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Brief

What is Machine Learning and How Does it Power Adaptive Learning?

By Pam Baker

Idea in brief

Machine learning increasingly plays an important role in next-generation, adaptive learning platforms. By applying data mining techniques to information collected during online coursework, computer software powered by a machine learning model can analyze and assess student performance, increasing the power of the tools instructors have to do their work. Combining that information with other external data about a student's GPA, academic standing and demographics, software engineers are now able to produce a predictive model that provides a more nuanced assessment of student learning.

The term "machine learning" intrigues business and other institutional leaders today because the technology drives a wide range of new applications. Many kinds of new software, some still on the horizon and some familiar from daily use, are powered by machine learning algorithms that not only recognize patterns but adjust their own activity based on those patterns. New and emerging technologies that depend on machine learning include automated investing and other financial services, personalized pharmaceutical development, the speech recognition used in customer service applications, book digitization projects using optical character recognition, and the news feeds you see on most popular websites.

Given how powerful machine learning can be for innovation and improvement in domains such as health care, publishing, retail, and finance, it shouldn't be any surprise to find that machine learning is also producing exciting advances in education.

What is machine learning?

According to Dr. Benny Johnson, director of research and development at Acrobatiq, machine learning involves algorithms that can learn from and make predictions based on data, using models of the underlying processes that give rise to the data. It starts by gathering large sets of data and then extracting actionable information.

With machine learning, computers can "learn" without being programmed to perform specific tasks. Using an analytical model, they are able to adapt independently as they are exposed to new data. The models are trained by giving them example inputs and their desired outputs.

Take, for example, the call you sometimes get from your credit card company asking you to confirm a recent purchase. An advanced version of this fraud detection software is not just following explicit instructions to treat certain purchases as suspicious. It is also learning from every purchase and fine-tuning its own instructions over time so that it gets better at fraud detection. In the first case, the program might be told from the beginning to flag every purchase from certain countries. In a later case, the program might figure out on its own over time, without a programmer ever entering those instructions, that two purchases in the same day from gas stations in the consumer's ZIP code is unusual.

The goal of machine learning in these contexts is to have the software learn a general rule that maps inputs to outputs. The computer can then look at streams of data and analyze activities or the behaviors of users. The computer learns patterns in data and then predicts similar patterns in new data. Through an iterative process, machine learning allows computers to find hidden insights and produce reliable, repeatable decisions, predictions, and results.

Johnson explains that "machine learning programs get better with experience. Given more observations from which to 'learn,' their predictions get better." That's exciting news for the world of education and what machine learning can do to support instructors and students in higher education. Machine learning can extend the ability to deliver personalized practice and feedback to help students succeed.

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How does machine learning power adaptive learning?

According to Johnson, Acrobatiq's approach uses a statistical model developed at Carnegie Mellon's Open Learning Initiative (OLI), which harnesses the Power Law of Learning to understand how a student learns.

The Power Law of Learning is a mathematical formulation of a well-known concept that learning a new topic or skill does not happen at a constant rate. When a student begins work on a new subject or skill, they typically make rapid gains at first. But, as more proficiency is acquired, greater amounts of practice are necessary to keep making gains. The model can use several parameters, such as the student's current learning ability, how fast they are learning, and where they are struggling.

With machine learning, through an iterative process the model is able to independently adapt as it is exposed to more and more data. The learning experience subsequently adapts to the student's evolving needs. For example, it will spend more time on a topic that the student appears not to comprehend yet. Student progress on key learning outcomes is then displayed in real time through a dashboard.

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Why is machine learning important to higher education?

Universities and colleges today, particularly in the United States, are facing major challenges in course and degree completion rates, as well as overall retention. The *Journal of Learning Analytics* article, Early Alert of Academically At-Risk Students: An Open Source Analytics Initiative, reports that only 36 percent of students starting bachelor's degree programs complete them within four years. Consequently, the United States now ranks 12th globally in the percentage of 25- to 34-year-olds with an associate's degree or higher.

With machine learning, data mining, and analytics technologies, higher education has new tools to help address the challenge of improving degree productivity. As more higher education institutions begin to integrate online adaptive learning into traditional lecture-based courses, the benefits to students and instructors multiply, and those colleges and universities can chip away at dismal completion and retention rates.

While a course using adaptive learning may appear on the surface like any other online course, below the surface it is capturing a rich stream of data about each student's progress and comprehension. Acrobatiq, for example, uses machine learning techniques to make a real-time estimate of student learning for each student against every learning outcome. The benefit of this approach is that instructional content can be adapted to each student's demonstrated learning proficiency, tailoring the experience to their unique needs.

