

Research-based Active-Learning Instruction in Physics

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Based on:

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