Towards an Adaptive Intelligent Assessment Framework for Collaborative Learning

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Keywords: Computer-Supported Collaborative Learning, Assessment, Adaptation, Assessment Model, Group Learner Model, IMS/QTI, Ontology.

Abstract: Assessing in an online collaborative learning environment is a complex task due to the variety of elements and factors that intervene in how a group of learners collaborates to achieve an assessment task. This paper aims to improve both learners' and group performance at a given activity or a set of activities by adapting the assessment process to the learner level. To that end, we propose a general framework to illustrate our adaptive approach for assessment in an online collaborative learning environment. To do so, we take the concept of adaptation, generally based on three models: the learner model, the domain model, and the adaptive model, as a point of departure and extend it by designing two other new models that are an assessment model and a group learner model. To present our assessment model, we are based on IMS/QTI standard and ontology for the formalization of the question. We aim to combine collaborative learning, assessment, and adaptation to provide an adaptive assessment, an adaptive group composition, and an adaptive collaboration.

1 INTRODUCTION

Nowadays, learners use technology anyplace, anytime, as a consequence, they require adequate learning types that are challenging and engaging (Mariel Miller, Allyson Hadwin, 2015). The use of information and communication technologies in the education sector for learning and assessment in various forms has been the object of intense research for several years (Gembarski, Paul., 2020). Within the new era for assessment, learners are provided with timely and quality feedback to scaffold their learning process and to maintain their progress and success (Susan Finger, Dana Gelman, Anne Fay, Michael Szczerban, 2006). Learners play major roles in the assessment process as they participate in alternative forms of assessment based on their behavior and performance. However, traditional instructor-centered examination remains the primary means for assessing learner performance, and collaborative learning is undervalued and marginalized. In a large part, this is because the assessment of collaboration requires new approaches and methodologies. In this paper, we focus on how to make the assessment process intelligent and personalized. Doing so, we propose an intelligent assessment framework in an online collaborative learning environment. It is paramount to provide intelligent real-time feedback while performing collaborative tasks and to analyze the behavior characteristics of online learners to intelligently adapt online assessment strategies and enhance the quality of learning. In previous research work, we have already focused on personalized feedback generation in online learning Environments (Belcadhi, 2016). The underlying problem is: How to make our assessment strategy intelligent and personalized to learner and group profile, performance level, and preferences, in an online collaborative learning environment?

The first problem here is the collaboration itself, how a system can effectively support collaboration patterns, and how it can be aware of the current collaboration status? To overcome this issue, our framework will be based on Computer-Supported Collaborative Learning (CSCL). It provides the possibility of learning through collaborative interaction, and the social construction of knowledge through the utilization of information technology (Allaymoun M. H., 2021).

For the personalization challenge, adaptation is often proposed as a way of overcoming it. In our context, the assessment process has to meet the groups and learners' levels and preferences. Adaptive

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tutoring systems can consider learner characteristics such as knowledge, affective state, and learning style as a basis for providing adaptation. In our case, we are more interested in the profile, level, and activities preferences for both individual and groups of learners.

This paper contributes to the assessment, CSCL, and intelligent tutoring system. We propose an approach for the adaptation and personalization of the assessment task and instruction offered to learners and groups in an e-learning environment. Changing assessment activities based on individual and group's performance on the previous task: the difficulty of activities will increase as a learner does them accurately, while if the student struggles the tasks get easier. To do that, we are based on the classical architecture for the adaptive educational system, we extended it by adding both an assessment model and a group learner model. Our main contribution for these areas is a conceptual framework, which proposes an original approach to the integration of the intelligent adaptive aspect inside the assessment process in an online collaborative learning environment. To our knowledge, there is no system whose development is carried out in this perspective, and this would therefore constitute the originality of the approach conducted in this paper.

The rest of this paper is organized as follows. First, we mention some concepts and works related to our research. Then, we present our approach for the proposed adaptive collaborative assessment system including a general conceptual scheme for the adaptive final intelligent system and a meta-model for the assessment platform. Finally, conclusions and future research work are outlined.

2 LITERATURE REVIEW

In this paper, we propose to tackle assessment in an Online Collaborative Learning Environment. In such an environment, students learn in groups via interactions with each other by asking questions, justifying their opinions, explaining their reasoning, and presenting their knowledge (Soller, 2001).

