A Foray into the World of Adaptive Learning

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What do virtual reality, micro-learning, conversational robots, mobile learning and… adaptive learning have in common? They are all at the top of the list of educational technologies to watch. With advances in artificial intelligence (AI), adaptive learning could become a promising pedagogical approach in higher education. Let's take a look at its current and potential uses.

Adaptive learning applications can be found in many of the games and platforms we use. For example, if you want to learn Italian for your next trip to Tuscany, you can use the Duolingo application. As you complete the lessons and exercises, the app continuously analyzes your correct and incorrect answers. Duolingo then assembles a sequence of lessons and exercises that will target your weaknesses—for example, the gender of nouns or past participles—and optimize your language learning.

To do this, the Duolingo application has relied since 2012 on an AI system called Birdbrain, which collects a wealth of learning data from its hundreds of millions of users around the world. This data includes, among other things, correct and incorrect answers, as well as the time required to complete lessons and pass the various competency levels in Italian. By using this massive data set for machine learning, Birdbrain is able to predict the most effective learning sequence for your user profile. Your path will therefore be different from that of another person starting out in Italian at your level of competency.

Adaptive learning is a vast field of research at the intersection of education science, computer science and data science. Kaplan (2021) proposes a definition that brings all these disciplines together:

> *Adaptive learning, also known as adaptive teaching, is an educational method which uses computer algorithms as well as artificial intelligence to orchestrate the interaction with the learner and deliver customized resources and learning activities to address the unique needs of each learner.*

Nuances between adaptive learning and differentiated instruction

To better understand the nature of adaptive learning and its integration into teaching activities, we can compare it to a more common approach: differentiated instruction.

Differentiated instruction makes it possible to respond to the particular needs or interests of one or more subgroups in a class by making adaptations to the learning sequence. There are three main families of adaptations: those that affect the content to be taught (concepts, principles and procedures), the learning process (activities to be carried out) and the product (traces or evidence of learning). The latter involves, for example, giving students the choice of the presentation format (written, oral or video) that reflects the learning that has been achieved.

In essence, differentiation recognizes the uniqueness of the individual, and dispenses with the model of the "average" student that educators sometimes aim for. It also recognizes that not everyone learns in the same way or at the same pace. Differentiation promotes the learner's autonomy by offering choices that match their interests.

It's a formula that asks a lot of teachers. First and foremost, differentiation requires good observation skills to identify the needs and interests of each class group. It also requires good design skills to create and adapt activities to meet the identified needs and interests. Feedback also requires flexibility to adapt to students and guide them toward success. And anyone who uses differentiation knows that preparing one class using this approach is practically the same as preparing two or three classes!

With adaptive learning, teachers retain the same roles as content specialists and instructional designers. The big difference is that adaptive learning involves automating one or more steps in the learning sequence. Although this approach is necessarily deployed in a digital environment, it can still be integrated into a face-to-face course with certain online activities. Consider a diagnostic test to group students according to their level of competency in a language course. We could also think of making digital resources available to learners after they have completed a survey about their interests in science.

The benefits of adaptive learning

Differentiated instruction and adaptive learning help to target the same goals of preventing students from dropping out and of promoting student success. Indeed, by adapting content to take into account the needs of weaker students, we can expect teaching to better meet their needs, and encourage them to persevere in their studies. For high-achieving students, these approaches provide greater challenges that will enrich their studies.

We know that adaptive learning has positive effects on academic results thanks to Bloom and Cohen's research in the early 1980s. Bloom demonstrated the effectiveness of personalized teaching in a seminal article. He showed the power of teacher-student tutoring compared to conventional teaching (at a 30:1 ratio) and an enhanced version of conventional teaching with more formative testing. In 2010, Bourdeau

and Grandbastien published the article "La modélisation du tutorat dans les systèmes tutoriels" [Modeling tutoring in tutorial systems, Ed.], based on the work of Bloom and Cohen, among others. The researchers concluded that tutoring is a solid foundation on which to build adaptive and interactive systems. In other words, adaptive learning is intended to imitate or approximate the teacher-student tutoring that is recognized for its contribution to academic success.

According to Valéry Psyché, Professor of Educational Technology and Distance Learning at Université TÉLUQ, one of the strengths of adaptive learning is that it optimizes learning time by spending less time on concepts already assimilated and more time on consolidating knowledge and introducing new concepts. Adaptive learning always begins with a diagnostic test to determine a student's level of knowledge. Based on these results, an adaptive system will remove activities that have already been mastered from the learning sequence. In this way, we avoid revisiting concepts that have already been mastered, and which might even bore some of the students, adds Valéry Psyché.

