The quest for evidence-based digital learning materials

E-learning materials need to offer much more than reused content and flashy tech

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Teachers face many challenges as they attempt to integrate technology into their classrooms, one being a lack of high-quality teaching and learning materials. Most existing materials suffer from one of two problems: First, they are often designed without taking into account how students learn. While developers like to incorporate all the bells and whistles that technology has to offer, research has shown that most students are overwhelmed by such flourishes. Flashy graphics are likely to distract them from what is essential, interactive features may require them to make challenging decisions on when and how to respond, and a multitude of resources can keep them from recognizing what is relevant for achieving the learning objective.

Second, many textbook publishers simply produce a digital copy of their existing printed materials – often resulting in digital textbooks that are no more than hyperlinked PDFs of their printed originals. These textbooks fail to take advantage of the potential of technology to promote learning, thus producing no noticeable change in students’ knowledge.

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The eChemBook project constitutes an evidence-based approach to addressing the problem of a lack of high-quality digital instructional materials. Its aim is to gather evidence on the design of effective digital instruction and science education and then, based on this evidence, to develop a prototype of a digital textbook for use in an introductory chemistry course. Importantly, it uses technological features whenever they can be expected to contribute to better learning – but not just for their own sake.

The prototype follows a number of evidence-based design principles, such as the following:

1. To make sure that explanatory texts are easy to understand, common language is used and the texts are written so that the relationship between one sentence and another is evident, for instance by avoiding synonyms and pronouns. A computational analysis of their linguistic complexity showed that the texts are less complex than similar texts intended for the same grade level – with no loss of scientific accuracy.

2. To increase students’ motivation to learn, content is linked to students’ personal experiences, underscoring its relevance.

3. Misconceptions are addressed and refuted by providing accurate scientific explanations. Design decisions are explicitly geared to preventing such misconceptions (for example, the convention of depicting sulfur as yellow might lead student to conclude that particles possess such visual characteristics as color, shape, or size).

4. To enable learners to make efficient use of graphics, text-picture combinations are designed to reflect the findings of multimedia design research. Rather than using purely decorative graphics, a decision was made to design graphics schematically to emphasize relevant structures and relationships. Signals such as color coding and spatial proximity are used to highlight the associations between texts and pictures, and dynamic visualizations are used only when dynamism is necessary to demonstrate a scientific concept (e.g., changes in temperature are reflected in changes in the movement of particles).

5. To promote active cognitive engagement, students are assigned interactive learning tasks, such as drawing important structures and relationships. Learners are also given the opportunity to analyze videos of experiments rather than conducting these experiments in class. Finally, virtual experiments are included in which learners can simulate and explore relationships among variables (e.g., the impact of the number of particles on the pressure in a container).

6. All interactive learning tasks are accompanied by instructions on how to handle the materials, and feedback is provided. Such feedback will be helpful to students in regulating their learning activities in future self-regulated contexts.

An initial evaluation has shown that the eChemBook is an effective learning tool that promotes knowledge acquisition while at the same time helping to dispel students’ typical misconceptions. Its positive effects were especially noticeable in weaker learners. Students who used the eChemBook to learn about the particle model of matter showed greater comprehension than students who had been taught the subject matter in traditional classes.

While this is, in some ways, a success story, as it shows how scientific evidence can be translated into educational practice, there are some limitations: First, the design guidelines were documented and illustrated with examples intended to serve as training material for the publisher’s textbook developers, who were then asked to develop a second chapter of the eChemBook. However, in the course of this work it became clear that it takes more than a set of design principles to translate scientific findings into practice. It also requires in-depth knowledge of the relevant research as well as more extensive training in designing effective digital textbooks.

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Second, while we know that the eChemBook is an effective tool for self-regulated learning, it is still unclear how teachers will integrate it into their teaching and how much support they will need to make it an effective teaching tool. This is currently being evaluated in a second field study.

Third, the business model for developing evidence-based digital instruction is not yet clear. Publishers will not want – or be able – to invest in a three-year research project before publishing a digital textbook.

In any event, the project was able to demonstrate that developing a digital textbook will require starting from scratch; that is, simply making some modest modifications to existing printed
materials will not do the trick.

More about eChemBook:
The eChemBook project was funded by the German Research Foundation in response to a special call for research that "translates evidence in the humanities and social sciences into practice" (Erkenntnistransfer in den Geistes- und Sozialwissenschaften). The project was conducted by Prof. Sascha Schanze (chemistry education, Leibniz University Hannover) and Prof. Katharina Scheiter (educational psychology) in cooperation with Schroedel Westermann Publishers and SMART Technologies.

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