2.1 Collaborative Learning

Collaborative learning is often defined as "a situation in which two or more people learn or attempt to learn something together, and collaboration involves the mutual engagement of participants in a coordinated effort to solve problems together" (Dillenbourg, 1999). Several researchers have pointed out the importance of a collaborative environment and how significantly effective it is in terms of learning gain (Hayashi, 2014). it's important to tell apart collaboration and cooperation within the method participants perform the actions to a shared objective: "collaboration means the work is accomplished by all the participants together; whereas cooperation means that participants act towards a shared goal, but each of them performs specific and independent actions to achieve part of the overall goal" (Jeremy Roschelle and Stephanie D Teasley, 1995). Rapid developments in computer-mediated communication in the late 1980s led to a new discipline in the 1990s now referred to as CSCL (Lipponen, 2002). It is also one of the most important computer-supported learning fields that improve learning and employ collaborative work to enable learners to discuss their ideas and present their views, allowing the exchange of ideas and information (Lipponen, 2002).

2.2 Computer-Supported Collaborative Learning (CSCL)

CSCL is a fundamental paradigm that uses information technology tools that help to learn processes (Allaymoun H. , 2014). It is one of the most promising innovations to enhance teaching and learning using ICT tools. It includes a range of situations in which interactions take place among students using computer networks to improve the learning environment. The primary aim of CSCL is to provide an environment that supports collaboration between students to improve their learning processes (Karel Kreijns, 2003) and facilitate collective learning (Pea., 1994) or group cognition (Stahl, 2006).

Collaboration is a complex activity that involves both individual and group effort. To encourage collaboration, each aspect should be assessed (David.W. Johnson and Roger.T. Johnson, 1992). The way to ensure individual accountability, in which students are held responsible for their learning, and positive interdependence, in which students reach their goals if and only if the other students in the learning group also reach theirs, according to Johnson and Johnson, is to assess both individual and group learning (David.W. Johnson and Roger.T. Johnson, 1992). To show the benefits obtained from using CSCL, especially in tutoring systems, Kumar and Rose, in 2011, built intelligent interactive tutoring systems CycleTalk and WrenchTalk that support collaborative learning environments in the engineering domain (Conati, 2009). According to Rohit Kumar and Carolyn. P. Rosé, students who worked in pairs learned better than students who worked individually (Rohit Kumar, Carolyn P. Rosé, 2011) (Rohit Kumar, Carolyn. P. Rosé, Yi-Chia. Wang, Mahesh Joshi, and Allen Robinson, 2007). Another tutoring system that supports collaborative learning is described in (Jennifer K. Olsen, Daniel M. Belenky, Vincent Aleven, Nikol Rummel, 2014) for teaching mathematical fractions.

2.3 Adaptation

Adaptation in learning systems can be defined as the ability of a system to adjust instructions according to the learners' abilities and/or preferences. It considers that identification of learning style is a very crucial tool to improve the individual learning of a learner, especially in online learning (Bhawna Dhupia, Abdalla Alameen, 2019). The objective is to act on the identified characteristics of the learner and to improve the effectiveness and efficiency of learning (Steven Oxman and William Wong, 2014). The basis of adaptive learning can be identified by three elements shared by all adaptive systems (Peter Brusilovsky, 2000). The learner model represents the source of the adaptation, the domain model describes the adaptation target, and the connection established between the learner model and the domain model is implemented by the adaptation model. The introduction of other components in the system architecture is also possible (Blake, Robert J., 2009). Nevertheless, the three models mentioned above are a necessary precondition for each adaptive system to identify the individual characteristics of the learner and to decide which, when, and how an adaptive instruction will be delivered to a particular learner.

Adaptation provides adaptivity in terms of goals, preferences, and knowledge of individual students during interaction with the system. In our case, we seek to filter and order assessment activities given to learners. Rather than offering the same activity to everyone, our approach aims to select the next assessment activity to perform a certain learner based on the previous performance. This allows adaptation at each stage of the assessment process. We attempt also to use knowledge about collaborating peers and group interactions represented in the learner model and group learner model to form a matching group for different kinds of collaborative tasks. This is a new approach expanding ideas from the classic adaptive system, CSCL, and assessment to make an adaptive collaborative framework for assessment in an online collaborative learning environment.

3 ASSESSMENT FRAMEWORK

This section discusses the proposed framework to implement our adaptive approach for assessment in an online collaborative environment. The adaptive assessment framework will be able to cater to the needs of the heterogeneous type of users.

