Reconsidering the Textbook

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workshop summary for use in preparing dissemination materials

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More than 50 leading scientists, educators, and technology professionals "Reconsidered the Textbook" during an intensive three-day workshop at the National Academy of Sciences in Washington, DC. Through small and large group discussions, the assembled group examined the current state of the textbook and its relationship to the growing number of electronic tools that also serve as learning resources for today's student. Together, the participants looked forward and, based on their knowledge of student learning, technology, and effective educational strategies, imagined the textbook of the future.

What's the Problem?

For decades, the printed textbook has been the means by which factual knowledge is both organized and distributed to students in the STEM (science, technology, engineering, and mathematics) disciplines. Textbooks serve to gather and bound an established body of knowledge; they function both as a mechanism for initial learning and as a reference for the future. The peer-review process vets information in texts (a good thing in most cases) while the time lag from writing to publication tends to date material in rapidly evolving fields (a drawback).

In the past decade, dramatic changes in technology have changed the relationship between students and information. The world-wide-web and search engines such as *Google* put information at student fingertips. No longer is information itself power; rather, power is gained from the ability to access the right information quickly. Advances in computing and the rapid decline in the price of computers have placed laptops in the hands of many students as they come to class; others carry increasingly powerful cellular-phones, palm pilots, and blackberries, portable computing platforms in their own right. Electronic media are a commonplace and comfortable part of academic life for most of today's higher-education students. How then does a 1200-page introductory science textbook fit into the cultural and learning environment of today's student?

Furthermore, textbooks, and their prescribed and encyclopedic style of presentation would appear to stand in contrast to advances in pedagogy strongly supported by educational research. Pertinent questions abound. How does one reconcile "just in time teaching" or inquiry-catalyzed instruction with assignments in a textbook to be read before coming to class? What are the best practices for integrating current texts with modern pedagogical approaches to create a learning environment that is effective for as many students as possible? Can a new generation of textbooks be written to encourage active, student-centered learning while at the same time supporting new faculty to use best teaching practices as they enter the profession?

With the explosion of digital technology in our students' lives and the increasing awareness among STEM faculty that established teaching techniques are becoming less effective for this generation of students, the time is ripe to reconsider the textbook. Will there be textbooks in the future? If so, what will they look like, who will create them, and how will they best serve our students?

Our Goals

The workshop had three inter-related goals:

1. We sought to understand the current alignment or misalignment of textbooks, other learning resources, and inquiry-based Science, Technology, Engineering, and Math (STEM) education.
2. We envisioned the future, imagining what the most effective mix of learning resources might look like.
3. We planned how to disseminate this knowledge and vision to the rest of the scientific community in order to catalyze meaningful change.

What did we learn?

After three days of extensive discussion by experts in a variety of different fields, we concluded that textbooks are not dead but their appearance and roles are changing fast.

The current state of the textbook -- Textbooks function as authoritative sources around which many courses are organized. They present the consensus overview of a field and are vetted by peer-review, assets that set them apart from many other learning resources. However, information in the printed textbook is not easily accessible to the non-expert. Only the index and table of contents sort the textbook and for the learner who does not know the structure of the field or its specific vocabulary, such sorting is likely of limited use. Not only is the information in textbooks tough to find but recent advances or findings cannot quickly be incorporated in a revision cycle than spans several years; thus, the perceived relevancy of the printed textbook is diminished. Today's science texts are often adorned with CDs providing auxiliary materials or linked to web sites containing more up-to-date information or problem sets for the student. We see these additions as the first steps down the road mapped out below.

Imagining the future – The textbook of the future will be more than a static printed volume. It will function as a guide, interweaving and coordinating a variety of different learning resources including animations, simulations, and interactive exercises. Such a package of resources will be easily searchable and thus learner-accessible with a flexible electronic interface. The textbook, whether printed or electronic, will be the organizing hub of an integrated learning environment where the student experience is key. The goal here is to retain the core stability and authority that make the textbook so valuable while at the same time providing the flexibility, timeliness, and inquiry-focused approach that the web and other electronic resources provide.

