ELEMENTS OF ADAPTIVE LEARNING FOR DEVELOPING PROFESSIONAL COMPETENCIES AT FUTURE ENGINEERS

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Abstract. *Developing professional competencies to future engineers is essential for their integration into professional life. The process of developing professional compentencies is influenced by several internal and external factors. Internal factors are determined by the learning needs of student, their level of knowledges and so on. External factors are the requirements of society, employers, etc. Usually in designing and developing competencies, teachers are focused on external factors, and less attention they paid to internal factors. However, the knowledge of internal factors allows to identify the elements that make possible an adaptive learning. The basic idea of adaptive learning is to orientate learning to the personality of the learner, to his / her interests and performance. The major advantage of adaptive learning is that students have the opportunity to develop their professional competencies according to their own learning path.*

1. Adaptive learning approach

The main task of the university is to develop at the future specialists the professional competencies that will allow them to be prepared and succeed in professional life. For an authentic and deep learning, it is required to allow learners to progress at their own pace, place and convenience. It is known that all learners are different and at the same time, most educational materials are the same for all. We need to change a one-size-fits-all mentality and propose to our students an adaptive learning. This pedagogical approach is partly the result of the consciousness that tailored learning on a large scale was not feasible with traditional and non-adaptable approaches. Adaptive learning refers to the idea that, to be effective, teaching must be as personalized as possible and managed according to the needs of the learner. According to Chieu "adaptability is the ability of a learning system to provide each learner with appropriate learning conditions to facilitate his or her own process of knowledge construction and transformation" [1].

In this context, computers dynamically adjust the system to student interactions and performance levels, delivering types of contents in an appropriate sequence, which individual learners need at specific points in time, in order to make progress. Thus, to achieve the same goal, each student will follow the path that suits him best. These systems employ algorithms, assessments, student feedback, instructor adjustments/interventions, and various media to deliver new learning material to students who have achieved mastery and remediation to those who have not. Adaptive learning systems use a data-driven and, in some cases, nonlinear approach to instruction and remediation [2]. Adaptive learning systems endeavor to transform the learner from passive receptor of information to active collaborator in the educational process.

An e-learning system is considered to be adaptive if it is capable of: monitoring the activities of its users; interpreting these on the basis of domain-specific models; inferring user requirements and

preferences out of the interpreted activities, appropriately representing these in associated models; and, finally, acting upon the available knowledge on its users and the subject matter at hand, to dynamically facilitate the learning process [3].

Adaptive learning topic is researched in many studies. Some authors propose to achieve adaptation, based on student learning styles [4, 5], others consider the tasks or content adaptation more relevant [6]. There are works that propose to combine these two approaches [7].

2. The elements of an adaptive learning system

On the market, there are many products, which are declared being adaptive learning systems. It is difficult to know at what someone is referring to exactly, when he says a product is adaptive. Sometimes adaptation is confused with a simple interactivity. Generally, adaptive learning systems are built on three core elements [8]:

- A *content model* refers to the way the content domain, is structured, with thoroughly detailed learning outcomes. Although the idea of adaptive learning is that sequencing of content can change according to student performance, some initial sequencing of content is pre-determined. The system must be able to identify which content is appropriate, conforming to the student knowledge at any point in time. Some systems may have larger chunks of content that go together, and a student is assessed only after passing this unit of learning; others may assess a student understanding at a finer level.
- A *learner model* contain information about each learners, about their performance. They may numerically estimate the student's ability level on different topics, or carefully track the student's existing knowledge base. Learner models continue to become more complex, considering additional variables such as the student's motivational state and emotional response.
- An *instructional model* determines how a system selects specific content for a specific student at a specific time. In other words, it puts together the information from the learner model and content model, ideally, generating the learning feedback or activity that will be most appropriate to advance the student's learning.

3. Adaptive learning from the perspective of Competence Based Approach

Adaptive learning system must provide different paths for different learners, similarly the teacher who can teach the same concept in many different ways. In an adaptive learning experience, each student literally sees a different course based on his or her individual learner profile and demonstrated progress.

According to Karampiperis and Sampson [9] adaptive educational sequencing is based on concept selection process and content selection process.

In the concept selection process, learner, or in some cases teacher selects a set of learning goals from the designed Learning Goals Hierarchy. Learners achieves a filtering of learning goals through the perspective of their own needs, background and preferences. Each learning objective is related to several concepts from the Domain Concept Ontology. These concepts are filtered by the pre-existing knowledge of the learner and it allows creating a sequence of missing concepts that need to be covered in order to reach the selected learning goals. In the content selection process, learning resources related for each missing concept are selected from the Resource Description Model. The educational characteristics of learning resources are retrieved according to the cognitive characteristics and learning preferences of learners. The result of this process is a personalized learning path that matches the selected learning goals.

