CASE REPRESENTATION AND ADAPTATION IN SmartLP
A Web-based Lesson Planning System

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Abstract: Lesson plans help teachers to organize content, materials and methods for their teaching. Appropriate lesson plans are crucial to accommodate student differences in various aspects. Currently there are limited mechanisms to support decision making in constructing lesson plans based on the constraints teachers have. Since lesson plans have a standard format, they can potentially be shared. SmartLP, a web-based lesson planning system, was developed to assist teachers in preparing suitable lesson plans based on various constraints; students' profile, curriculum and facilities. In SmartLP, teachers can make modification to the retrieved plans according to their constraints, as opposed to generating new ones from scratch. Implementation of such systems insists on a proper case representation as it facilitates case retrieval and subsequently case adaptation to handle differences in hand. An ontology for the lesson plan domain has been built in the form of a taxonomy. This is followed by case definition that consists of problem description and solution. Cases are represented as attributes - value representation in a case base. Transformation, a kind of case adaptation, is implemented in the system to facilitate teachers in adding, deleting or editing the contents of the retrieved lesson plans. The adaptation can be derived from one case or several cases.

1 INTRODUCTION

Lesson plans are written documents produced by teachers using a standard format and based on the same curriculum. Such plans help teachers to organize content, materials and methods for their teaching and these items need to be prepared to meet the diverse constraints and factors each teacher has. The constraints might be different from one teacher to another depending on numerous factors such as experience, students' ability, facilities available and many more.

Currently there are few mechanisms to support decision making as well as determining suitable elements in a lesson plan based on constraints teachers have.

These limitations could be improved through the implementation of a web-based lesson planning system whereby best practices in preparing lesson plans can be shared among teachers. The sharing of experiences might be useful for teachers to create new plans or to make modification and improvement to existing plans according to their own constraints and students' profile. It is often more efficient to customise existing lesson plans as opposed to generating new ones from scratch.

However, to simply use other teachers' lesson plans is often not practicable because of the various factors and constraints that need to be considered. Therefore, it is advisable to make some adaptations to the solution given by the system. Solving a problem in this system involves obtaining a problem description, measuring the similarity of the current problem to previous problems stored in a database, retrieving one or more similar cases and attempting to reuse the solution of one of the retrieved cases, possibly after adapting it to account for differences in problem descriptions. This process is similar to Case-based reasoning (CBR) which offers a potential solution to lesson plan construction by retrieving relevant cases that solved similar problems. Teachers can reuse the retrieved lesson plans after customising the lesson plans according to their constraints. The adaptation process of the previous solutions in CBR will fit the current problem context which subsequently brings in new

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solution to the problem.

While the implementation techniques may vary, most CBR systems include the following five steps in some form or other (Raman, 1995; Watson and Marir, 1994):

- representation where problem storage is handled;
- retrieval where the closest-matching precedent is identified;
- adaptation where a solution is generated from the retrieved problem;
- validation where the accuracy of the solution is verified; and finally;
- update, where the database is modified or updated with the information gained from this problem solving process.

According to Craw et al. (2006) in design tasks, it is common for the retrieved solution, to be regarded as an initial solution that should be refined to reflect the differences between the new and retrieved problems. This adaptation is done in SmartLP via a customisation function. Here, users can edit, add or delete elements in the retrieved lesson plans.

Hence, to develop a comprehensive web-based lesson planning system (SmartLP) a good knowledge representation is crucial as it contributes to case representation and facilitates case retrieval and subsequently case adaptation.

Although much previous research indicates the role played by knowledge representation, very little research has focussed on knowledge representation in the educational area, particularly in lesson planning.

This paper will discuss knowledge modelling, case representation and case adaptation that was implemented in the SmartLP system. The modelled knowledge is presented as cases that are stored in a case base for retrieval. Adaptation to the retrieved cases can be executed by a customisation function in the system, followed by a verification process.