Another advantage is that teachers or program teams working with adaptive learning have a dashboard to visualize student learning. This dashboard integrates what's called *learning data*, the same data you'd find in your gradebook. When learning takes place in a digital environment, the system can also record a wealth of data about each student, allowing us to understand their interactions with the system. For example: the time taken to complete an exercise, the number of resources

consulted, the amount of time spent engaging with audio or video files. All this data, according to Valéry Psyché, also benefits teaching staff, who can optimize their practice and their understanding of what each learner understands or doesn't understand, thanks to the identification of their strengths and weaknesses.

AI in education and its risks

It's a hot topic at the moment: the use of AI in education raises a number of issues that educational institutions and teaching teams will need to evaluate. The scientific literature often mentions those related to the opacity of AI operation, referring to the "black box" it represents. This refers to the complexity of machine learning and the difficulty of explaining the resulting decisions or predictions. In machine learning, a system manipulates a large amount of data to solve a problem by formulating a mathematical equation. This equation or algorithm is then validated and used, for example, to create a learning path for a user. However, an institution should be able to explain the choice of a learning path, without letting the system make decisions that aren't clearly understood by specialists.

We need to distinguish AI-based machine learning from symbolic AI, which is a set of rules created by humans to enable a system to make a particular decision. Imagine a decision tree with branches. Symbolic AI doesn't have the black-box problem.

Florence Sedaminou Muratet, a digital pedagogy project manager and educational engineer at Collecto, argues that perhaps the biggest risk is the transformation of the role of teaching staff brought about by AI. With adaptive learning, teachers no longer hold all the knowledge, some of which is carried by the digital learning environment. The teacher must not become an assistant to the technology deployed, but an expert in learning a subject with the help of digital tools: it's a major paradigm shift, argues Muratet. She believes that most teachers will be able to adapt, but that there is a risk for those with a transmissive view of teaching.

In addition, educational institutions will have to maintain the confidentiality of student learning data. This responsibility is even more important when private companies are involved in the services provided to institutions. These technologies should help to create an environment conducive to learning, rather than creating a climate of mistrust regarding the use of personal or learning data. This could be achieved, for example, by allowing students to choose what data to share.

We can also question the extreme personalization of learning paths, as highlighted in a UNESCO discussion paper on adaptive learning. Let's imagine that the fastest students in a group find themselves "distanced" from the slowest. In the learning process, the classroom plays a fundamental role. That's why it's vital not to over-personalize to the detriment of the group, whose learning pace should remain close (UNESCO International Bureau of Education, 2022, p. 15). In this way, it remains possible to carry out group work and have group discussions in which everyone is at the same level, or close to it.