There are three basic models for an adaptive learning environment namely, domain model, learner model, and group model. To these models, we propose to add the assessment model and the group learner model. Therefore, the proposed adaptive assessment framework revolves around five models. The basic element of the proposed framework is the assessment platform. This is primarily a source for all types of data required for the system to carry forward. It includes all the information relevant to the assessment process with all the elements. The assessment platform will provide assessment indicators calculated while performing assessment activities for all, the learner model, the group learner model, the domain model, and the adaptive model.

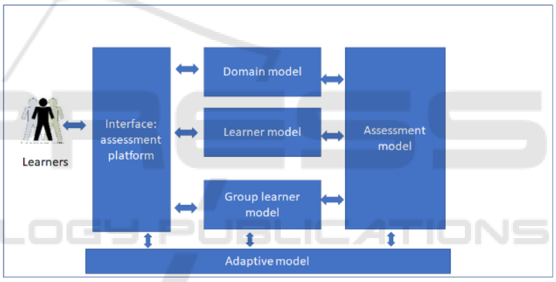

Figure 1: The general scheme for the adaptive framework.

3.1 Assessment Framework Description

To define the communication interface for the adaptive assessment framework we propose a meta-model using the Unified Modelling Language (UML), a standard language for specifying, visualizing, constructing, and documenting concepts and artifacts. Specifically, the modeling elements from the Class Diagrams of the language are used. The meta-model for the Assessment platform is shown in Figure 2. The different elements of the meta-model are detailed next.

The concept of activity is the basic abstract concept of the platform. An activity is a structured object possibly containing an arbitrary number of assessment tests. Activities are executed by an actor, which can be a single person, a group of persons. Activities also have Resources, representing elements created or manipulated by the activity. Resources are used to perform an activity, learning outcomes, or learning goals to be evaluated while performing the activity. Indicators will be calculated based on individuals' and groups' traces tracked while performing assessment activities. An indicator is a significant element, identified using a set of data, that makes it possible to evaluate a situation, a process, a product, etc. According to (Angelique, 2004) an indicator is "a mathematical variable that has a list of characteristics. It is a variable that takes values represented by digital, alphanumerical, or graphical forms. The value has a status: the value is calibrated to other variables". A lot of works is revealed regarding indicators, typically respecting this definition. For example, (Olga C. Santos, Antonio R. Anaya, Elena Gaudioso, Jesus G. Boticario, 2003) offers a tool that calculates from the interactions, the degree of involvement of each learner during the learning unit. It identifies participative learners, useful learners, non-collaborative learners, learners who take initiative, and communicative learners.

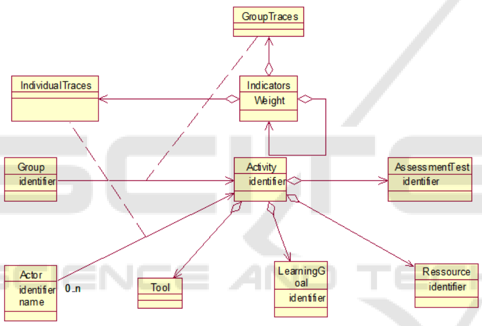

Figure 2: Meta-model for the assessment platform.

3.2 The Domain Model

The domain model includes a representation of the knowledge and expert skills of a domain that can be transmitted by didactic and pedagogical methods (Nwana, H. S, 1990). Depending on the domain, knowledge modeling will be performed. This knowledge and skills are unpacked as knowledge components (KC) in a way that facilitates their representation as facts, principles, or rules according to a hierarchy generally based on their complexity (Tardif, 1999), and in a way that facilitates an incremental acquisition in a learning process (John Whiting and David. Bell , 1987). The domain model provides our system with a baseline for inferring the knowledge state of the learner or groups of learners.

3.3 The Learner Model

The learner model is defined by (Millán, 2007) as a representation of information about an individual user that is essential for an adaptive system to provide the adaptation effect, i.e., to behave differently for different users. The learner model is a representation of the learner profile deduced from the assessment activities. It is responsible for discovering the individual learning behavior of the learner (Abdalla Alameen, 2019). The learner profile can be conceived at the epistemic level and the behavioral level (Wenger, 1987). It aims to identify the individual characteristics of each learner's strengths, preferences, and motivations (Hongchao Peng, Shanshan Ma, Jonathan Michael Spector, 2019). At the epistemic level, the data collected in the learning environment is used to infer the learner's knowledge status. This includes theoretical and declarative knowledge, as well as procedural knowledge (Wenger, 1987).

