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An orientation and remediation tool for solving mathematical exercises for secondary education

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Abstract
The personalized assistance of students in solving mathematical exercises (Problem) is at the heart of mathematical learning in elementary school. This specific activity attached to mathematics caught the attention of many researchers in mathematics education (Charnay & Houdement, 1999), but also in cognitive psychology (Vergnaud, 1997; Fayol, 1996). In science, problem solving takes a prominent place. Generally, this is the method used to diagnose the problems and deficiencies student and to assess its mastery to various didactic concepts. It is therefore important to help the student in solving exercises, diagnose problems and intervene appropriately based on their profile. The purpose of this article is to make a model (Onto E-orientation-Math-Bridge) to guide the Moroccan profile to the most appropriate exercises to his skills, preferences and motivation. This model allows to mix two models: E-orientation model (Guerss F., Ait daoud M. & al, 2014; Guerss F., Ait daoud M. & al, 2015) that allows the orientation of Moroccan students remotely according to their profiles And extended ontology of Math-Bridge project (Lmati & al, 2014). This allows to structure the mathematics courses as pedagogical concepts PC (Definition, theorem,...) linked by semantic relations. These concepts may be useful to specify evaluation exercises according to themes and sub-themes mathematics. Each of theme is attached to a given level which characterizes the Profile.

Keywords: Profile, Exercise, Ontology, E-orientation, Math-Bridge, E-orientation-Math-Bridge.

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1. Introduction

The evaluation exercises provide a very useful feedback to the student. It allows situating him in relation to the requirements and in relation to its group (Desmarais, M. C, 2011). This information is particularly important in an autonomous and distance learning environment. In this context, the possibility of providing a more accurate assessment adequate to the student skills proves a significant advantage, because he may get tired quickly of evaluation exercises which are out of his learning level.

To put our work in the context of orientation, we cite some scientific research which studied the student orientation to suitable exercises. For example, we find the project of Auzende (Auzende &, 2009) which used the competency criteria for selection of suitable mathematical exercises. It allows the classification of the exercises to facilitate research. For the classification, it is related to mathematical concepts independently of school programs (School levels). Example of competence: "Simplify an expression with square roots ", "Complete an expression with square roots " ... In comparison with our work, the competency criteria is more generic, it is not related to the prerequisites of pedagogical concepts as used in our work.

Heeren (Heeren, 2008) has developed a language of strategies specification to resolve exercises. The language is used to automatically deduct feedback when users make erroneous measurements in a calculation. These strategies can automatically calculate all kinds of desirable feedback (Syntax error, rewrite error, error in terms of strategy for solving exercise, etc).

In the context of remediation, several research use adaptive tests to diagnose the level of the student, find the weak points and to intervene appropriately.

Pepite project (PREVIT &, 2004) based on a multidimensional model of competence in elementary algebra which allows to connect the different skills (adequate or not) that a student has built with the skills expected. The problematic of project Pepite is a problem of cognitive modelling. It’s about the implementation of test batteries that allow obtaining cognitive profile of students in algebra, which may deduct these strengths, weaknesses to respond appropriately.

ActiveMath (Melis &, 2004) represents also a tool for solving arithmetic problems. It allows combining the orientation and remediation part. This is an adaptive learning environment for mathematics that dynamically generates mathematical courses and interactive exercises adapted to student profiles. During the generation of course, the system check if the level of mastery of concepts is sufficient for competence of goal. Otherwise, it presents the concepts and/or missing explanations, examples, exercises for these concepts to the student when a new session is requested. Our approach uses the same idea of the project ActiveMath, which is the mastery level test of pedagogical concepts for useful purposes.

All of these researches has served as a basis for the development of the approach that groups the orientation part to the remediation part, which we will describe later in this article.

2. Approach

Our approach allows guiding the student to the appropriate mathematical exercises. Furthermore, it allows the remediation to enhance the skills of the student in parts of the course that are not well mastered. We can define the approach in two steps:

- Orientation: based on the rate of mastery of prerequisites PCs useful for solving an exercise chosen by the student
- Remediation: proposed to the student in the case of low mastery previous prerequisites. This remediation is given as:
  - Viewing the content PC of nonmastered prerequisites for student

- Extraction and proposal of application exercises adequate for PC.

3. Generic functional architecture of the proposed approach

The proposed architecture allows to give an orientation method to choose appropriate exercises according to preferences, level of study and rates of mastery of prerequisites (Prerequisites PC found) by the student.

This architecture has several functions: Fig. 1:

3.1. The user interface

The interface allows the users to enter their coordinates, preferences (Choose the type of exercises: Application or compound) and the general theme for evaluation (great chapter in the ontology of mathematical topics: Function, equation ...).

