Content modeling plays a fundamental role in the development process of educational modules. In spite of its relevance, there are few approaches for modeling educational content. Motivated by this scenario, in a previous work we proposed IMA-CID (Integrated Modeling Approach – Conceptual, Instructional, Didactic) – an integrated approach for modeling educational content. In this work we discuss the evolution of IMA-CID by exploring the use of ontologies at its conceptual level. The goal is to provide a better comprehension of the knowledge domain to be taught as well as to ease the knowledge sharing and reuse among authors. We illustrate our ideas by using an ontology of software testing for developing an educational module on this domain. The development of a supporting tool to help on the importation of ontologies and on the automated edition, interpretation and “execution” of the IMA-CID models is also discussed.
Using Ontologies for Modeling Educational Content

Vanessa Araujo BORGES and Ellen Francine BARBOSA
University of São Paulo (ICMC/USP) – São Carlos (SP), Brazil
{va.borges, francine}@icmc.usp.br

Abstract.
Content modeling plays a fundamental role in the development process of educational modules. In spite of its relevance, there are few approaches for modeling educational content. Motivated by this scenario, in a previous work we proposed IMA-CID (Integrated Modeling Approach – Conceptual, Instructional, Didactic) – an integrated approach for modeling educational content. In this work we discuss the evolution of IMA-CID by exploring the use of ontologies at its conceptual level. The goal is to provide a better comprehension of the knowledge domain to be taught as well as to ease the knowledge sharing and reuse among authors. We illustrate our ideas by using an ontology of software testing for developing an educational module on this domain. The development of a supporting tool to help on the importation of ontologies and on the automated edition, interpretation and “execution” of the IMA-CID models is also discussed.

Keywords. Ontology, content modeling, educational modules, supporting tool.

1. Introduction

Several initiatives on using computing technologies have been investigated in order to facilitate the learning processes in general. The idea is to provide ways to establish quality educational products, capable of motivating the learners and effectively contribute to their knowledge construction processes in active learning environments.

Educational modules, which consist of concise units of study delivered to learners by using technologies and computational resources [1], can be explored in this perspective. Similar to software products, educational modules require the establishment of systematic development processes to produce reliable and quality products. In short, the development of such modules can involve developers from different domains, working on multi-disciplinary and heterogeneous teams, geographically dispersed or not. They should cooperate, sharing data and information regarding the project. Furthermore, there is a need for adaptability and reusability – educational modules should be seen as independent units of study, subject to be adaptable and reusable in different educational and training scenarios, according to parameters such as the learner’s profile, instructor’s preferences, learning goals, course length, among others.

Motivated by this scenario, in a previous work we proposed IMA-CID (Integrated Modeling Approach – Conceptual, Instructional and Didactic) [1] – an integrated approach for modeling educational content, composed by a set of models, each one considering specific aspects of the development of educational content.

In this work we intend to explore the use of ontologies [5] as a supporting mechanism for modeling the content of educational modules. The goal is to evolve IMA-CID
by using ontologies at the conceptual level of the approach in order to provide a better comprehension of the domain to be taught as well as to ease the knowledge sharing and reuse among authors/designers. We illustrate our ideas by using an ontology of software testing [3,2] for developing an educational module on this domain. The development of a supporting tool to help on the importation of ontologies and on the automated edition, interpretation and “execution” of the $IMA-CID$ models is also discussed.

The remainder of this paper is organized as follows. In Section 2 we describe the main aspects of $IMA-CID$. In Section 3 we discuss how ontologies have been explored for evolving $IMA-CID$. In Section 4 we illustrate the application of our ideas into the development of an educational module for the software testing. In Section 5 we present an automated tool for modeling and generating educational content according to the new version of $IMA-CID$. Finally, conclusions and further work are presented in Section 6.

2. $IMA-CID$: An Integrated Approach for Modeling Educational Content

Content modeling plays a fundamental role in the development process of educational modules. It helps the author to determine the main concepts to be taught, providing a systematic way to structure the relevant parts of the domain [1]. Actually, how the content is structured impacts on the reusability, evolvability and adaptability of the module. Despite its relevance, there are few approaches for modeling educational content.

Motivated by this scenario, we proposed $IMA-CID$ (Integrated Modeling Approach – Conceptual, Instructional and Didactic) [1] – an integrated approach for modeling educational content, composed by a set of models, each one considering specific aspects of the development of learning content. The Conceptual Model consists in a high-level description of the knowledge domain, representing its main concepts and the relationships among them. In order to construct the conceptual model, we focused on the conceptual mapping ideas [7]. The Instructional Model characterizes what kind of additional information (e.g., facts, principles, procedures, examples, and exercises) can be used to develop learning materials. The Didactic Model characterizes the prerequisites and sequences of presentation among conceptual and instructional elements.

We have also introduced the idea of open specifications, which provide support for the definition of dynamic contexts of learning. Depending on aspects such as audience, learning goals and course length, distinct ways for presenting and navigating through the same content can be required. An open specification allows to represent all sequences of presentation in the same didactic model. So, from a single model, several versions of the same content can be generated according to different pedagogical aspects.

3. Evolving $IMA-CID$ Approach by Using Ontologies

An ontology is a formal explicit specification of a shared conceptualization [5]. That is, a simplified way of perceiving a piece of reality, often conceived as a set of relevant terms and their relationships, whose structure is constrained by some rules. Based on the principles and characteristics of ontologies, we are now interested in exploring them as a supporting mechanism for modeling educational content, as part of $IMA-CID$.