Because of this integration between printed and electronic media, the textbook will become increasingly adaptable, customizable, and responsive. It will also be far slimmer than today's encyclopedic texts. Modularity, the ability to build a textbook that specifically fits the goals and content of each course, is the ideal. Such a text could be customized to provide a place-based learning environment for location-sensitive fields such as geology, biology, and engineering while at the same time ensuring that the learner is exposed to the most important tenets of the discipline. The ideal text would not only be customizable by content but also by level, allowing individual students to learn more deeply by accessing increasingly advanced material if they were so interested. As a guide, the textbook of the future and all its component parts, should help students make connections among a variety of ideas and concepts, all the while encouraging higher-level thinking.

Creating learner engagement is key to learning. An adaptable, hybrid textbook will likely increase such engagement. Adaptability and linkage to a variety of other learning resources will provide increased access and relevancy for students from different cultures as well as those having different preferred learning styles. Place-based curricula will allow learners to understand otherwise abstract material in a meaningful context. Intelligent software that responds interactively to student progress will guide the learner based on past successes, failures, and interests. Clearly, a content management system will be integral to the textbook of the future.

Getting from here to there -- Creating the textbook of the future will be a collaborative effort involving not only faculty but also experts in learning and technology. The social organization used in the creation of successful, well-integrated learning materials will be complex. Despite this challenge, the real hurdle will likely be convincing teachers to accept rather than marginalize these new ideas and materials. Indeed, the textbook in whatever form is only part of the equation for positive change; faculty and student acceptance of any new learning paradigm is critical. Here, there is a great need and many opportunities for rigorous assessment. Indeed, such objective evaluation is critical to add value and to encourage adoption. For such a major change in textbook structure to move forward, it must be grounded in evidence demonstrating that it represents a step forward from existing texts.

What might happen along the way -- It's not clear how we get from here to there. Questions abound including who will create the textbooks of the future, how will they be accessed, and what is the business model for their creation and maintenance? The existing paradigm of textbook creation has strong economic incentives both for the faculty author and for the publishing firm but what happens if future texts are created by faculty, essentially publisher-free publishing. Could a wholly new model, the unforeseen disruptive technology, evolve along the lines of Wikipedia? If so, what are the incentives for contributors, who will create content, and how will intellectual property rights evolve? Clearly, sustainability of any future endeavor is key. Without private sector involvement it's not clear what resources will support the development, production, and revision of learning tools. Could it be that that the democratization provided by the web will allow consumers, both faculty and students, to evaluate textbooks and provide informative commentary? Perhaps a community feedback system, such as that provided by Amazon and others will evolve thus allowing for more informed selection of learning resources.

Some broader and unanticipated impacts – We suspect that the textbook of the future will be an unanticipated but critical and major agent of change. Subtly, but dramatically, the adaptable, flexible textbook will shift the way in which higher education is accomplished. We see the new textbook as an important part of the shift from faculty-directed to student-centered learning. The creation of this new textbook, enabled by technological advances and societal responses, could well be the "painless pathway" to an educational system where each student chooses how they will learn. In the end, we envision a system of learning resources that is responsive to student needs and adaptable to different learning styles, a system where students increasingly control the use of their texts. Adaptable textbooks, catering to different learning styles and intensities, could dramatically broaden the audience for both formal and informal science education by making learning far more inviting for distance, independent, and out-of-field learners.

Catalytic Speakers

Nine speakers catalyzed the breakout group discussion with short (mostly 15 minute) presentations. Each presentation introduced a variety of technologies and considered their impact on the textbook and student learning.

Diane Ebert-May (Michigan State University) led off the workshop with an extended keynote address that engaged the workshop participants and got them moving around the room in an exercise modeling the student-centered learning environment. She emphasized the importance of backwards design where learning resources, such as textbooks, are designed to meet specific pre-established learning goals.

Tanya Atwater (University of California, Santa Barbara) highlighted the importance of animations for understanding complex spatial and temporal phenomena. While viewing animations is not the invention of knowledge, Atwater argued that people are innately drawn to moving things (sometime long ago we needed to avoid moving things with big teeth) and thus there is significant student engagement when animations are used to convey understanding of complex, time-dependent phenomena.

Thomas Banchoff (Brown University) documented the growing importance over time of the student-centered learning environment and along with it the growing size of textbooks as they have become increasingly encyclopedic and expensive. Banchoff illustrated the power of students learning from students in the on-line environment as well as outlining desirable qualities of future texts including: non-linearity, modularity, customizability and spirality, the ability to come back to the same material at a higher level.