3.2. The E-orientation-Math-Bridge interface

The exercise selected by the user is analyzed question by question based on the extended ontology Math-Bridge (Lmati &., 2014). The system extracts the relevant PCs to resolve the question Q(i) (Lmati &., 2015). It compares the educational level of each PC found with the level of the student:

- If level (Sub_Themes(PC)) > level (student)), the system tests the level of mastery of prerequisite PC from its history (Model of profile).
- If the rate of mastery of one of the prerequisites (Pr1 (PC), Pr2 (PC)...) is less than 50%, a remediation is returned to the student to overcome his weaknesses (Viewing the contents of PCs related to unearned prerequisite with their application exercises).

Figure 1. General architecture for guidance and personalized remediation
2. Models of architecture

To facilitate the exchange of data between the different modules of the functional architecture, we present the different models used:

2.1. First point Ontology of mathematical themes

![Figure 1. Ontology of mathematical themes](image)

This ontology is extracted from the Math-Bridge project (Durand-Guerrier &., 2012). During the didactic preparations of project, all mathematical topics were organized hierarchically as an ontology of concepts relevant to the target group.

See for example Fig. 2 for algebra concepts.

2.2. Ontology of Profile

There are several representations of the student’s Profile models (Razmerita, 2005). The rest of this section provides a global vision on the various most pertinent models.

AHAM (De Bra P, 2004) is a very general model used to describe the adaptive hypermedia systems (SHA) for teaching, online help, System Information (SI) online, etc. This model divides the SHA in three layers which are interconnected between them:

- The model storage layer is a set of nodes and links. This layer is organized into three components which are the domain model, the student’s model, and the adaptation model
- The domain model shows the hypermedia application area as seen by the authors
- The user model contains pertinent information on the user utilized for adaptation
- The adaptation model collects rules that are used for adapting hypermedia by combining the information on the domain model and the user model
The "content components" layer specifies the content and structure of the nodes. The adaptation of the hypermedia is performed by the adaptation engine forming part of the "Specification of presentation" interface.

The execution layer.

The Munich model (De Bra P, 2004) is a very general model that is not only used for educational SHA but also for other types of SHA. This model was developed independently of the AHAM model. The major supply of this model is that it uses a graphical language for describing the various components of a SHA. The layered architecture has been replaced by a UML package diagram and description of the user model, domain and adaptation was illustrated by UML class diagrams. These diagrams are also used to describe the various features that are offered by the three models.

The ALEM (Adaptive Learning Environment Model) model (Tadlaoui, 2014) is an extension of the Munich model. This model contains the same three existing layers in the Munich model; it extends their functionality for better modeling of educational systems and includes an additional layer that is educational layer.

The different layers of ALEM model are:

- The component content layer: contains the content and structure of hypermedia nodes and it also serves to isolate the other layers specific details to the media;
- The storage layer: stores information about the structure of the hypermedia. This layer is composed of three meta models:
  - Meta domain model describing the scope of hypermedia
  - The meta student model describing the characteristics of useful learning for customization of hyperspace
  - The meta model describing the adaptation strategies and adaptation rules.
- The educational film is an abstract representation of the course. This layer contains the course of the structuring model
- The execution layer is the description of how the presentation of nodes. This layer is responsible for interacting with the student, the acquisition of student data and session management.

The user model INT (Duitama, 2005) is a triplet: <student, preference, knowledge>:

- Student is the ID of the user
- The user preferences match to their language or their favorite presentation. Each element of the set of preferences is represented by a pair <attribute, value>
- The user's knowledge is represented by triples of the form: <domainConcept, role, educationalState>.

The user model E-orientation (Guerss F., Ait daoud M. & al, 2015) is a: <Characevolutif, Caracpermanant>:

- Characevolutif evolving Characterics of a student
- Caracpermanantpermanantcharacteristics of a student.
The Munich and AHAM models are very similar. Munich and ALEM model the system hypermedia adaptive SHA from the viewpoint of the "object-oriented" approach. However, AHAM models the SHA from the perspective of the "database" approach.

The user model E-orientation treated the psychic and stylistic modeling of the student profile, and on the other hand the adaptation of profile to one or more appropriate choices. The last model responses to our approach Fig. 3.

Figure 3. Profile Model Onto E-orientation (Guer S Fatima zahra &, 2015)
We choose the concept ‘historique’ of Onto E-orientation which can review the last level of student skills to define the needed prerequisites to resolve mathematical exercises, and the concept ‘niveau’ of Onto E-orientation which may precise the adequate exercises to evolve his level. The tow concepts will allow to update the student profile.

3. Conclusion

In this paper, we proposed a new personalized approach to resolve problem based on pedagogical concepts as exercise mathematical. We referenced to the ontology onto E-orientation proposed by Guerss. It represents the student in two permanent and evolving characters. Our new proposition will be used to recommend students according to prerequisite and skills level.

We will prepare a student knowledge base combining profile to adequate level. Then studying to ensure that the courses offered by our approach are adequate according to the notes that will be obtained by students in mathematical exercises.

References