The updating of learner profile means the updating of values associated with the Concept Competence. It is based on the learner's performances on the pedagogical resources of type test (exercise, problems, MCQ, question, etc). The process of updating the learner's profile is necessary to keep track of the learner's evolving competencies. This updating affects the accuracy of the pedagogical assessment activities proposed to the learner, which in turn will help increase the learner's performance.

3.4 The Adaptive Model

The learner model, the group learner model, the domain model, and the assessment model are sources for all types of data required for the adaptive model to carry forward. It is the most important part of the Adaptive framework. It will also track the preferences, achievements, and activities during the whole assessment process. According to VanLehn and du Boulay (Vanlehn, 2006), it works as a combination of loops, the outer loop decides which task should be offered to the learner and the inner loop organizes the steps to complete the task assigned to the learner by the outer loop. This process in the adaptive model is implemented with the help of a learning algorithm.

3.5 The Group Learner Model

The group learner model contains all the information regarding each group of learners such as their domain, level of knowledge, assessment pattern.

Moreover, on our group learner model, we focus on both size and group composition. There is limited research in CSCL on the effects of the size of the group. But there is recognition that group size depends on the scope, duration, and complexity of the assessment activity. The group learner, however, needs to be small enough to enable students to participate fully and to build group cohesion (Tammy Schellens and Martin Valcke, 2006).

Our learner group model also focuses on the heterogeneity of groups in terms of personality traits and performance levels. The quality of the learning process in the context of collaborative work highly depends on the characteristics of the group. Related work showed the importance of personality attributes, gender, school background, ethnic background, motivation (Liana Razmerit, Armelle Brun, 2011) in group performance. Another important criterion in group composition is the learning style (Martín, Estefanía; Paredes Barragán, Pedro, 2004). It has been determined that the standard and quality of learning in groups is influenced by their diversity. Heterogeneous groups may outperform homogeneous groups. Some studies emphasized that heterogeneous groups may be more creative and innovative (Nijstad, B. A., & Paulus, P. B., 2003) and they may be more effective for individual learning.

The ability to change the group member composition in real-time and dynamically enables the leveling up of assessment results and improvements in the learners' social relationships. The group learner model is a representation of the profile of each group of learners deduced by the collaborative assessment activities. To illustrate the group, we need the parameters of each group (meta-parameters) and a grouping system that relies on grouping algorithms to compose them.

3.6 The Assessment Model

The hypothesis put forward by the assessment model suggests that the resolution of assessment tasks might be justified by either the mastery or the non-mastery of certain knowledge components (KCs) derived from the domain model. This in its turn permits information to be transmitted from one activity to another. The specification of KC is essential for each assessment activity since these components are involved in the process of answering the instructions of each activity by the learner.

Question & Test Interoperability (QTI) provides a good starting point for modeling and designing assessment systems. The Design of assessment tests to our proposed model needs to conform to the IMS QTI standard to better the reusability of the assessment system and provide the basis for interoperability specifications for the assessment creation process: from construction to evaluation.

The QTI standard (Consortium, 2020) specifies how to represent assessment tests and the corresponding result reports. Figure 3 illustrates part of a test and the way the items are structured into sections, sub-sections, and assessment items.

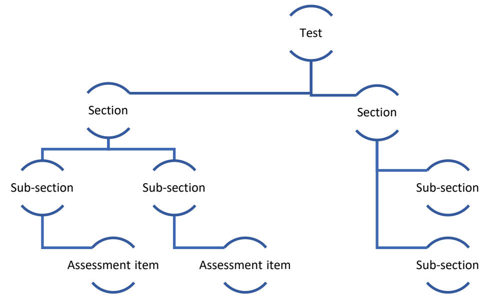

Figure 3: The structure of the test Reproduced from (Consortium, 2020).

An assessment item should not be confused with a “question”. It is more than that since it is an amalgamation of elements: it involves the question and the instructions of how this question should be introduced, as well as the answer treatment to be applied to the candidate’s response. To present the same question but in varied manners, the presentation provides the structure for defining different possibilities for the same question. Each answer within the question can also have different structures. The response processing determines the assessment method. Results of a test can be recorded and saved for future reference by other systems (Consortium, 2020).

Figure 4 illustrates the core metaclass, AssessmentItem, in the model and how other metaclasses are connected to it. According to (Consortium, 2020), the ItemBody metaclass represents the text, graphics, media objects, and interactions that describe the item's content and information concerning how it is structured (Consortium, 2020).