In addition to making predictive estimates about student learning, machine learning technology is also showing promise to educators and students in the following ways:

- *Comprehension increases and retention improves.* Students report getting more out of the lecture experience when traditional coursework is integrated with online adaptive learning. Sitting in a passive lecture does not teach students as much as when they read the coursework online, then answer a few questions on each page to test their comprehension of the subject. Machine learning transforms that process into a responsive, adapted experience for the student. Numerous studies demonstrate the effectiveness of adaptive learning. For example, the study "Interactive Learning Online at Public Universities: Evidence from Randomized Trials" from Ithaka S+R found comparable learning outcomes between traditional and hybrid courses with the potential for cost savings and productivity gains over time.
- *Instructors can use data to improve their course.* When student activity data is collected and analyzed in real time by the machine learning model, new and sometimes surprising insights emerge. For example, was there a set of questions that everyone failed? Did the course have particular sections in which the majority of the class needed additional help or reinforcement? The instructor can review the results of online work and identify areas where the majority of students had trouble. It then becomes easy to target which pages or chapters in the coursework need to be rewritten.
- *Instructors can identify students who are struggling academically.* Machine learning software applies data mining techniques to assess student performance. Because machine learning can discover and display patterns buried in data, instructors are more easily able to identify students who are doing poorly. With access to the data captured by online coursework, professors can review a student's comprehension rate and identify specific areas wherein they may need help — without waiting for exams to reveal problems.
- *Students can get additional help when they need it.* Imagine if every student could go home with a one-on-one tutor. Johnson points out that "one of the goals of Acrobatiq is to help every student be able to achieve academically. " If the machine learning model can detect where a student is struggling — for

example, through a pattern of failed comprehension questions — it can adjust the presentation of the material or even provide tailored online help while he or she is studying. What's more, the highly nuanced overview of where students are struggling enables more impactful interventions like customized tutoring sessions. At a more practical level, the student doesn't have to wait until the next class to ask questions.

- *Universities and colleges can deliver instruction more economically.* Using blended learning strategies, instructors can conduct classes from large lecture classrooms but still reach students on an individual basis through adaptive learning tools. By moving the foundational learning activities online and using face-to-face meeting time for higher-level learning activities like group work, universities can offer students the best of both worlds: effective online learning along with high-impact face-to-face learning.

New in higher education: automated early alerts about at-risk students

In addition to personalizing the learning experience for students, one very exciting development beginning to emerge is automated systems that give early alerts about at-risk students. How do machine learning and data mining move us closer to improving retention and completion rates in higher education? With machine learning we can now analyze the data captured online, discover meaningful patterns, and make predictions about the student's likelihood of success.

Data for a student's performance is already captured by the software. An instructor can identify where a student is struggling, how fast they are learning, what their comprehension rate is, and how much time they are spending online. By integrating external data about a student's GPA, academic standing, demographic, and aptitude, Acrobatiq can make an accurate prediction about whether a student is at risk of withdrawing or failing the first exam.

Some institutions are hoping technology can impact the "D/F/W problem," whereby large-enrollment courses have very high numbers of D and F grades and withdrawals. With this predictive analysis, the instructor now has the ability to intervene earlier and help each student receive additional help to achieve a better outcome. An email from an instructor indicating a student's performance is poor creates a situation in which the student is more likely to respond and address it directly with the instructor.

How can universities and colleges better embrace machine learning?

To maximize the benefits of machine learning, higher education institutions will need the ability to integrate data from their computer systems with data from the adaptive learning platform. To supplement the technology that improves outcomes for students, higher education institutions should also revisit their strategy for supporting students by:

- Identifying resources available to students — such as tutors, academic advising services, and writing labs — and promoting those services.
- Promoting discussion forums and other areas for peer-to-peer engagement.
- Promoting increased faculty-student interaction by asking students to visit during office hours and encouraging contact through email.

And finally, Johnson says, "It's a hard problem to make these products usable. It's incumbent upon companies developing adaptive learning and predictive analytic technology to make sure the product is designed to be easy to use."

Johnson sees that as the biggest challenge for universities and colleges that have not kept their IT systems up to date. That may mean an investment in the institution's IT infrastructure, and planning should start now.

The learning experience adapts to the student's evolving needs — for example, spending more time on a topic that the student appears not to comprehend yet.

In fact, incoming freshman classes will soon begin to expect personalized learning experiences. As Tom Vander Ark, a thought leader in education technology for K-12, recently told Acrobatiq in an interview, "Children in even the earliest grades are getting individualized skill building that prepares them to engage in project-based learning. In higher education, young people are going to expect a much higher percentage of their learning to be at their learning level, in their best learning modality, and in a high-engagement pedagogy and high-engagement environment."

In an environment with limited resources, it will be difficult to achieve that level of personalization without machine learning tools. Fortunately, getting there doesn't require an all-or-nothing calculation. Educators and instructional design teams can take a crawl-walk-run approach to implementing personalized learning by first assigning technology-enabled learning tools such as adaptive courseware to students, and then phasing in the use of learning dashboards and data.

As machine learning technology becomes mainstream in education, faculty and other educators will find that it extends their ability to focus on and personalize learning for each individual student.

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About us

Backed by Carnegie Mellon University (CMU), Acrobatiq is a learning optimization company building on CMU's strengths in cognitive and learning science, and applied research in technology-enabled learning from CMU's pioneering Open Learning Initiative.

Our enterprise platform, fast-start content library and services enable institutions to rapidly author, deliver, evaluate, and continuously improve outcomes-based learning experiences that adapt to the needs of each learner. Insights generated from student learning data provide educators and student support teams with detailed information about which learners need help and with what, leading to improved student engagement and academic achievement.

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For more information on how Acrobatiq personalizes learning for students, or to request a meeting with an Acrobatiq representative, please visit us online at www.acrobatiq.com

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