Texas Education Review

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Smita Bakshi, MBA, PhD
CEO and Co-founder, Zyante

Volume 1, pp. 95-103 (2013)
Available online at www.txedrev.org

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"Learn by Doing" with the Modern Textbook

Smita Bakshi, MBA, PhD
CEO and Co-founder, Zyante

I clearly recollect my *Circuits and Systems* class in a freshman class of 45 students, where every 3rd period was a time for the professor to walk amongst us as we solved problems and raised our hands for help. Learning happens by doing, and we had an opportunity to do just that with the help of our professor.

Now that's pretty valuable use of class time.

A lot of the deep learning and mastery took place outside of the classroom, in labs and semester-long projects, through weekly assignments, and with the help of teaching assistants, instructors and fellow students. We relied upon a textbook and hand-written notes taken during lecture. Even though there were no chat rooms and discussion forums, help was readily available. Departments were more intimate, ratios were smaller, and cohorts were tightly knit.

As for student assessment, it was often done continuously throughout the semester via short quizzes, measuring participation in class, and performance on homework, midterms and finals. The usual. Perhaps what was most different was we knew where we stood in class at all times, as did the professor. Feedback was quick, frequent, and easily obtainable. Many professors cared enough and had the bandwidth to offer customized help to the bottom 15% of the class.

Fast forward to today. The push for "college for all," while certainly reflecting an important societal norm, has overwhelmed the capacity of the traditional university models. Ratios in many lower-division undergraduate classes can be at

1:300 or worse. Class-time has primarily become a one-sided lecture with little-to-no-interaction.

Inefficiency has crept in. Students walk across campus, attend a 50-minute 300-person lecture, finding it really hard to stay engaged. So, they take out their favorite device to browse or text, and walk away with a list of reading material, homework problems, and a sense of being overwhelmed. There are of course exceptions, but the scenario above seems to be the growing norm.

Pretty ineffective use of 50 minutes – both for the student and the instructor.

In terms of assimilation and learning, these almost always take place outside the classroom – sometimes in discussion sections with a teaching assistant, but most often alone in a dorm room, library or favorite café. The learning material has also changed. Though there is a recommended textbook, many students don't buy the book because of its cost, and because there are an overwhelming number of often disjointed resources to use.

Recently I asked my nephew, a freshman at UC Berkeley, what resources he uses for his classes. His response surprised me: course material such as a syllabus, problem sets, and lecture slides; class announcements on *bSpace*, a learning management system; lecture notes in his notebook, his textbook; an online homework system; and topic-specific online resources that he finds on Google. He can have 5 different logins for these systems. Lots of overlap, lots of weeding through material, all of this requiring lots of time.

Though education is rife with problems of high cost, low outcomes and retention rates, it is also in a revolutionary period. Incredible innovation is underway in almost every facet of K-12 and higher education, including learning materials that are adaptive to the student, free online courses from Ivy League

professors, auto-graded homework systems, social platforms for teachers, students and parents to communicate, and so on.

What interests me most about this technology is its power to transform the very core of learning at a basic, micro, individual level. These technologies and web-based services can remove inefficiencies, automate mundane tasks, reduce costs, provide each student with a customized learning experience, improve outcomes, and much more.

This technology also has the power to provide that 1:45 type of experience even with ratios of 1:1000. Technology enables scale. And everything is in place to make that scaling possible – low-cost robust cloud services, ubiquitous wireless, HTML5 and the prevalence of tablets and other devices.

Just within the past year, this technology has shown promise to once again bring value back into the face-time an instructor has with his students. Think *flipped-class*, a term you've probably heard before. The idea is simple. Provide students with interactive learning material and require them to read, assimilate and prepare *before* class. Then, use class-time for delving deeper into concepts and problems that the students struggled with the most.

The central piece of technology required for this model to work lies within the learning material itself. It needs to be phenomenal. Always relevant. Easy to use. Fun. Interactive. Measurable.

It is the **modern textbook**: *content, tools and services built specifically for the Web and, when woven together, they form a customizable, integrated learning environment.* It needs to excel along every dimension, cater to every student, instructor, discipline and social, cultural or economic context. A one-size-fits-all approach is no longer effective, and when human 1-on-1 interactions are not possible, technology has the potential to

personalize and optimize the learning path for each and every student.

Let's examine our ideal modern textbook in some depth.

First, it should be pedagogically sound and outcomes-based. In practical terms, that means it needs to be data-driven and intrinsically modular, malleable, and customizable. All student and instructor activity should be logged and analyzed to address questions on performance, outcomes and efficacy, as well as to provide metrics to the modern textbook authoring teams on what's working and what needs to be addressed in a future revision. As the field of big data analytics advances, so too would the relevance of the feedback and metrics regarding learning activity.

Next, it should be interactive and engaging, using a variety of "web-native" methods to illustrate concepts: animations, interactive tools, short video clips, games, topic-specific simulators and more – anything to enable students to "learn by doing." This level of interactivity is particularly well-suited to science, engineering, and math, but also applies to analytical and qualitative topics within other disciplines like economics, medicine, business, and psychology.

The textbook would allow for students to assess themselves with frequent embedded questions and receive immediate feedback. The material could also be adaptive to the student's learning ability and style – smart algorithms working on large banks of configurable examples, animations and problem sets could personalize learning pathways for individual students based on a large set of markers such as a student's personality, preferences, cultural context and usage data.