Understandably, the integration of digital technology and AI in the classroom raises fundamental questions. The good news is that a number of research teams and publications are focusing on these issues and will be able to formulate guidelines based on best practices.
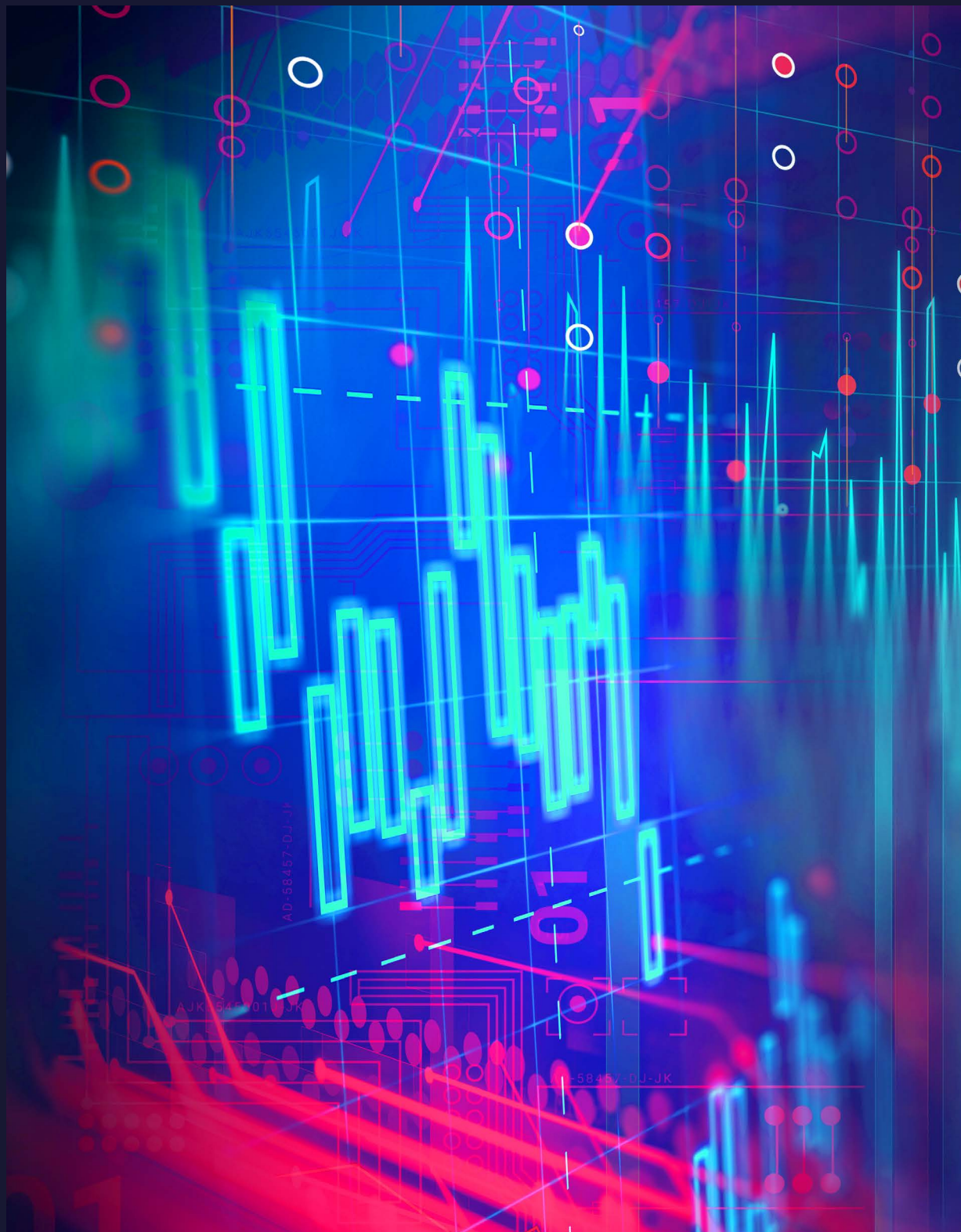
Levels of adaptive learning integration

Adaptive learning can take many forms and be integrated into different pedagogical approaches. To provide clarity, we suggest exploring three levels of integration that allow us to reflect on its use and its contribution to pedagogy.

Examples of adaptation for the three levels of integration

First level: the sequence and number of questions in an online placement test are adapted to the learner's answers as they progress.

Second level: the content and number of items of a learning sequence are adapted to the learner's needs, based on the results of a test.

Top level: content, its amount, format and layout take into account the learner's learning preferences, as determined by an AI system.

First level of integration

Adaptation can take the form of an adaptive knowledge test, where the difficulty level of the questions is automatically adjusted. If a correct answer is given, the next question is of a higher difficulty level. If an incorrect answer is given, the difficulty level is lowered by one level. In this way, the student progresses through the questionnaire, which records their progression. Finally, the tool gives the student a score, and can also provide a performance report. It's important to note that each student progresses through the questionnaire differently.

This is how the second-language placement test of the Centre collégial de développement de matériel didactique (CCDMD) works, for example. The results are continuously analyzed, allowing the test to display questions to fine-tune the assessment of the learner's skills.

Compared to a linear test, an adaptive test is more effective: it evaluates a student's language skills faster and with fewer questions. The CCDMD's second language test ranks students on a 10-level scale, using approximately 100 oral and written comprehension questions. Because the language test comprises several categories of questions, the results can be used to determine what each student can or cannot do, in order to direct them to the language course best suited to their needs.

If you're familiar with the Moodle learning environment, you can see a simple example of an adaptive quiz in the video *How to create a Moodle Adaptive Quiz*.[1] It demonstrates the whole process, from importing and labeling questions to installing the module and setting up the quiz. The mathematics example (fractions) can be applied to a variety of disciplines. Your first pedagogical challenge in creating such a quiz will be to compose a bank of multiple-choice questions with varying levels of difficulty.

Second level of integration

Adaptive learning can be integrated without completely changing your pedagogical approach and, above all, without teaching exclusively at a distance! It can be integrated into a blended learning approach that includes a variety of learning activities that can take place in the classroom (synchronous face-to-face or distance activities) or at home (asynchronous or distance activities).

