Research-based Active-Learning Instruction in Physics

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David E. Meltzer and Ronald K. Thornton, “Resource Letter ALIP-1: Active-Learning Instruction in Physics,” Am. J. Phys. **80**(6), 479-496 (2012).

Valuable Reference:

Jose P. Mestre, “Implications of research on learning for the education of prospective science and physics teachers,” Phys. Educ. **36**, 44-51 (2001).

Definition for “Research-based Active-Learning Instructional Methods in Physics”

[often known as “Interactive Engagement”:

R. R. Hake, “Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses,” Am. J. Phys. **66**, 64-74 (1998).]

Definition for “Research-based Active-Learning Instructional Methods in Physics”

1) explicitly based on research in the learning and teaching of physics;
2) incorporate classroom and/or laboratory activities that require all students to express their thinking through speaking, writing, or other actions that go beyond listening and the copying of notes, or execution of prescribed procedures;
3) tested repeatedly in actual classroom settings and have yielded objective evidence of improved student learning.

Inclusion Criteria

- Useful for undergraduates in colleges and universities
- Developed using methods of research in physics education, and subjected to efforts to evaluate the learning of students who use them
- Existence of peer-reviewed publication that documents, in some fashion, evidence for the pedagogical efficacy of the method or material

Common Characteristics:

A. Instruction is informed and explicitly guided by research regarding students' pre-instruction knowledge state and learning trajectory, including:

- *Specific learning difficulties related to particular physics concepts*
- *Specific ideas and knowledge elements that are potentially productive and useful*
- *Students' beliefs about what they need to do in order to learn*
- *Specific learning behaviors*
- *General reasoning processes*

B. Specific student ideas are elicited and addressed.

C. Students are encouraged to “figure things out for themselves.”

D. Students engage in a variety of problem-solving activities during class time.

E. Students express their reasoning explicitly.

F. Students often work together in small groups.

G. Students receive rapid feedback in the course of their investigative or problem-solving activity.

H. Qualitative reasoning and conceptual thinking are emphasized.

I. Problems are posed in a wide variety of contexts and representations.

J. Instruction frequently incorporates use of actual physical systems in problem solving.

K. Instruction recognizes the need to reflect on one's own problem-solving practice.

L. Instruction emphasizes linking of concepts into well-organized hierarchical structures.

M. Instruction integrates both appropriate content (based on knowledge of students' thinking) and appropriate behaviors (requiring active student engagement).

Crucial Supplementary Notes

- A non-expert classroom observer may be unable to recognize the presence of specific, topic-dependent research-based instructional materials and methods
- There exists no clear quantitative measure of how, and in what proportion, the various characteristics of effective instruction need be present in order to make instruction actually effective.
  - Does or does not a score of “4 out of 4” on characteristics *E*, *F*, *G*, and *H* on the above list outweigh a score of (e.g.) “3 out of 4” on characteristics *A*, *B*, *C*, and *D?*

“Teaching” and Curriculum are Linked

- Instructional developers gather and analyze evidence on *specific instructional implementations of specific curricula*
- Firm evidence of effective instructional practice always occurs in the context of a large set of tightly interlinked characteristics, each characteristic (apparently) closely dependent on the others for overall instructional success.

Summary

- Evaluation or assessment of physics “teaching” as isolated from or independent of *specific curricula linked to specific instructional methods* is not supported by current research.
- It may well *never* be so supported, so *Caveat Emptor*: Adoption of specific “research-based *teaching method*s” may not yield improvements in learning.