Homework and quizzes could be provided within context and could be graded automatically using discipline-specific tools and proctoring technology. Help could be available when a

student needs it, either from peers, online tutors, or sophisticated technology that could pinpoint the precise point of confusion. The learning platform would be integrated with social networks, not merely to enable chat sessions, but also to enable innovative group-based activities.

Further, the modern, integrative textbook should be easily customizable. Instructors could select specific examples and problem sets, teach material in any order, interweave it with pre-lecture videos and adapt it for any length of class. The modern textbook never has to get stale; it can be continually updated, refined, and re-released. And perhaps best of all, the modern textbook could be a gateway to collect data on usage and learning.

Though this may sound obvious, it's worth calling out: the modern textbook should be *web-based*, readily accessible on any device, yet available offline to support the millions of students who don't have ready access to the internet at home.

Sounds impossible to achieve? Not quite. The education technology industry has already made headway in two critical areas: content and platforms. They have individual strengths today, but when integrated they will give rise to my vision of the modern textbook.

Content and Online Courses

Several years ago, traditional textbooks transitioned to online formats, first to PDF and then to web-based formats where students can highlight, take and share notes. Though visually appealing, these eBooks do not really change the learning or teaching experience. eBook providers include the traditional publishers – *Pearson*, *McGraw Hill*, *Cengage* – and newer players like *Chegg, Kno* and *Inkling,* who enhanc traditional textbook offerings by inserting questions into the material,

creating interactive figures, and providing reading tools such as underlining, word look-up, searching and voice over. This is probably the most that one can do with content written for a paper-based medium.

The truly "modern textbook" needs web-native animated interactive content. If a picture is worth a 1000 words, then an animation, video clip, or other interactive tool is worth 10,000. And yes, it is possible to replace 2 pages of text with one interactive tool that more intuitively explains the concept.

Let's look at a few examples. In the first, students are provided with a simple tool that allows them to click on a series of buttons and toggle between the values of '0' and '1'. These series of numbers represents a binary number, and changing the values of each of the digits, changes the value of the binary number. To develop an understanding of this concept, the tool provides the decimal equivalent along side. In a typical textbook, a binary number is explained in 2-3 pages. In the modern textbook, it requires a short paragraph and this tool.

[To interact with this tool, visit txedrev.org/"Learning by Doing"]

Consider another example from Computer Science. Before teaching complex algorithms to sort a series of numbers in ascending or descending numbers, students are provided with a tool that allows them to play around with swapping numbers and to develop and intuitive understanding of what constitutes a sorting algorithm. Try using this tool below to sort the numbers. And then click on the animations below that to see how different sorting algorithms work.

[To interact with this tool, visit txedrev.org/"Learning by Doing"]

Web-native content and tools have traditionally been one-off university projects, but now new companies like *Zyante* and *Flatworld Knowledge* are bringing these technologies to market. *Zyante* focuses on STEM – science, technology, engineering and math courses and provides a highly interactive and customizable textbook rich with animations, games, interactive tools, embedded coding environments and embedded question sets. Other companies like Flatworld Knowledge develop new web-native content with a focus on the social sciences. Since the content is web-native, student activity data can be recorded, analyzed and used in meaningful ways to improve the quality of instruction in the classroom and the quality of the material itself.

Online courses can also be used to supplement and to flip traditional classes. 2012 saw the rise of the *Massive Open Online Course* or MOOC from companies such as Coursera, Udacity and edX. These predominantly video-based courses have been used by individual students to learn, and more recently by a few universities to flip the class.

Platforms – Analytics, Authoring, Social

Another significant group of players are platform providers. *Knewton* offers a platform for adaptive, customized learning. *Gooru Learning* provides a search engine built on a tagged catalog of millions of learning resources from sites with educational content such as Khan Academy, National Geographic and others. It also focuses on data analytics to determine the factors that lead to positive learning outcomes. *Inkling Habitat* provides a platform for authoring collaborative HTML5 content that's beautiful to visualize. *2U* provides a platform for offering full online classes. *Piazza* brings together professors and students in a discussion and Q&A forum, providing an efficient way for

students to post questions and get quick responses from fellow students or instructors. *Edmodo* provides a way for K-12 students and teachers to communicate, collaborate, post homework, and so on. *TopHat Monocle* provides a tool for professors to poll and survey their students in real-time.

My intention is not to provide a laundry list of EdTech companies, but rather to point out that education is ripe with innovative technologies - many of which are being used to address point-specific needs for specific communities and disciplines. One particularly exciting thought is how these technologies will evolve and undoubtedly merge to realize solutions that collectively provide benefits even greater than the individual sums. For instance, Zyante's technology is best served with a strong analytics engine that also customizes the material – like what GooruLearning and Knewton provide. Similarly, Piazza and TopHat Monocle are complementary, with both providing better ways for students and professors to communicate and share course-relevant information.

A decade from now, university education will undoubtedly be different - very different -from what we are used to today. There will be a variety of ways in which students will learn, and technology will continue to play a critical role in improving learning outcomes while keeping cost at bay. Which specific technologies will be in use ten years down the line? It's hard to say. But I do know that so long as we keep interactive, innovative learning as our primary focus, and we keep innovating, experimenting, measuring, failing and getting back again the future of education is bright.

Smita Bakshi is the CEO, co-founder of Zyante, a new kind of publishing company dedicated to creating interactive animated material primarily for the challenging lower-division university courses in STEM (science, technology, engineering, and math) subjects. Prior to this she was a professor at UC Davis and has also spent over 10 years in the software industry across a variety of engineering and business roles. Bakshi has a PhD in Computer Science from UC Irvine and an MBA from Harvard Business School.