

Book Review

Science Learning and Instruction: Taking Advantage of Technology to Promote Knowledge Integration. Marcia C. Linn and Bat Sheva Eylon. New York, NY: Routledge, 2011. 360 pp. ISBN-13: 978-080586055X. Paperback, \$39.95.

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In *Science Learning and Instruction: Taking Advantage of Technology to Promote Knowledge Integration*, Linn and Eylon make a critical shift in the focus of assessment. In the quest to assess what students learn, they show why we must also assess how they learn. These researchers argue that this approach to assessment can substantively increase the quality of student knowledge when embedded in a process called “knowledge integration” (KI). They also demonstrate how KI can improve the quality of science learning overall when instruction, assessment, professional development, and school leadership are systematically aligned. These ameliorative possibilities begin with a simple premise: “Everyone can learn science” (p. ix).

In daily life everyone observes, predicts, reflects upon, and has intuitive beliefs and ideas about things that occur in the natural world. Linn and Eylon illustrate how science instruction can effectively build on these experience-based understandings of the natural world. They show how learning can be guided through processes of interrogating information, gathering evidence, and using technology to help students elicit, add to, distinguish, sort, reflect on, and evaluate scientific ideas. They see assessment within this process as not just descriptive of what students learn, but as generative of how they learn. When students are taught and assessed in this manner, a foundation is established for them to successfully employ scientific perspectives to understand the natural world and to become life-long science learners.

Science Learning and Instruction: Taking Advantage of Technology to Promote Knowledge Integration counters the notion in education that transmitting information is central to learning. The authors call this widely accepted notion “the absorption approach.” Its hallmarks in science instruction require students to listen to lectures, read textbooks and complete exercises, and conduct prescribed experiments or investigations following step-by-step procedures. Fundamental aspects of the absorption approach do not directly build on the interests and intuitions of learners.

In contrast, Linn and Eylon’s knowledge integration approach offers a different process that focuses on learning as increasing abilities to make sense of increasingly complex ideas. In their approach information trans-

mission is supplanted by idea generation, and the process begins with the learner’s own ideas. So, the concept of “ideas” is core to KI. They define an idea as “each distinct view held by the learner. Ideas include observational, intuitive, mathematical, visual, and analogical views” (p. 26).

Students hold many ideas and beliefs about a range of topics including science topics, but these intuitive views are usually not scientifically accurate. But they are important starting points for developing understanding of science. The authors note, “By eliciting ideas instruction takes advantage of the diverse, culturally-determined views students develop and ensures that all students can build on their views” (p. 26). The ability for instruction to connect science topics to previously held views of learners is crucial for students to take on identities as science learners. One value of the KI approach is that it methodically develops and complicates student ideas in ways that are reflective of how scientists research and solve problems and increase their understanding of the natural world.

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The KI approach stimulates and guides the development of a repertoire of ideas by surfacing the views already held by the learner. It facilitates learners adding new ideas to those previously held based on their backgrounds, experiences, personal interests, and cultural frames. Through instructional activities, students work to generate, distinguish, sort, and reflect on ideas and use multiple levels of analysis to discover emerging and resilient patterns or connections. Eventually, students are enabled to evaluate the significance and accuracy of emerging ideas using increasingly nuanced, evidence-based criteria. This process for achieving coherent, scientific understanding is what the authors mean by knowledge integration.

Throughout the book instruction and assessment practices that use the knowledge integration approach for teaching a range of science topics are described, analyzed, and contrasted to the absorption approach in order to illustrate the advantages of KI. Case studies of curricular and pedagogical designs for teaching thermodynamics (Chapters 3) and the particulate structure of matter (Chapter 4) reveal definitive KI advantages for learning in these domains while also illustrating how the KI foundation and framework emerged.

Each chapter addresses ways to align assessment with instruction, the advantages of technology for enabling KI, and specific roles for teachers in guiding students’ knowledge integration. “Reflection Activities” are also provided at the end of each chapter to encourage further consideration, discussion, and understanding of the topics

and issues covered as well as to promote lifelong science learning. A major benefit for educators, researchers, and software designers is that most of the science curricula discussed are available for free as Web-based Inquiry Science Environment units (complete with open source authoring tools) at WISE.Berkeley.edu.