From the Competence Based Approach we consider that this model can be improved. The mentioned processes can be specified in the following way. The concept selection process is viewed

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as a process of choosing the learning outcomes. Each learning outcome is related to a certain family of situations. The level of complexity of the situations from the corresponding family is settled in agreement with the learner profile. For each situation, the system provides the connected resources, required in order to solve it. The principle of offering educational resources is similar as described in the content selection process.

The processes represented above are cyclic processes and their new loop depends on how the previous loop was handled. The process of monitoring students' success and failures is an important aspect of the adaptive learning system, because the adaptation is possible only if the system has data about students' performances. The new content is presented to different learners based on his or her performance during the learning process. For this purpose, a wide range of evaluation tools can be used, that can be more or less adapted to individual students' characteristics. Assessment is related to a certain competence that refers to a family of situations and is meant to check if selected learning outcome is achieved.

Figure 1 presents the connection of the above mentioned processes.

The *learner* model represents various learner characteristics, which can be used to adapt learning environment. This component stores all user-related data, i.e., the users' profiles, including personal information and preferences.

Adaptive learning systems have mostly one of two different types of *instructional models*. In the literature, the most popular are rule-based and algorithm-based [8]:

- Rule-based systems are built using a series of if-then functions. At their simplest, these systems employ a straightforward branching architecture. A student is asked a question; if he gives the right answer, he moves to the next selected activity; if the answer is wrong, he is given some additional content to assist him. That assistance may be a hint, a repeated content, or a content that explains the material in a different way. A system might be linear, giving the student no control, or it might provide an option to see a hint, to re-answer a question, or to skip and move on, etc. In essence, this is a type of manual adaptivity, easy to understand but not taking advantage of the computational power that drive the future of adaptive learning. The Smart Sparrow, Adapt Courseware, JONES & BARTLETT LEARNING are rule-based systems.

- Algorithm-based systems use mathematical functions to analyze student or content performance, or both. These systems can involve even machine learning capabilities. In this case, the system learns more and more about the student and content as it goes along. Such systems may make use of educational data mining and advanced analytics to deal with big data. They employ complex algorithms for predicting probabilities of a particular student being successful based on particular content. The Knewton, CogBooks are algorithm-based systems.

To express different manifestations of adaptive behavior in a learning environment Paramythis and Loidl-Reisinger realized a high-level categorization [3]:

- *Adaptive Interaction* - adaptations that take place at the system's interface and are intended to facilitate or support the user's interaction with the system, without, however, modifying in any way the learning "content" itself.

- *Adaptive Course Delivery* - adaptations that are intended to tailor a course to the individual learner. The intention is to optimize the "fit" between course contents and user characteristics / requirements, so that the "optimal" learning result is obtained, and additionally, the time and interactions expended on a course are brought to a "minimum".

- *Adaptive Content Discovery and Assembly*, refers to the application of adaptive techniques

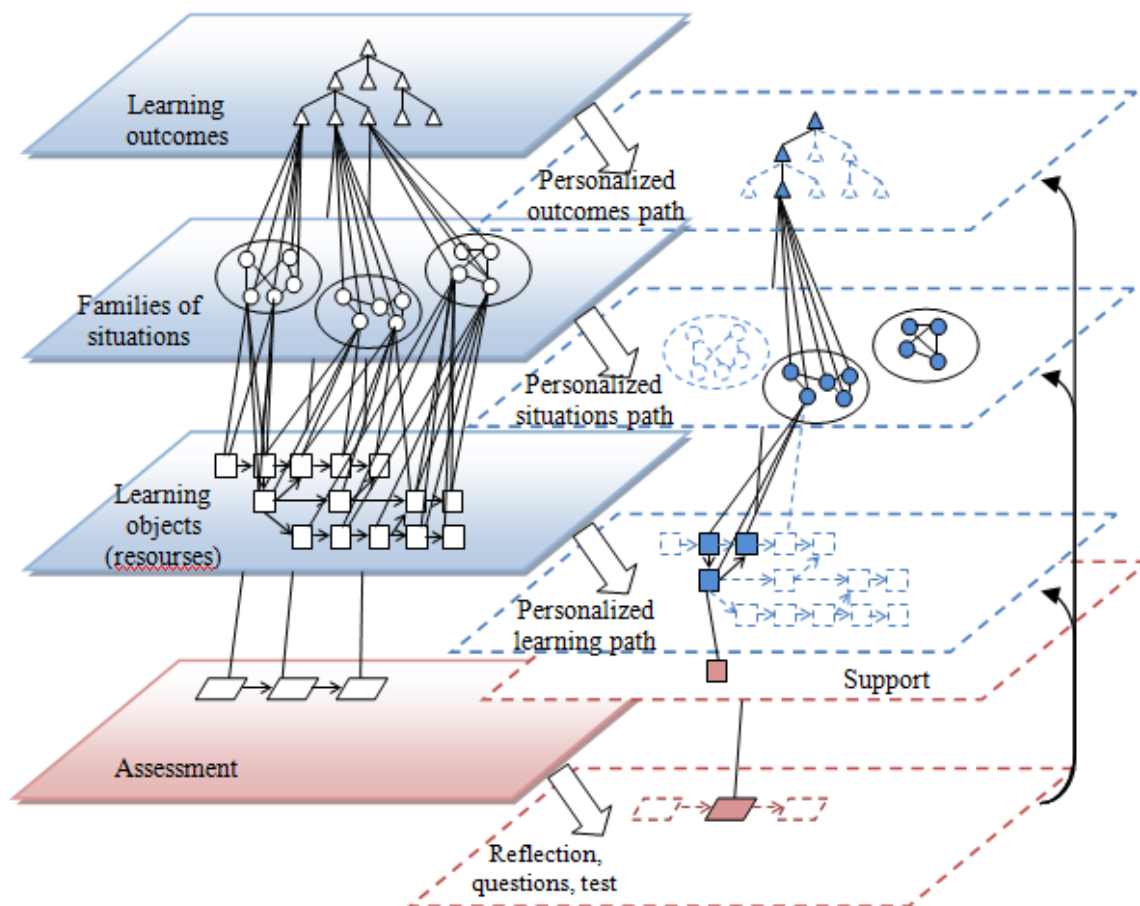THE USE OF MODERN EDUCATIONAL AND INFORMATIONAL TECHNOLOGIES FOR THE TRAINING OF PROFESSIONAL COMPETENCES OF THE STUDENTS IN HIGHER EDUCATION INSTITUTIONS, Profadapt_FCP, december 7–8, 2018, Alecu Russo Balti State University, Republic of Moldova