2 KNOWLEDGE REPRESENTATION

Sun et al. (2003) reported that the organization of elements in knowledge representation must facilitate the retrieval of useful information from the case base. Two criteria that can facilitate retrieval are problem classification and the expected target. This is aligning with case representation that consists of problem descriptions and solution. In addition, Urosevic et al. (2006) point out that one problem in knowledge representation is how to store and manipulate knowledge in an information system in a formal way, so that it may be used by a mechanism to accomplish a given task.

Ontology is a formal representation of the knowledge by a set of concepts within a domain and the relationships between those concepts. Ontologies are specific, high-level models of knowledge underlying all objects, concepts, and phenomena in a domain. Generally, an ontology is a metamodel describing how to build models. The good thing about using such metamodelling is that we never sacrifice the usefulness of any specific model. Ontologies do the same for knowledge models (Sormo et al., 2007).

According to Mizoguchi (2004), ontology provides us with a guideline for modelling the world. To do this, it consists of carefully chosen top-level categories which are reliable enough to explain lower concepts.

An ontology of the lesson plan domain was built in the form of a taxonomy. In SmartLP, a taxonomy of the general lesson plan domain was produced based on a semantic net that was constructed first, to see how all elements and concepts in a lesson plan relate to each other. This type of representation was chosen due to its acceptability as a standard modelling mechanism. The structure of a semantic net is shown graphically in terms of nodes and the arcs connecting them. Nodes are often referred to as objects and the arcs as links or edges. Two types of commonly used links are IS-A and A-KIND-OF (AKO). The semantic net is an example of a shallow knowledge structure because all the knowledge is contained in the links and nodes.

Matching ontologies from their relational (or external) structure is very powerful because it allows all the relationships between entities to be taken into account. This must be grounded on other tangible properties, which is why it is often used in combination with internal structural methods and terminological methods (Euzenat and Shvaiko, 2007). In addition they claim that the most commonly used structure is the taxonomy. It is the backbone of ontologies and has received a lot of attention from designers.

Ontologies are now central to many applications such as scientific knowledge portals, information management and integration systems, electronic commerce, and semantic web services. Noy and McGuinness (2000) in (Abdollahi, 2007) state that an ontology is needed to:

- share common understanding of the structure of information;
- reuse domain knowledge;
- make domain assumptions explicit;
- analyse domain knowledge

A taxonomy consists of carefully chosen top-level categories which are reliable enough to explain lower concepts. A taxonomy for lesson planning domain has been built and shown in Figure 1.

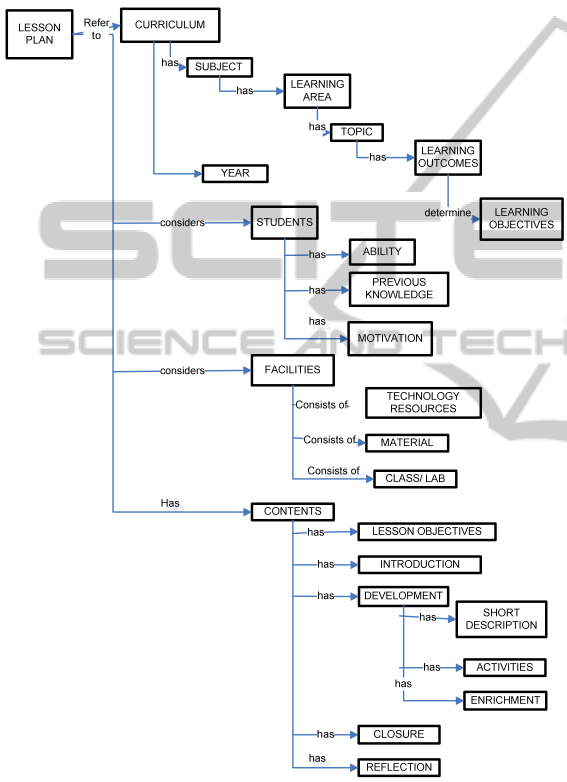

Figure 1: Lesson Plan taxonomy.

Lesson plans consist of four main nodes which are curriculum, students, facilities and content. Each node is then divided into detailed nodes. The ontology introduced above is mapped to a case of SmartLP system as can be viewed in Table 1.