As a formal and declarative knowledge representation, an ontology includes [5,8]: (i) the vocabulary required for referring to the concepts in the domain; and (ii) the logical statements which describe what the concepts are and how they are related. Hence, it provides a vocabulary for representing and communicating knowledge about some topic as well as a set of relationships which hold among the concepts in that vocabulary.
Such definition matches with the goals of the conceptual modeling phase of IMA−CID. Based on this, we have extended IMA−CID to allow that both conceptual mapping and ontologies can be used for structuring and representing the knowledge domain. By using ontologies at the conceptual level of IMA−CID we intend: (1) to provide a better comprehension of the knowledge domain to be taught; (2) to ease the knowledge sharing among authors; (3) to provide a well-established structure for a knowledge repository; and (4) to provide support for interoperability, considering the relationship among different paradigms and languages. Notice that the use of ontologies (at the conceptual level) can also be explored together with the idea of open specifications (at the didactical level) aiming at providing knowledge reuse in different learning contexts.

We have also extended IMA−CID at the instructional level. In this case, we have adopted a specific ontology for establishing the media to be related to the information items and instructional elements. The ALOCoM-Ontology (Abstract Learning Object Content Model - Ontology) [9] establishes a formal representation for learning objects and their components. In short, it distinguishes three types of components [9]: content fragments, content objects and learning objects. To define the adequate media for the information items and instructional elements we have explored the set of content fragments, which characterizes: (1) continuous elements (audio, video, simulations and animations); and (2) discrete elements (texts, graphics, links and images).

It is worth to notice that the establishment of adequate media at the instructional level of IMA−CID, specially the continuous ones, is a relevant aspect for the development of interactive educational content, capable of motivating the learners and effectively contribute to their knowledge construction processes in active learning environments.

Moreover, the adopted representation is in agreement with the ALOCoM framework, which supports the use of XML schemas for importing and exporting the educational content for different models and specifications, such as SCORM (Shareable Content Object Reference Model) and LOM (Learning Object Metadata) [6]. The standardization obtained from the use of ALOCoM-Ontology aims to guarantee interoperability, sharing and reuse to the educational content developed according to the IMA−CID approach.

4. An Educational Module for the Software Testing Domain

We have applied the IMA−CID approach into the development of an educational module for the software testing domain. As the conceptual model we have used OntoTest [3,2], an ontology of software testing, which aims to support acquisition, organization, reuse and sharing of knowledge on the testing domain. Due to the complexity of the testing domain, we have adopted a layered approach to the development of OntoTest. On the ontology level, the Main Software Testing Ontology addressed the main concepts and relations associated with testing. On the sub-ontology level, specific concepts were refined and treated into details – testing process, testing artifacts, testing steps, testing strategies and procedures, and testing resources. For the sake of illustration, Figure 1 shows one of the OntoTest sub-ontologies – Testing Strategy and Procedure.

Based on the concepts and relations represented into OntoTest, we have developed the instructional and the didactical models, according to the IMA−CID approach. For the sake of space, these models will not be illustrated here. In the end, the software testing educational module was composed by concepts, facts, principles, procedures, examples

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and exercises, which were modeled and implemented as a set of slides, integrated to HTML pages, text documents, learning environments and testing tools.

To provide a preliminary evaluation on the effectiveness of the testing module, it was applied in: (1) a three-hour short-course; and (2) in two one-semester undergraduate courses at ICMC/USP [4]. The results obtained so far provide some evidences on the practical use of the IMA−CID approach (and also the adoption of ontologies at its conceptual level) as a supporting mechanism to the development of effective educational modules. However, we highlight that applying it without an automated support is an error-prone activity. So, we are working on the development of a tool for helping the construction of the IMA−CID models. An overview on the IMA Tool is provided next.

5. An Automated Tool for Modeling and Generating Educational Content

AIM Tool aims at providing automated support for content modeling, focusing on the collaborative construction of the IMA−CID models. We also intend to use its resulting specifications on the automatic content generation, which could be customized according to pedagogical interests, learner’s profile, instructor’s preference, course length, etc.

Figure 2(a) summarizes how IMA Tool works, based on the IMA−CID models. An ontology is imported as an OWL file, playing the role of the conceptual model of IMA−CID to support the concepts definition. Information items and instructional elements are related to the concepts (ontology terms), establishing the instructional model. Notice that the media is classified according to the ALOCoM-Ontology. The didactic model is developed by defining the navigation sequence among the objects already modeled. Finally, from the didactic model, AIM Tool can automatically generate and package the content according to the LOM specifications. Figure 2(b) illustrates OntoTest being imported and visualized. AIM Tool has been developed in Java, as a Web application. We are now in the final phase of its development, working on the content generation module.

6. Conclusions and Further Work

In this paper we discussed some aspects of evolving IMA−CID, specially by using ontologies at its conceptual level. To illustrate our ideas, an ontology of software testing was used as the conceptual model of IMA−CID for developing an educational module on this domain. As a further work, we intend to keep investigating the use of ontolo-
gies to support the development of the other $IMA-CID$ models, specially the didactic one. We are also motivated to keep evolving and evaluating the mechanisms we have proposed in different domains, for other areas and broader projects. At the very end, we are interested in establishing a culture for “open educational modules” so that the use and evolution of them by a broader community would be better motivated and become a reality. The adoption of ontologies should be explored in this perspective as well.

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