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Grand challenges in digital education

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Our goal as education researchers is to make a difference. We want to help students learn better, or perhaps we want them to learn just as well but at lower cost to our institutions. Decades of research tell us that it is difficult to make a significant difference with technology. This is especially true if we are trying to do the same things. The true value of new technology comes when it permits us to do something new.

Education researchers are blessed to be working at a time when the computer is just starting to fulfill its promise as an agent of change. The key is that the computer allows for flexibility that no previous educational technology could match. While one might argue that none of the affordances provided by a computer are truly "new," the results are stunning. A few examples:

- While students have always been given practice exercises, their value has traditionally been limited by the ability of the instructor to give meaningful feedback. When the computer is able to give the feedback, then students can practice as much as they want, such as when K12 math students practice math exercises at the Khan Academy website (http://khanacademy.org).
- While teachers have always guided students, and while individual tutoring is the gold standard, the fact is that we often do not have the resources available to give every student the ideal amount of individual tutoring. But if the computer can properly interpret a student's progress and problems, and respond appropriately, then every student can get the benefits of individual tutoring.
- Massive Online Open Courses (MOOCs) allow many more students to have access to high-quality instruction than ever before (if we can only figure out how best to take advantage of the opportunity).

A useful principle for making progress is that, we do not know how to automate everything with computing. But this does not mean that there is no value to automating what we can. In particular, if we can automate certain aspects of education, then the teacher can focus his or her time on those parts that cannot be automated. In practice, these often turn out to be the most intellectually challenging parts.

The purpose of this article is to list some grand challenges in digital education, as I see them. So, here is my list of important topic areas for digital education research today and into the near future.

1. Develop and promote *theoretical underpinnings* for the work. There exist good underpinnings for courseware, such as cognitive theory of multimedia (Mayer, 2008). For general pedagogy, there are traditional underpinnings such as constructivist theory. But what theoretical guidance do we give for how to design a MOOC? We have a long way to go on this.
2. *Evaluation* is fundamental to everything that we do. Our goal is to make a difference. We have to evaluate to know if we did make a difference.
3. *Automated assessment* is crucial to improving many aspects of education. In particular, the MOOC is now becoming an integral part of education for many. The weakest part of MOOCs in my opinion is the ability to give good exercises. Automating the assessment of a rich set of new exercise types can have a profound impact on the quality of the overall MOOC experience.
4. *Intelligent tutoring* follows automated assessment, providing the possibility of personalized feedback and guidance in the learning process.
5. *Tacit knowledge*, such as knowing "how to do" something is intrinsically hard to learn. Can we use the power of computerized instruction and intelligent tutoring to improve the teaching of topics that are more about understanding or performing than about knowing?
6. *Data analytics* allow for unprecedented ability to understand how students actually learn, and how to guide individual students. How do we make the most of this?
7. *Online education*: MOOCs have made headlines recently, but now we need to see how they will really impact education. There are many aspects to this fast-evolving technology. For example:

- Can MOOC content move beyond what is essentially a model based on video-taped lectures? What is a better metaphor for delivering online content at scale?
- What is the relationship between MOOCs and courseware? Is it the same as the relationship between traditional lecture and textbook? Or will the "lecture" and the "textbook" merge to form a more integrated experience?
- What is the right balance between synchronous (where students can collaborate) and asynchronous (where students can do work on their own schedule)?
- How do we solve the most pressing policy issue of online courses at scale: how to assess and award college credit and degrees?

To me, the most exciting aspect of digital education is the fact that no one discipline can provide all the answers that we need. Digital education is an interdisciplinary field, and so the greatest progress will come from integrated teams that include experts in the subject being taught, working closely with experts in education and experts in technology. It is my hope that Frontiers in ICT: digital education can encourage such interdisciplinary work. We all have much to learn from each other.

REFERENCE

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