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Book Review

Effective Instruction for STEM Disciplines: From Learning Theory to College Teaching

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Publisher's Description: This groundbreaking book offers information on the most effective ways that students process material, store it in their long-term memories, and how that effects [sic] learning for long-term retention. It reveals how achieving different levels is important for "transfer" which refers to the learner's ability to use what is learned in different situations and to problems that might not be directly related to the problems used to help the student learn. Filled with proven tools, techniques, and approaches, this book explores how to apply these approaches to improve teaching (citation from Amazon.com).

This book was written by a commendable group of engineers who were interested in examining their own teaching practice and the impact of different teaching methods and strategies on their college students' learning. Mastacusa et al. first explored research about how students learn. In fact, I conducted a literature search from the journal, *Advances in Engineering Education* (*AEE*), and found only four published articles with the search term "learning theory."

The authors' learning theory research allowed them to move away from lecture and PowerPoint™. They tried new strategies, some which seemed counterintuitive [such as creating "desirable difficulties" (Bjork, 2004) and "the spacing effect" (Dempster, 1988)] to helping students learn, in their own college engineering courses. One of the merits of their work was the collaborative nature of it. They were not working in isolation and I think this book should be read and discussed in a collaborative atmosphere. In fact, I envision it as a book used in a professional development setting. Each chapter could be read by participants and then discussed. This would help build the required schemata (this term is well-defined in the book) for understanding the somewhat complex learning theory the authors cite.

The authors begin the book by posing the questions, "Is There a Problem? Or Is the Problem That We Don't Think There Is a Problem?", and they surmise that there are problems. Students enter college STEM (Science, Technology, Engineering, and Mathematics) courses unprepared and with misconceptions about the content. College faculty do not consistently employ teaching methods that are based on research related to how students learn. Many professors use the transmission model of teaching; students' minds are empty vessels which need to be filled with information supplied by the professor.

This transmission model of teaching is not working for many students and within Chapters 2, 3, and 4, the authors discuss "Learning and Memory", "Perception", and "Processing

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and Active Learning." They allow the reader to grapple with how learners construct their own knowledge rather than knowledge being something that is simply "transmitted from the professor's brains to the students' brains" (p. 14). Additionally, the authors discuss how the learner needs to process material in working or short-term memory so that it can be transferred and stored in long-term memory (in the form of schemata or knowledge structures). Active learning (eg., interactive engagement with others, minds-on, and Problem-Based Learning) "can produce substantial gains in learning when compared with more traditional methods such as lecture" (p. 69). When students are actively engaged, the material can be both remembered and learned. The authors use citations of important studies to support their conclusions.

Although many education scholars already draw on Bloom's Taxonomy of Educational Outcomes, the authors advocate its use by STEM faculty when they write objectives for their courses. Bloom's taxonomy includes different levels of knowing from the least sophisticated to the most sophisticated: Knowledge; Comprehension; Application; Analysis; Synthesis; and, Evaluation. They acknowledge the fact that faculty need to write goals at the application level and above because at these levels students will retrieve information from existing schemata and thus learn with understanding. In fact, the Appendix is a good resource for how to write goals which use the higher levels of Bloom's taxonomy and suggestions for action verbs that describe each level.

Chapters 6, 7, and 8 focus on interactive engagement, active learning strategies, and Problem-Based Learning (PBL). In contrast to asking students to solve exercises from a textbook, PBL encourages students to solve problems embedded in real-life situations. PBL activities offer students the opportunity to build schemata with rich connections to other content both within and outside of the discipline being taught. This also allows for transfer (Chapter 9).

Transfer, according to the authors, is what we want to ultimately foster. The concept of transfer has two main aspects: "(1) long-term retention of material; and, (2) the ability to use and apply material in situations different from the ones in which material was learned" (p. 153). In order to foster transfer, the authors advocate decontextualizing the information, having students re-represent the information in different formats, and striving to help students develop some sort of abstract representation of the material. The authors' logic behind these suggestions is based on learning theory and cited literature.

In the final chapter, the authors note, "The most important thing to take from this book is an understanding of what is important in the learning process …" (p. 191). They warn readers to "start simple and go in stages" (p. 194) when making changes in their teaching practice. Additionally, they make some excellent suggestions for how to accomplish the simple start in stages.

Of course other learning theories based on STEM disciplines could also have been explored by the authors, such as: social constructivism (Vygotsky); modes of representation (Bruner); or, Levels of Geometric Reasoning (van Hiele). Perhaps an appendix with a list of other learning theories important in STEM content areas could enhance the use of the book as a resource for faculty seeking additional learning theories for specific courses which they teach.

In summary, although there are some minor points made by the authors with which I disagree, my own schemata could be changed based on conversations with colleagues who also read the book. Therefore, I reiterate my point that this is a book which could be used in a collaborative professional development setting. As I think back on my own growth as a teacher and teacher educator, I have often contemplated these questions: "What changed first for me? As I learned more about learning theory did my beliefs change my practice? Or did my change in practice change my beliefs? Do beliefs and practice change somewhat concurrently?" Based on reading *Effective Instruction for STEM Disciplines: From Learning Theory to College Teaching*, I now ponder: What will change first for STEM professors who read this book? Will they be satisfied with the status quo of lectures and PowerPoint™ presentations once they grasp the impact of active learning strategies on their students' learning? I would hope not.

References

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