The FeedbackBlock metaclass is very important to present any material to the students. The feedback that the QTI system provides is based on the result of responseProcessing. It is controlled by the values of outcome variables (Consortium, 2020).

To well define the technical structure of the question and guarantee its interoperability, our assessment model will be conform to the IMS QTI specification. We also refer to ontology, as defined in

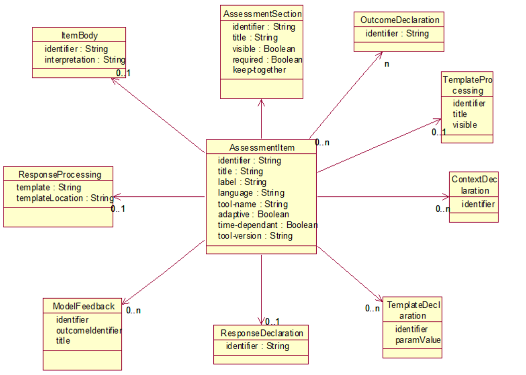

Figure 4: A meta-classes for the assessment item.

(Gruber, 1993) as "specifications of conceptualizations". It is indeed a semantic representation of complex knowledge intended for the development of intelligent applications. It is also defined as social constructions intended for communication and the crystallization of domain-specific knowledge. For this purpose, we used ontology. The ontological model illustrated in figure 5 provides all the features used in practice while doing assessment tests.

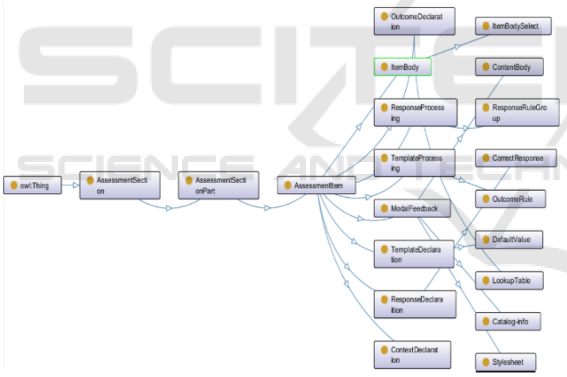

Figure 5: Graphical representation of the assessment ontological model.

4 DISCUSSION

There are several varied models for representing knowledge, teaching styles, and student knowledge. Each model has its advantages and disadvantages. By reviewing several works, we can conclude that adaptation has been used in many learning contexts. A personalized adaptive learning framework has been constructed based on a recommendation model of the personalized learning path and following four aspects, namely learner profiles, competency-based progression, personal learning, and flexible learning environments (Hongchao Peng, Shanshan Ma, Jonathan Michael Spector, 2019). Similarly, to provide a method of assessing the difficulty of learning content and students' knowledge proficiency, Elo-rating is a method that was designed to assist the instructor in assessing large course programming assignments throughout the semester (Boban Vesin, Katerina Mangaroska, Kamil Akhuseyinoglu, Michail Giannakos, 2022). Compared with our work, we consider our approach adequate to be used in an online collaborative environment. To do that, we added two additional models to the classical architecture of an adaptive system so that it covers adaptation on both assessment and collaboration. The assessment model formalized based on IMS/QTI standard and described using ontology allows the development of the framework using IMS/QTI specification and the verification of the conformity of an item to the IMS/QTI specification to guarantee its reuse and interoperability.

5 CONCLUSION AND FUTURE WORK

Designing an intelligent assessment framework in an online collaborative environment presents us with a major challenge: ensuring adaptation. While several adaptation models exist in learning systems, this is not yet the case for the adaptation of the assessment strategy in an online collaborative framework. The scope of the article is an adaptive approach for a collaborative assessment framework in an online environment. First, we designed a meta-model for the collaborative assessment platform that acts as the communication interface of our adaptive assessment framework. Then, we proposed the extension of the general architecture of an adaptive system which allowed us to circumvent three important dimensions: collaboration, assessment, and adaptation. In addition to the domain model, the learner model, and the adaptative model, we proposed to add two other models to the final adaptive system: the learner group model and the assessment model conformed to the standardized formalism IMS/QTI. To well formalism and describe it, we referred to ontology. A meta-model using UML diagrams has been as well-developed covering assessment resources content and assessment results sections.

Finally, our perspective for this research is to study the implementation and then the validation of our assessment system for various assessment domains and various learner and group profiles.

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