3 CASE REPRESENTATION

Representation is the issue of deciding what to store and how the memory should be organized in order to retrieve and reuse old plans effectively and efficiently. Cases can be represented using a variety of notations. In SmartLP, the combination of hierarchical and attribute – value representation is used. According to Liqing and Kumar (2005), case representation is generally regarded as one of the most important issues and is crucial to the success of case-based reasoning systems.

This is supported by Spalzzi (2001) who insisted that the efficiency and effectiveness of a case-based planner heavily depends on its plan representation and memory organization. This is a natural consequence of the fact that its problem solver is primarily based on retrieving and adapting previous plans. Bergmann et al. (2005) suggest that object oriented case representation has an expressiveness similar to frame representations, but have a different origin. They make use of the data modelling approach of the object-oriented paradigm, including is-a and part-of relationships as well as the inheritance principle. Cases are represented as collections of objects, each of which is described by a set of attribute-value pairs. The structure of an object is described by an object class. They suggest that object-oriented representations are particularly suitable for complex domains in which cases with different structures occur. It seems similar to what has been discussed by Giarratano (1998) as object-attribute-value triples (OAV) or triplet.

It is convenient to list knowledge in the form of a table, and thus translate the table into computer code by rule induction. If inheritance is not required and only a single object is to be represented, attribute – value pairs (AV) may suffice. Many types of real world knowledge cannot be represented by the simple structure of a semantic net (Giarratano and Riley, 1998:66).

According to Abdollahi (2007), the first step in building a CBR model is the "Representation of Cases" as well as knowledge. This means how to define and describe the cases in the model in order to recall and reuse them for reasoning. He highlighted four main challenges for case representation as the following:

- Case searching and matching;
- Integrating new cases into the existing memory (model);
- Qualitatively and quantitatively data types to store in cases;
- Organizing and indexing cases for effective retrieval and reuse.

Components of a case in CBR consist of problem description and solution. Problems in a lesson plan context are the various constraints that teachers face in constructing lesson plans. This is shown in Table 1.

Table 1: A case of SmartLP.

Problem	Node	Elements
	Students	Ability, knowledge, motivation, No of student per class
	Facilities	Resources, material, venue
	Curriculum	Year, subject, learning area, topic, learning objectives, learning outcome, skills, suggested activities.
Solution	Lesson Plans	Appropriate teaching aid, skills, learning outcome, short description, introduction, explanation, activity, timing of each activity, enrichment, assessment, extension, closure.

In SmartLP, case searching can be done via five types of search; basic search, weighted search, terms, expansion search and browsing. As justified by other researchers, matching and ranking are applied in these types of search in order to select the most appropriate lesson plans to the constraints users have.

Reyes and Sison (2002) state that matching and ranking is a procedure in case retrieval that selects which cases are appropriate among the cases in the case library. As the process of searching the library is done, the search process asks the matching function to compute the degree of match among indexes. Based on the result of the matches, the search function collects a set of cases that partially match the new situation. The matching cases are then ranked to identify which best address the requirements of the new situation**.**

The hybrid approach, which combines computational and representational approach, was used for the case retrieval and matching process in the system. Hierarchical representation together with linear representation, based upon measures of similarity, was used together with a computational approach, in terms of weighting. In addition, query expansion and query weighting are used in this system to give flexibility for users and to produce a better search result. Query expansion gives flexibility for users to choose related terms to the searched keywords by expanding the query using words or phrases with a similar name. Searched keywords may have different importance for different users. Therefore, query weighting facilitate users to indicate the importance of their searched keywords. The weights are taken into account in calculating the similarity of the searched keywords and attributes in cases in the case base.

SmartLP used attribute-value representations for its case which is a lesson plan itself. This is shown in Table 2.

Table 2: Table lesson.