The authors of the *Guide sur la personnalisation des apprentissages en formation à distance pancanadienne francophone* state that personalization consists above all in offering learners a degree of flexibility, while remaining within a certain predefined framework (Chovino and Dallaire, 2018). The authors highlight the multiple possibilities for adaptation that can have an impact not only on the content of a course, but also on the learning materials, the teaching methods, the pace of learning, as well as the support tools of the teacher.

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[1]   See the video explaining how to create an adaptive survey in Moodle [bit.ly/3PdbOPG].

Grégoire Aribaut, pedagogical counsellor at the Centre de pédagogie universitaire de l'Université de Montréal and the Moodle Centre of Excellence, explains that the Moodle learning environment can automate a number of actions. For example, it is possible to track a student's progress based on the sections and resources they have consulted, he explains. You can then unlock content or activities according to their progress. Grades obtained after a test can also be used to suggest adapted resources: students with low grades could benefit from resources (videos, exercises, quizzes, etc.) to consolidate their knowledge, while others could access other resources to deepen their knowledge. What's more, Moodle makes it possible to link several tests together: depending on the grade obtained on a first test, it is possible to direct the student to a second test, adapted to their level. Grégoire Aribaut adds an important nuance: these tests adapted to the student should only apply to formative evaluations; summative evaluations, on the other hand, should remain uniform for the group.

In 2021, Collège Sainte-Anne integrated adaptive learning into some of its classes. The project was aimed at students in Secondary 1 and 4, but regardless of the target group, the strategy chosen is of interest. In this case, the strategy is aimed at consolidating knowledge—and not specifically at learning—using the methods of knowledge recall and spacing.

With the *B12* application, students in participating courses receive multiple-choice questions on their cell phones or computers on content covered since the beginning of the year in French and science. The answers they provide allow the application to assess their level of knowledge and select the next questions that will help them activate their knowledge. In this project, AI is used to determine the topic of the questions, their level of difficulty, and when to display them.

Teachers use the learning data compiled in the dashboard to prepare students for end-of-year exams. In particular, the dashboard shows which questions were more challenging over the course of the year.

The top level

Adaptive learning in its most advanced form will adopt the model of an intelligent tutoring system (ITS), which is capable of building a learning path for a student profile. When AI and advanced algorithms are involved, it is called *intelligent* adaptive learning. In this case, teaching is fully online and asynchronous. Students progress at their own pace, completing activities and evaluations. The ITS adjusts the course along the way to guide the student toward achieving the learning objectives.

The possibilities for adaptation are vast, and not just in terms of content. For example, the system can also provide more video or visual content than audio or text-based content. The system will select the format that best supports the learner's learning. To do this, the system needs to know and model the learner, using a variety of data about them, including data extracted from diagnostic assessments and personal preferences.

Creating an adaptive learning path requires course content to take on a "granular" format. This means breaking down content (concepts, principles or procedures), learning activities, resources and evaluations into a number of small "learning nuggets." In this way, students follow a path optimized for their profile, needs and preferences.

Several companies are competing to carve out a place for themselves in this burgeoning market for products with "adaptive" features. Educational publishers already offer platforms with a wealth of ready-to-use course content and activities in various post-secondary fields of study, such as mathematics, chemistry, languages, geography, psychology, education or biology. Other companies offer their

own learning management system (LMS) that provides access to adaptive learning, but without the content. A quick review reveals that ready-to-use courses are currently targeted at English-speaking institutions, which represent a larger market than French.

An avenue for professional development

Integrating adaptive learning into your practice, at any level, requires a great deal of energy, time and planning. Perhaps the first question to ask yourself is where automation could support you. Are there repetitive tasks that could be delegated to some form of assistant? Since adaptive learning aims to meet the needs and interests of individual students, this will lead you to think about the profiles that might constitute distinct subgroups in your class.

You could also consult other members of your department to rally colleagues with similar needs to your own. Given the time and resources required to implement adaptive learning, it's best to work collaboratively.

Questions about available technologies will arise quickly. Does your school's digital environment allow for adaptive deployment? Do you have access to a pedagogical counsellor who could help you with a pilot project?

Such a project focused on digital integration will present itself as a possible professional development opportunity giving you the chance to acquire new competencies in designing online activities, interpreting data, providing feedback and generally working with AI and algorithms.

According to pedagogical counsellor Grégoire Aribaut, the first year can be a time-consuming investment, but one that can be recouped in a course with a lifespan of five years. After all, adaptive learning seeks to free up teachers' time for the most important task of all: guiding their students to success. ▬

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