Using Ontologies for an Effective Design of Collaborative Learning Activities

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Abstract. Although artificial intelligence has been successfully introduced to enhance Education through technologies in the past few years, major challenges still remain. One of them is how to represent the knowledge of intelligent systems. To represent the knowledge of systems to support collaborative learning is particularly challenging because it is based on various learning theories and given the complexity of group learning. The main objective of this work is to introduce an ontological infrastructure on which we can build well-grounded theoretical knowledge based on learning theories and to show how we can use it to develop programs to support intelligent guidance for an effective design of group activities.

Keywords. Collaborative learning, ontological engineering, intelligent educational system.

Introduction

To develop intelligent systems to support collaborative learning (CL) is especially challenging in view of knowledge representation. Current knowledge concerning CL is based on various learning theories, which are always expressed in natural language and are particularly complex given the context of group learning where the synergy among learner's interactions affect the learning processes and hence learning outcome. Without the explicit representation of learning theories it is difficult to support the design of group activities based on well-grounded theoretical knowledge.

Our approach calls upon techniques of ontological engineering to make theories "understandable" both by computers and humans. We then propose techniques to reason on these theories which contribute to dynamic guiding and instructional planning. Also we have been developing an intelligent support system that represents theories graphically to facilitate the design CL activities with theoretical justifications.

1. Representation of Learning Theories on GMIP

The use of ontological engineering for knowledge systematization has shown significant results concerning how to represent the knowledge of educational environments considering theories [2]. In CSCL (Computer Supported Collaborative Learning) research, ontologies have been successfully applied to solve problems such as: group formation, CL representation, interaction analysis and patterns and modeling

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of learner's development [3]. Nevertheless, there are some limitations: (a) it is not easy to determine which learning theory is appropriate to explain and support learner's development; and (b) it is difficult to propose activities in compliant with the theories to enhance interactions among learners and lead them to achieve desired goals.

To overcome these limitations we re-analyzed seven different learning theories frequently used to support CSCL activities. And then, we proposed the ***Growth Model Improved by Interaction Patterns*** **(GMIP)** [4]. The GMIP is a graph model based on an ontological structure to describe an excerpt of learning theory. It represents, in a simplified way, the learner's knowledge acquisition process and skill development process, explaining the relationships between learning strategies, educational benefits and interactions used to achieve these benefits.

The GMIP graph has twenty nodes, which represent the levels of the learner's development at a certain moment of learning. Each node is composed by two triangles. The upper-right triangle represents the stage of knowledge acquisition, while the lower-left triangle represents the stage of skill development. The nodes are linked with arrows that show possible transitions between nodes in compliance with [1] and [5]. Using the GMIP graph, we show the benefits of learning strategies by highlighting its path on the graph and associating each arrow with interactions activities (Figure 1).

The main contributions of GMIP for CL design are (a) to allow the graphical visualization of theories and their characteristics. Thus, users can quickly interpret the theories, their benefits and propose sequence of activities in compliance with them; and (b) to provide a formal structure based on ontologies which allows systems to reason about the theories and the features (actions, roles, strategies, etc.) prescribed by them.

2. An Ontology-based Support System to Design Group Activities

To support group activities there are many learning theories (such as Anchored Instruction, Peer Tutoring, LPP, etc). Thus, to assign roles and strategies for learners in a group we can select appropriate set of learning theories considering necessary pre-conditions and desired educational benefits for learners. This flexibility of choosing different learning theories provides us with many ways to design and conduct learning processes. However, it also suggests the difficulty of selecting the appropriate set of learning theories during the instructional design to ensure learners' benefits and the consistency of learning processes. Therefore, to help users (instructors, teachers, designers, etc) to design effective group activities we need an elaborated system that considers different learning theories to support the design in compliance with them.

In order to develop a system to support the design of CL activities we have been developing **CHOCOLATO** – *a Concrete and Helpful Ontology-aware Collaborative Learning Authoring Tool*. It is an ontology-aware system that uses ontologies developed in Hozo ontology editor (http://www.hozo.jp) to provide its theoretical knowledge. One of its sub-systems called **MARI** – *Main Adaptive Representation Interface* allows to represent learning theories on the screen using the GMIP (Figure 1). Since 2006, MARI has been implemented in Java and uses Hozo API to interpret ontologies. Through the use of ontologies it allows high expressiveness and interoperability among theories and their features. It currently has 6 theories and 12 strategies, besides other information in its database. Using ontologies and the GMIP MARI can reason on the theories to select appropriate learning theories and strategies and to suggest consistent sequence of activities for learners in a group.

The **suggestions** given by our system are only guidelines for users to propose CL activities based on theories which: (a) preserves the consistency of the learning process; and (b) guarantees a suitable path to achieve desired benefits. However, expert designers can propose their own sequence of activities. In such case the system also can assist these users providing other information that can be useful in various situations.

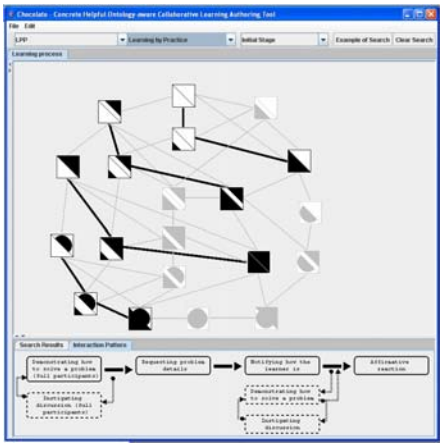

Figure 1. Screenshot of MARI showing the theory *LPP* using the strategy *Learning by Practice*. On the top it shows the path on the GMIP and on the bottom the sequence of activities in compliance with the theory.

3. Conclusions

The main contribution of this research is to introduce our model GMIP based on an ontological structure to describe learning theories for CL and to develop a support system that uses it rationally. Through the use of ontologies we aim to: (a) prevent unexpected interpretations of the theories; (b) provide a common vocabulary to describe them; (c) share and accumulate the knowledge; and (d) provide information for computational semantics which allows us to assist users based on theories.

Our approach uses a well-grounded theoretical knowledge to provide intelligent recommendations of role assignment and sequence of interactions which offers fundamental settings for an effective CL session and essential conditions to predict the impact of interactions in the learning process. Thus, we believe it is possible to provide an accumulation of knowledge about group interactions and learner's development allowing a re-formation of groups based on analysis of previous CL sessions.

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