lEARNING design for Intelligent Adaptive Learning

Valery Psyché1

1 Department of Education, TELUQ University, Montreal, Quebec, Canada

**Abstract**

Adaptive learning is the process of “building a model of the learner’s objectives, preferences and knowledge, and using it throughout his or her interaction with the environment to provide personalised feedback or to adapt content and interfaces to one’s learning needs” [1]. In a theoretical and idealistic viewpoint, the adaptation is performed in real time using algorithms (machine) that make inferences from the learner’s actions in the learning session. An example of inference is the diagnosis of their errors. The more the machine simulates the behaviour of a human tutor, the more “intelligent” it is. This is referred to as an intelligent tutor and intelligent adaptive learning. In this paper, we discuss issues involved in the process of integrating adaptive learning into the learning design and the authoring of digital learning environment.

**Keywords:** adaptive learning, learning design, intelligent tutoring system, intelligent learning environment, e-learning platform.

1. **INTRODUCTION**

**1.1 Use Case**

Ana is a teacher who offers online courses. One observation blocks her in her teaching momentum: many students are unengaged as the course progresses over time. They seem to need a personalised accompaniment that doesn't show up. Some drop out or fail. Ana would therefore like to find a pedagogical innovation that better responds to the new coaching challenges presented by the online training context. Ideally, Ana would like the training to be adapted to each student's profile, i.e. to the state of their knowledge and their behaviour throughout the training thanks to a personalised learning path. By doing research, she finds studies on adaptive learning. This teaching method appeals to her because it corresponds to her desire for pedagogical innovation. She therefore decides to take the plunge when she updates her next online course. She contacts the learning design team that usually accompanies her. At TELUQ university, an online learning university, this learning design team is composed of: learning designer, a graphic and digital media designer, a computer programmer/authoring tools expert, content expert/subject matter (usually the professor), a project manager, copyright specialist, quality assurance (QA) expert, linguist reviewer, cameraman, video editor. This team works together by relying on an ADDIE-type learning design model. ADDIE [2] is the acronym for Analysis, Design, Development, Integration and Evaluation.

After a few months, Ana releases her first online course based on the adaptive learning approach and the results are very encouraging: student performance and retention improve in the course. In addition, the professor now knows what each student profile needs in terms of learning. To conclude this case, in her process of looking for a pedagogical innovation, Ana did a Design Inquiry of Learning which means, with the help of her learning design team, she was able to: Investigate (identified a suitable pedagogical innovation); be Inspired (Reviewed literature); Ideate (conceptualise a solution); Prototype (Implement her idea in a prototype); Evaluate (QA test). Reflect (documented the process).

**1.2. Benefits of adaptive learning**

There are many reasons to adopt an adaptive learning approach:

1. Improvement of the learner’s outcomes thanks to guided and mastered learning [3] and an increase in the learner’s motivation, confident and autonomy.
2. Optimization of the learning pace. The learner does not waste time on concepts that he has already acquired.
3. Provide a learner-centrered remediation.
4. Personalization of learning with individualized pathways according to the profile of the learner, their interest, and their progression during the online course.
5. Optimization of teaching: the teacher is aware of what each learner understands or not thanks to the identification of their strengths and weaknesses.
6. Experimentation by the teacher of a pedagogical innovation in which pedagogical strategies are programmable for supporting each individual’s learning.
7. **DEFINITIONS**

Intelligent adaptive learning is a pedagogical approach where the intelligent learning environment adjusts to the needs of the learner through algorithms. This learning consists in building a model of the learner with the objectives, preferences and knowledge of each learner. Then this model is used throughout the interaction with the learner to adapt to his needs. Systems also try to be more intelligent by incorporating and performing certain activities traditionally given by a physical teacher, such as mentoring or coaching learners or diagnosing their misperceptions [1]. In summary, the fact that the content, presentation and navigation are adapted to each learner maximizes their chances of success at each stage of learning (assimilation, reinforcement and application).

Intelligent adaptive learning stems from, among other things, the work of Piaget [4] for whom intelligence is a cognitive adaptation which results in the ability of an organism to structure itself in its environment according to two interrelated processes: assimilation and accommodation, but also pioneers in the field of Intelligent Tutoring Systems (ITS) [5-7]. Since Bloom's demonstration (1984), the effectiveness of tutoring has been recognized, which has favored its implementation in ITS, in adaptive hypermedia or more generally in e-learning systems, intelligent or not.

Adaptive learning is increasingly integrated into e-learning systems. With this approach, teaching is optimized according to the pace of learning and the teaching strategy for the needs of each learner. In addition, it allows adaptive support during the progression of the tasks to be performed in order to carry out the work noted throughout the course.

Adaptive learning becomes intelligent when artificial intelligence is used to enhance the learning experience, for example by providing personalised feedback about mistakes made by the learner. It is by means of an algorithm and a machine learning technique that the learning system can perform reasoning according to the learner's data collected in real time during the online course session, added by data from the learner profile.