Attributes	Types
LessonID	Auto increment
ParentID	Int
Date	Varchar
Form	Int
Subject	Varchar
Learning area	Varchar
Topic	Text
Learning outcome	Text
Objectives	Text
Ability	Varchar
No of Students	Int
Minutes	Int
Skills	Mediumtext
Resources	Varchar
Value	Varchar
Prerequisite	Mediumtext
Introduction	Text
Step1	Longtext
Step2	Longtext
Step3	Longtext
Step4	Longtext
Step5	Longtext
Assessment	Longtext
Extension	Longtext
Closure	Text
Reflection	Longtext
Verified	Varchar

Indexing is applied in the case base to allow the database server to look up rows more quickly, thus speed up the retrieval. Several attributes which are used for indexing the cases, are year, subject, learning area, topic, learning outcomes, skills, values, time period, no of student, and ability. Each of these attributes has their similarity value in comparison to the searched keywords. Some are using hierarchical similarity measure and some use linear similarity measure. The structure of the similarity table is shown in Table 3.

Table 3: Attribute- value representation for similarity table.

Field	Type
Id	Int
Query	Varchar
Case	Varchar
similarity	Float

4 CASE ADAPTATION

The adaptation process is crucial in SmartLP as it is the process whereby users can change the elements of the retrieved lesson plans to tailor to their own constraints. As discussed before, users might have different constraints in constructing lesson plans in students' profile such as ability, previous knowledge and many more. This is achieved by a customisation function in the system.

Hanney et al. (1995) review a large number of CBR systems to determine when and what sort of adaptation is currently used. Their initial taxonomies show that CBR systems using adaptation are predominantly used when prediction and design are required.

Kolodner (1993) cited by Craw et al. (2006) identify three types of adaptation:

- Substitution - replaces values in the retrieved solution with new values appropriate for the new problem (e.g. changing a house price);
- Transformation - alters the retrieved solution by adding, deleting or replacing parts of the retrieved solution to suit the new problem (e.g. altering steps in a plan);
- Special methods apply specialised heuristic knowledge to repair the retrieved solution, or replay the method used to derive the retrieved solution for the new problem.

For adaptation, the task is to recognise when an adaptation should be applied because the new and retrieved problems are sufficiently different in some relevant way, and to perform some changes to the retrieved solution. An adaptation can be considered as a situation (problem description)/action (solution) pair. The situation contains the differences between the new and retrieved problems. In SmartLP, transformation was used. The retrieved cases can be modified by users to suit their constraints in hand. Although the adaptation process is done manually, the system makes the process easier via the smart interfaces it offers.

This adaptation can be made based on one case or several cases. If just one case is selected to be modified, users just need to view the details and click a customise button. All fields will become editable. Users can modify the elements in this lesson plan and this plan will be saved as new lesson plans. The author of this customised lesson plan is identified by user session.

A new lesson plan can be generated from several customised cases. Here, two or more lesson plans can be chosen to be compared. Elements from these different lesson plans can be chose to be included in the customised plan. The selected lesson plans will be compared in a table as shown in Figure 2.

Figure 2: Selected lesson plans to be compared.

Here users can select whatever fields they want to have in their customised lesson plans. The selected value will be combined into their particular elements and can be edited by the user. If users prefer most elements in a particular lesson plan they can check a *select all* button at the bottom of that lesson plan.

Here, all fields are editable and attachment files can also be added or deleted. Users can modify the elements in this lesson plan and they will be saved as a new generated lesson plan. The author of this customised lesson plan is identified by user session.

Figure 3: The generated new lesson plan.

5 CONCLUSIONS

The implementation of SmartLP system based on CBR should solve teachers' problems in deciding appropriate elements in lesson plan construction by customising their own lesson plans. This can be done by retrieving previous lesson plans, reusing and revising those lesson plans and subsequently retaining them in the same system.

The knowledge modelling discussed in this paper transforms detailed requirements into complete, detailed case representations that will be used in the retrieval phase. While the system-based view is concerned with efficient search techniques to match query and document representations, the user-based view must account for the cognitive state of the searcher and the problem solving context. These two views were taken into account during the retrieval process. The flexible adaptation process based on one or several cases helps teachers to generate their own new lesson plans. These new lesson plans will be verified and subsequently retrieved by other users. By having this dynamic process, the system will expand dynamically.

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