The authors' considerations of the value of visualizations threads throughout the book and offers a focal point for discussing how their compelling approach to assessment connects to evolving roles for teachers and technology in guiding student learning. They describe the significance of visualizations with regard to the success of instruction in both case study chapters (3 and 4), and they further explicate its value in Chapter 8. Teachers can utilize technology to support high levels of science learning because it helps generate and add to the complexity of ideas about things in the natural world that cannot be directly observed.

This approach to assessment can substantively increase the quality of student knowledge when embedded in a process called “knowledge integration.”

Essentially, modern, on-line learning environments enable more sophisticated scientific visualizations. For example, they allow learners to explore chemical or molecular reactions that are too small, or too massive, or that occur too rapidly to be apprehended by the naked eye. They also allow interactive manipulations in connection with these phenomena like user customizations, prototyping, simulations, virtual experiments, and other self-directed explorations. Importantly, the authors provide extensive examples of how technology aids teachers in embedding assessments directly and seamlessly in the actual process of student learning.

Learning assessments enhanced by visualizations can be embedded within each stage of the KI process. But as the authors indicate, “Matching visualizations to the knowledge levels of students is essential for the visualizations to succeed” (p. 207). In chapter 8 they present findings and insights from numerous studies that show the efficacy of visualizations for helping students elicit, add to, distinguish among, sort out, and reflect upon scientific ideas. In making complex thinking visible at each KI stage, opportunities for assessing intricate and discreet aspects of learning are enhanced in ways that clearly extend the quality of student learning overall.

Linn and Elyon also describe how student writing (and drawing) can be incorporated into the stages of KI as additional ways to assess and make student learning visible. For example, they report that in a thermodynamics unit students were asked to write critiques of responses to

how well a thermal equilibrium experiment was conducted. The critiques were coded and scored using a KI rubric and compared to responses of another group of students who watched a visualization of a similar experiment as well as to responses of a third student group that conducted their own virtual experiments. The assessment and scoring rubric also included an item for all three groups of students to draw and explain pictures to show how heat is transferred. Based on pretests and posttests, outcomes were that all three groups made significant gains on KI questions although the critique group outperformed the other two. Ultimately, the results suggest that a range of visualization activities and strategies help students develop more coherent understanding of complex scientific phenomena.

The authors also critique uses of visualizations in the absorption approach and argue that these uses are often problematic. For example, the absorption approach sometimes uses visualization in attempts to motivate or engage students in learning. But without nuanced designs and guidance of learning as shown in the KI approach, visualizations aimed at transmitting information have been found to be inappropriate, misaligned, or overly complicated in terms of interpretation demands for achieving systematic science learning. In this regard the authors note, “Visualizations add value when they align with the knowledge of the learner, focus on difficult ideas that are hard to express in other formats, take advantage of interactivity, and support self-directed explorations for science topics that are fundamentally dynamic” (p.27).

Is the KI approach applicable for improving student learning beyond science topics? Yes. In fall semester of 2011, I used *Science Learning and Instruction: Taking Advantage of Technology to Promote Knowledge Integration* in a graduate class on urban education for a diverse group of pre-service elementary teachers and secondary science, math, and English teachers. They read, discussed, and presented on chapters in the book and also explored some of the web-based resources. But I initially introduced the knowledge integration process by modeling a literature lesson using a canonical poem by Robert Hayden entitled “The Whipping.”

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After a volunteer read the poem to the class, students were asked to write their ideas about what happened on their paper copies. Afterwards, volunteers were asked to share their ideas with the class as I recorded them on the board without making evaluations. Students were asked to add more ideas to those on the board. Then working in groups, they discussed ways to distinguish and sort the ideas. After further reflection they evaluated

which ideas provided the most coherent and convincing meaning(s) of the poem based on their evolving understanding. As the lesson concluded, students saw the advantages of generating, adding, distinguishing, evaluating, and eventually integrating a wealth of ideas about a complex written text. Rather than transmitting a preconceived meaning of the poem, students were guided to develop and collaborate on a range of coherent and defensible meanings with clear opportunities for embedded assessments of learning at each stage.

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Linn and Eylon's use of writing for assessing learning within the KI process also connects to its value for assessment beyond science learning. Elements of their methods for using problem-based writing prompts with automated scoring rubrics can be appropriated across a range of disciplines to increase the effectiveness of teachers in continually assessing and guiding students in the actual process of learning. Overall, this book provides clear direction for the transformation of science learning and instruction, and it has important implications for teaching and learning in other disciplines as well.