

# **Towards Designing an Intelligent Educational Assessment Tool**

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## Abstract

Assessment is an important part of learning process. It can be defined as the process of gathering information for the purpose of making judgments about a current state of affairs presumably for the purpose of enhancing future outcomes [1]. It determines whether or not the goals of education are being met. Typically, most assessment tools give a numerical score as the result of the assessment. This may not be enough to improve the student's progress. In this paper we defined main problems in current assessment tools and proposed a new assessment model that uses notions in knowledge space theory to overcome the shortage of the current assessment models. The experiment result showed that this new prototype made the assessment process easier and more effective. However, assessment affects decisions about grades, instructional needs and curriculum. This is an important phase of the learning process being showed in this paper in knowledge states framework. Future research will focus on making the tool behave intelligently to improve students' learning momentum.

## Keywords

Artificial Intelligent, Evaluation, Knowledge Space Theory, Precedence Relation, Competences

## **1. Introduction**

Educational assessment helps decision makers in any educational institution to make decisions about grades, advancement, instructional needs and curriculum, it also inspires us to ask the hard question: "Are we teaching what we think we are teaching?".

In most current assessment tools, the system gives the learner an indicator of the level of his/her knowledge in a specific field. However, they don't give any guidance to the learner or instructor about the next learning step, this is one of the main problems in current assessment models. Many assessment methods, performed by many specialists in schools and universities, are systematically based on the numerical evaluation. Such form of eval-

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uation may not be very accurate and may not give the needed feedback to both student and instructor. Assessment is more like a movie rather than a snapshot. What we really want to know is how students are progressing over time, not where they stand on a particular point of time [1]. According to Camacho, Ortigosahas, Pulido, and RMoreno [2], the application of AI (artificial intelligence) techniques in pedagogical and educational environments originated new possibilities to develop learning processes.

A considerable amount of research has been conducted about assessing the learners [1] [3] [4]. However, it is a challenging problem to capture and represent the amount of knowledge the learner has in a specific field. Furthermore, it is essential to give a valuable feedback or guidance to both instructor and learner about the next learning that must be followed.

According to the BEAR (Berkeley Evaluation & Assessment Research Center), there are four principles that any assessment and adaptation system or approach must address to be useful in e-learning settings [5]. These principles are:

1) Assessments should be based on a developmental perspective of student learning;

2) Assessments in e-learning should be clearly aligned with the goals of instruction;

3) Assessments must produce valid and reliable evidence of what students know and can do;

4) Assessment data should provide information that is useful to teachers and students to improve learning outcomes [6].

Most current assessment tools cover the first three assessment principles. However, the fourth principle seems to present a challenge and is not well covered.

In this research, we aim to design and implement an assessment model to propose a solution for issues and problems in current assessment tools, the model employs the notion of knowledge space theory [7]-[10]. In this theory, a field of knowledge is represented by a finite set of knowledge skills (knowledge states). Moreover, knowledge space theory assumes dependencies between these states in that knowledge of a given skill or a subset of skills may be a prerequisite for knowledge of another more difficult or complex skill.

The proposed model in this paper should provide guidance to both learner and instructor smoothly to move from one state of knowledge to a more advanced state using concepts of knowledge space theory. It will contribute to design a new concept of assessment that would hopefully add value to learning process and make it more efficient and effective. We shall investigate the usefulness of such concepts in assessing student competence rather than just using the traditional tests that provide numerical scores only.

#### 2. Related Work

A considerable amount of research has been conducted about assessing the learners [1] [3] [5]. However, it is a challenging problem to capture and represent the amount of knowledge the learner has in a specific field.

There are many assessment concepts and tools based on different techniques. One of them was designed in 2004 by using the (concept mapping) techniques. The research was working on the idea of making a diagnosis of learners' knowledge based on different categories of errors. For example, the result of the assessment for learner will be one of the following: unknown concepts, incomplete understanding, and false beliefs [4]. In [11], another assessment concept is designed to help instructor generate tests and correct them. It focuses on enhancing the cognitive aspects of assessment: while editing a question, the teacher tells which cognitive domain (from the six outlined by Bloom) he wants to assess, then the tool guides the instructor in designing the examination. Thus, writing an evaluation must be planned in order to enrich its educational value.

