framework based on the Semantic Web technology. Thanks to this framework, it becomes possible to process all useful resources from unified viewpoints by defining concepts and vocabularies to describe metadata of these

resources clearly in the RDF Schema Layer and the Ontology Layer. We described the way to realize this system and functions this system has.

In future work, we intend to author more metadata of other useful resources for IT/information education in RDF, and build a system that can reconstruct the resources and provide teachers with more information from a greater variety of viewpoints. Also, we intend to build an additional part of our whole support system that will help teachers to design instruction according to our proposed process model.

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