1. **LEARNING DESIGN AND ADAPTIVE LEARNING**

**3.1 In typical online courses**

There are many possible levels of adaptive learning depending on the human and technological resources available in an educational institution. Here are the parameters on which the teacher and the learning design team can intervene for a minimal integration in an online course:

1. First, the teacher and the learning designer create learners profiles based on previously identified learning needs and interests.
2. Then, for each established profile, they will adapt the course by creating a particular learning pathway that may include: activities and learning resources, a learning strategy based on sequencing of these activities and their feedback, a learning support strategy, and a recurrent formative evaluation strategy based on this feedback.
3. The teacher also works in close collaboration with the technical team who, in addition to designing the learning environment (the online course), will implement the auto diagnostic tools for identifying the profile of each person, the associated pathway, feedback to the learner's anticipated responses, and recurrent self-assessments. This programming will make the minimum environment necessary to adapt to learner profiles.
4. Once the course is online, the learner begins by taking an auto diagnostic test in order to be matched with a profile. If the learner thinks that the pathway is not suitable for them, they can change it. Based on their profile, a pathway is suggested to them. As the student progresses through the course, the learning objectives, the teaching strategy and the teaching content can vary according to the learner's mistakes or successes. Each time a learning objective is attained, an auto evaluation is proposed to the learner. These progressive and recurrent evaluations are indicators that are provided to the learner. This way, the learner can improve their learning results since they can understand the areas in the course that they need to improve on.

**3.2 In e-learning systems with intelligent tutors**

According to the complexity of the algorithms that are programed in the environment, it is possible to refine its adaptability thanks to the data collected about the learner in real time during their interaction with the environment. Therefore, it is possible to adjust the profile of the learner during their progression in the course using Artificial Intelligence (AI) algorithms. At this point, the learning environment can include an intelligent tutor. In this case, the selection of the pathway is done by the AI program or by the administrator of the environment and not by the learner. Generally, a combination of these are used. Therefore, using intelligent adaptive learning can take us very far with the help of intelligent tutors. An Intelligent Tutorial System (ITS) supports the resolution of specific problems, the evaluation of detailed competences, and the analysis of the steps with similar difficulties.

The intelligent tutor is a software that can be part of an e-learning system in order to make it adaptive. An example of this type of software component is an intelligent tutor for mathematics learning in which students progress by solving mathematics problems using step-by-step instruction. This software provides each student with personalised training that allows them to consolidate the concepts taught by the teacher. Teaching strategies can be implemented in the intelligent tutor. Here are a few examples: (a) providing (or not) formative feedback to the student based on his or her errors; (b) repeating problem types based on the problems missed by the student; (c) using the Intelligent Tutor with progression goals rather than time limits since students who make the most errors have many more problems to solve.

The teaching strategies put together represent the tutor model of the Intelligent Tutoring System. Similarly, the learner profile is included in the learner model, as are the typical mistakes made by the learner. The learner model can receive new data about the learner in real time, such as mistakes made during learning. All these models can be formalized in order to be manipulated by a program. Once formalized, they constitute a base of logical rules from which an artificial intelligence (AI) algorithm can deduce new rules and take actions that simulate those of a human tutor.

1. **TO GO FURTHER**

Since 2012, with the advent of Massive Online Open Course (MOOC), the domain has experienced a new boom since it provides personalised solutions to the learners thanks to Educational Big Data that gathers information from thousands of groups (profiles) of learners. Intelligent adaptive learning seems appropriate for the type of online course which offers the possibility of collecting a large amount of data throughout the training (example: success, errors, time spent). It is now possible to implement an adaptive intelligent learning inside the MOOC as a way to improve the academic performance and perseverance in learning. Finally, adaptive learning proves to be a promising approach to making learning environments more intelligent. The need to adapt the learning process will never disappear. On the contrary, it will be more and more present as MOOC developments continue and the supporting technologies follow them.

Companies have applied adaptive learning with success. This is the case of the American company Knewton and its competitors Aleks ([https://www.aleks.com](https://www.aleks.com/)) or Domoscio ([www.domoscio.com](http://www.domoscio.com/)). Knewton measured a significant improvement in learner outcomes with an increase in standardized test scores at Northeastern University and a significant drop in the dropout rate (47%) in courses at Arizona State University (Thot Cursus) (see <https://www.knewton.com/resources/blog/adaptive-learning/adaptive-learning-investment/).>

**REFERENCES**

1. P. Brusilovsky and C. Peylo, "Adaptive and intelligent web-based educational systems," International Journal of Artificial Intelligence in Education (IJAIED), vol. 13, no. 159-172, 2003.
2. R. M. Branch, Instructional design: The ADDIE approach. New York: Springer Science & Business Media, 2009.
3. B. S. Bloom, "The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring," Educational researcher, vol. 13, no. 6, pp. 4-16, 1984.
4. Piaget J., L'épistémologie génétique (Que Sais-je). Paris: PUF, 1936, p. 126.
5. D. Sleeman and J. S. Brown, Intelligent tutoring systems. Academic Press, 1982, p. 345.
6. Wenger E., Artificial intelligence and tutoring system: Computational and cognitive approaches to the communication of knowledge. Los Altos, CA, USA: Morgan Kaufmann, 1987.
7. J. R. Carbonell, "AI in CAI: An artificial-intelligence approach to computer-assisted instruction," IEEE transactions on man-machine systems, vol. 11, no. 4, pp. 190-202, 1970.