On the other hand, Clements and Sarama [6] have found that teachers' use of measurement learning trajectories facilitate all children's learning, especially those children who may have missed opportunities to develop higher levels of thinking strategies. When evaluating and comparing students' achievement gains across classrooms, Clements and Sarama [6] found the large gains for students in classrooms where teachers used number and measurement learning trajectories to assess student understanding and guide instructional decisions compared to the achievement scores of students in a control group. All of the models we mentioned above help learners and instructors somehow to assess their progress [11] [12], but they still have a problem in accurately capturing the learner knowledge state. Furthermore, it is essential to give a valuable feedback or guidance to both instructor and learner about the next learning that must be followed.

#### 3. Knowledge Space Theory

According to Doignon and Falmagne [3] [9], knowledge space theory (KST) is the most recent psychological

development applied in the field of e-learning. It is a set-theoretical framework, which proposes mathematical formalisms to operationalize knowledge structures in a particular domain. In this theory, a field of knowledge is represented by a finite set of knowledge skills (knowledge states) [13]. Moreover, knowledge space theory assumes dependencies between these states in that knowledge of a given item or a subset of items may be a prerequisite for knowledge of another more difficult or complex item [14].

The idea is that a knowledge skill and competences are interrelated and embedded. For instance, skill C requires both skill A and Skill B as prerequisite. A student who shows a high degree of mastery of skill C can be judged to have mastered both skill A and skill B. The key question is, given a particular subject, to partition it into appropriately related skill and to find the most appropriate prerequisite/embedment relationship between these skills as shown in **Figure 1**.

In the notion knowledge space theory, a precedence diagram is used to show precedence relations and dependencies between skills and competences [15]. For example, in the precedence diagram (**Figure 1**), the precedence relation between problems is symbolized by the downward arrows. For example, problem (e) is preceded by problems (d) and (a). In other words, the mastery of problem (e) implies that of (d) and (a).

Note that this precedence relation is part of a much bigger one, representing a comprehensive coverage of a greater knowledge space; knowledge space is a combinatorial structure, describing the possible states of knowledge of a human learner in a specific field.

#### 4. Framework of the Proposed System

In this paper, we are going to propose a sophisticated framework to enhance student learning. The framework simulates the knowledge state of the learner; it doesn't give the learner a numerical value in the end of assessment process but gives instead the current knowledge state of the student in addition to guiding the learner to the next knowledge state he is ready to learn in the current time.

The learning objectives will be declared at the beginning of the process, and then a matching process takes a place between the learning objectives and questions saved in the data base that were provided by the teacher in the first place. The prerequisite relation is an important part of the framework because it also takes a place in the matching process while creating quizzes. In other words, it helps construct questions by taking the knowledge states order respectively.

The framework has two main parts: one for teacher and one for student as shown in **Figure 2**. The teacher after signing up, he can define his classes and then define the objectives of each class with the dependences between them, as shown in the precedence diagram in **Figure 1**. For every objective the teacher will specify the prerequisite objective(s) of it in an easy way as shown in **Figure 2**.

The framework would also provide an efficient way for creating quizzes to assess the students, the teacher can create quizzes using this framework with questions in four different forms: Fill in the blank, Multiple choice, Multiple choice with more than one correct answer, True or False. The teacher can also add picture to the question and the student can provide answers with pictures, too.



Figure 1. Precedence diagram.



Figure 2. The proposed framework.

After the teacher finished creating the quiz, he can export the quiz for students who are registered in his class, and when the student finish answering the quiz, the teacher will import the answered quizzes from his students. On the other hand, students must sign up to have an account on the system and register in their classes.

#### 4.1. Output of the Framework

After analyzing the imported answered quizzes from students, the framework relying on the notions of the knowledge space theory and the dependencies between objectives the teacher has provided; it will output the following as shown in Figure 3(a) and Figure 3(b).

- 1) The current knowledge state for the student;
- 2) Mastered skills list: A list contains the skills that the student mastered so far;
- 3) Uncompleted skills: A list contains the skills that the student doesn't master yet;

4) Student's readiness list: A list that offers the student a selection of only the skills he is ready to learn at the current time.

#### 4.2. Unites of the Framework

In this sub-section, a more detailed view of the framework architecture is represented, the framework mainly consists of four main units as shown in **Figure 4**. A detailed description of each unit job is expressed below in addition to the interaction between units.

**The class definer:** In this unit the teacher will be able to define a class with a description of it, in addition to viewing students who are enrolled in the class. This unit is also responsible for declaring the objective or main outcomes of the class plus the dependency relation between them (dependency notions of knowledge space theory). The dependency relation can be inserted easily to the system.