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Fig. 1. The adaptive learning sequencing creation process.

in the discovery and assembly of learning material / "content" from potentially distributed sources / repositories, assembly and contextualisation of material that is intended for an individual learner.

- *Adaptive Collaboration Support*, is intended to capture adaptive support in learning processes that involve communication between multiple persons (and, therefore, social interaction), and, potentially, collaboration towards common objectives.

Chieu proposes two more additional category to concepts in the previous categorization: adaptive assessment and adaptive problem-solving support [1]. In *adaptive assessment*, the difficulty of assessment tasks is chosen in accordance with the student's answers and his/her performance level. *Adaptive problem-solving* support suppose that adaptive learning systems can help the learner with hints in the feedback when learner needs support.

With all the benefits that it has, adaptive learning faces barriers [10]. First of all, the cost of developing adaptive learning systems is usually high, especially when teaching material must be produced to match the needs and interests of different learners.

The design of an adaptive learning system requires colossal work. Developing branched packets of content at several levels would provide multiple pedagogical approaches, which suppose an authentic adaptive learning. This is why the design of adaptive learning systems can involve ordinarily years of research.

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References

1. V. M. Chieu, Constructivist learning: An operational approach for designing adaptive learning environments supporting cognitive flexibility (Unpublished doctoral dissertation). Louvain-la-Neuve, BE: Université catholique de Louvain (2005).

2. EDUCAUSE LEARNING INITIATIVE. 7 things you should know about Adaptive Learning. Available on the web: https://library.educause.edu/~/media/files/library/2017/1/eli7140.pdf

3. A. Paramythis, S. Loidl-Reisinger, Adaptive Learning Environments and e-Learning Standards, Electronic Journal of e-Learning. vol. 2(1), pp. 181-194, (2004).

4. N. Stash, A. Cristea, P. D. Bra, Authoring of learning styles in adaptive hypermedia: problems and solutions, Proceedings of the WWW 2004 Conference, May 17-22, New York, USA, pp. 114-123, (2004).

5. J. Lee, Adaptive Courseware Using Kolb's Learning Style, International Magazine on Advances in Computer Science and Telecommunication, vol. 3, no.1, pp. 45-59, (2012).

6. D. H. Jonassen, Aptitude-versus content-treatment interactions, implication for instructional designs, Journal of Instructional Development, vol. 5, no. 4, pp. 15-27, (1982).

7. J. Lee, Development of an Adaptive Learning System Based on Task-Trait-Treatment Interaction Theory International Journal of Software Engineering and Its Applications vol. 7, no. 2, pp. 49-66, (2013).

8. S. Oxman, W. Wong. Adaptive Learning Systems Available on the web: http://www.dvxlabsincubator.com/assets/DVX_WhitePaper-Adaptive_Learning.pdf

9. P. Karampiperis, D. Sampson, Adaptive Learning Resources Sequencing in Educational Hypermedia Systems. Educational Technology & Society, 8 (4), pp. 128-147, (2005).

10. M. Sharples, A. Adams, N. Alozie, R. Ferguson, E. FitzGerald, M. Gaved, P. McAndrew, B. Means, J. Remold, B. Rienties, J. Roschelle, K. Vogt, D. Whitelock, L. Yarnall, Innovating Pedagogy 2015: Open University. Innovation Report 4. Milton Keynes: The Open University, (2015). Available on the web: http://proxima.iet.open.ac.uk/public/innovating_pedagogy_2015.pdf

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