Elliot Soloway (University of Michigan) suggested that big changes in computing are just around the corner and that most people and companies don't have a clue what's coming next. Soloway views hand-held computers as the next seriously disruptive technology, one that because of its power, ruggedness, and low total cost of ownership can allow a dramatic improvement in the ratio of computers to students, a ratio that has barely improved at the K-12 level over the past decade.

Cathleen Norris (University of North Texas) contrasted static vs. dynamic learning resources; in particular, she argued that students learn when they create animations on their own. These animations are student-centered and function as personal interviews, allowing teachers and assessors the ability to see what students are thinking. Critical to widespread adoption of this technique is the ready availability and low cost of hand-held computing platforms.

Kurt Squires (University of Wisconsin) demonstrated that educational gaming engages students and allows them to learn experientially in contrast to a standard classroom model, which is centered on the direct transfer of knowledge from faculty or textbook to student. Squires argued that games catalyze student engagement because we live in an interactive age where simulation technologies are commonplace. Games, and their ideological worlds, not only allow students to evaluate information and see science as a socially involved activity, they are also learning resources that embed reflection, a key part of learning.

Marcia Kuszmaul (Microsoft) chronicled the evolution of reading from single volumes, to the printing press, to the digital age. She suggested that we are beginning to see products for which the screen is not a stepping stone before printing but rather, the entire design process is focused on producing content that may never be printed. In such an all-electronic world, information will flow flawlessly across platforms after a single development effort while flexible authoring tools will allow for non-linear, branching textbooks. The pieces are all falling into place for this sea-change with the growing ubiquity of broad-band internet and the development of portable, low-cost computing devices. The question remains, what does it mean when publishers and faculty can't control which content is being accessed and in what sequence?

Daniel Clancy (Google) envisioned the future where every book is on-line and accessible 24/7 through a true digital library. When this happens, the purpose of the textbook will change. Textbooks will become catalysts for linkage where connections to original documents are made through well-crafted summaries. Clancy argued that people expect everything will be on-line and that they will take the source that is easiest to get; as more and more hard-copy books are relegated to high density, inaccessible storage, the task of digitizing these books becomes ever more pressing. While the copyright issues are still debated, Clancy's view is that authors' biggest problem is not piracy but obscurity.

Angelica Stacy (University of California, Berkeley) argued that the textbook of the future needs to be a student-centered and student-tested guide to the field of study. Information, particularly main ideas, needs to be easily accessible, since most students use the textbook strategically to find specific information. To meet student needs, the textbook must highlight big ideas in the field, address common areas of confusion, and have meaningful illustrations and animations that help students understand process. Different representations of specific processes must be well integrated and consilient.

Attendees: Fifty-four professionals attended the workshop. At the core of the workshop were seven NSF Director's Distinguished Teaching Scholars, the highest award bestowed by the NSF to faculty for excellence in both teaching and research in STEM fields, or for excellence in educational research related to these disciplines. The DTS cohort was joined by five NSF CAREER awardees, faculty who had received the Foundation's most prestigious award for early career-development activities that most effectively integrate research and education. There were private-sector participants including representatives from Google, Microsoft, Science Education Solutions, Key Curriculum Press, and CAST. Over a third of the attendees were Program Officers or Einstein Fellows associated with the National Science Foundation. Together, this diverse group represented many disciplines including Engineering, Earth Science, Education, Math, Computer Science, Biosciences, Physics, Chemistry, Astronomy, Astrophysics, and Technology.

Next steps: During the concluding morning of the workshop, the attendees worked both together and in small groups to brainstorm, plan, and assign responsibility for specific dissemination tasks. Within each discipline, attendees have committed to writing workshop summaries and submitting them to weekly and monthly newsletters. Other attendees are organizing technical sessions at disciplinary meetings in order to determine how textbooks are being used and best practices for their integration with other learning resources and the student-centered classroom. At the suggestion of workshop attendees, the organizers are pursuing publication of the workshop findings in national publications.

Venue: The workshop was held at the National Academy of Sciences in Washington, DC.

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Workshop URL: http://serc.carleton.edu/textbook. A variety of information can be obtained from the workshop web page including the conference program, a list of attendees, presentations by the nine catalytic speakers, reports from breakout groups, and summaries reflecting participants' thinking on both the current state of the textbook and a vision for the future of learning resources.