The quiz creator: In this unit it is responsible for creating and building quizzes. It helps instructor in many ways in creating tests. It provides 4 types of questions (Multiple choice, Fill in the blank, True/False, Multiple choices with more than one correct answer) as shown in Figure 5 below. Teachers can also add diagrams and pictures to their questions for more clarifications, in addition to providing the correct answer for each question for the purpose of evaluation. One important thing has to be mentioned here is that every question can also be matched with one or more of the class objectives that have been defined by the teacher.

**Knowledge state recognizer:** In this unit, the system will match the students' answers with the correct answers provided by teachers, this comparison with result to recognition of the students' mastered skills and students' weakness points by matching his answers with the objectives of the class in the first place.

**Knowledge state visualizer:** In this unit the knowledge state of the student specified on the dependency diagram of the class will be viewed for teacher for the purpose of easier analysis of the student results. For example, as shown in **Figure 6**, the student is in knowledge state "b" and he is ready to move to the knowledge state "c".

#### T. Hamtini et al.



🖳 Quiz Result	• *
Your current knowledge state: d	
Your Mastered skills list is: a, b, d	
Your uncompleted skills list is: c,	e
You are ready to learn the followi	ng skills: c
(b)	

Figure 3. a) Output of the framework; b) List in the output of the framework.

## **5. Experiment and Results**

We implemented a prototype for the proposed framework and tested it with the help of graduate students in an e-learning course in University of Jordan in spring 2014. The students were divided into groups; each group has developed an e-learning course for a specific topic. However, students after building the e-course they tested the prototype for assessment purposes.

A questionnaire was given to the student to evaluate the tool and to give future suggestions for improving. The dimensions included in the questionnaire were mainly about:

1) Ease of use;

- 2) The indicator of the student progress during the assessment process;
- 3) Creating quizzes easily and efficiently;
- 4) Enabling the instructor to define the precedence relation in a clear form;

5) The ability of the framework to judge whether the student masters a specific objective of the material or not.

Students filled the questionnaire based on their testing with one of the following options (agree, neural, disagree) and the result of the questionnaire is showed in **Figure 7** below.

After doing this experiment and analyzing the results, it was clear that 75% of people who have tested the framework have agreed on three dimensions of the testing criteria which are:



Figure 4. Framewok main units.

Define Your Question	nswers Objectives		
Fill in the blank	<ul> <li>True or False</li> <li>True False</li> </ul>	<ul> <li>Multiple Choice</li> <li>Answer 1</li> <li>Answer 2</li> <li>Answer 3</li> </ul>	<ul> <li>More Than One Answer</li> <li>Answer 1</li> <li>Answer 2</li> <li>Answer 3</li> </ul>

Figure 5. Quize creator unit.		
Figure 6. Knowledge state visu	ulaizer.	



Figure 7. Experiment result.

1) The indicator of the student progress during the assessment process;

2) Enabling the instructor to define the learning objective in a clear form;

3) The ability of the framework to judge whether the student masters a specific objective of the material or not.

On the other hand, 50% of people who have tested the framework disagreed on the testing dimensions which are:

1) Ease of use;

2) Creating quizzes easily and efficiently;

3) The tool enables the instructor to define the precedence diagram easily.

The result of the questionnaire helped us put a plan for future work by focusing on the dimensions that were disagreed by most of the research samples. In addition, it helped us in planning how to enhance this framework to be more effective.

#### 6. Conclusions and Future Work

In this paper, an educational assessment model was proposed by using notions of knowledge space theory to overcome the shortage of the current assessment models and to provide guidance for instructor and learner through the educational process. The framework was tested in University of Jordan e-learning class and the experiment results are shown in this paper. The results showed that this framework contributes to make the assessment process easier and more effective and clarifies the way for future enhancement on this model.

The proposed model may be used in any educational institution through enabling the instructor to define the learning objects of the material and the dependencies between them, it also enables the student to answer the created quiz depending on those dependencies in order to give guidance to instructor and learner on the knowledge state of the learner.

In the future, we will continue the research in this area by working on the notions of skills and competencies in an intelligent way. Which means not only relying on the class objectives inserted by the instructor, but dealing with underlying skills and competencies of the class, which may need working on the notions of domain ontology in order to extract skills and competencies in an intelligent and scientific way. This approach will ultimately improve the tool and make it behave intelligently.

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