"Learning by Doing": Active and Inquiry-Based Learning Strategies in Science

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"To teach is to engage students in learning."
- Education for Judgement: The Artistry of Discussion Leadership by C.R. Christensen, D.A. Garvin, and A. Sweet - 1991

WHEN students start thinking about the importance and relevance of science and its impact on society, the learning benefits are amazing.

In the traditional approach to teaching science, the professor lectures and the students listen. In these classes, science is taught from the point of view of the expert (the teacher), emphasis is placed on content rather than learning, and the students have little to no responsibility for their own learning. Most professors who teach using a traditional approach argue that they need to lecture in order to cover course content, that students need to learn the basic concepts of science (i.e. knowledge is cumulative), and that science has been successfully taught this way for many decades.

In recent years, some educators have advocated the use of active and inquiry-based strategies in science teaching, promoting engagement in learning. In active and inquiry-based approaches, the role of the teacher shifts from expert to facilitator and students are expected to become active learners. The philosophy behind both strategies is that students "learn best by doing, not by watching or listening" (Felder & Brent 1999). Active learning incorporates strategies that require students to participate directly in their learning - to apply newly acquired knowledge to solve problems, to question and test theories, brainstorm, solve problems, hypothesize, summarize, or to critically think and interact with colleagues (Felder & Brent 1999; Hannula 2003; McConnell, Steer, & Owens 2003). Inquiry-based learning is a more specific term applied to learning situations where elements of scientific inquiry have been incorporated into active learning exercises (McConnell, Steer, & Owens 2003).

The Best of Both Worlds

Many professors who use inquiry-based techniques suggest that students learn best in the sciences when they invest a part of themselves in their learning. Therefore, classes which emphasize the scientific method by teaching students to question theories and develop hypotheses are effective because they engage students in the process of learning (Hannula 2003). Many studies have linked the use of active and inquiry-based learning to increased motivation in the classroom, improved student retention, increased concentration, better student-faculty interaction, enriched understanding of content, better feedback, and more supportive learning communities (Felder & Brent 1996; Smith et al. 2005).

On the other hand, active or inquiry-based exercises are time-consuming in terms of preparation time for the instructor and time spent in the classroom. In science, knowledge is indeed cumulative, and students need to learn basic concepts before progressing further in their studies. Should science teachers maintain a focus on content, or incorporate active and inquiry-based strategies in their teaching? Can they successfully do both?

I would argue that the answer to this question is different for each teacher. The question is rooted in our individual approaches to teaching, in our philosophy, and in our goals (Felder & Brent 1999). If you believe active or inquiry-based learning compromises your content or curriculum, then these are techniques you probably shouldn't be using (Felder & Brent 1999). If, on the other hand, your goals include promoting engagement or discovery, then active and inquiry-based learning may be extremely helpful in reaching those goals in the classroom. It doesn't come down to having to make a choice - many successful teachers build the best of both worlds by incorporating smaller components of active and inquiry-based learning in their lectures without compromising course material.

Incorporating Active & Inquiry-Based Learning Strategies in Your Teaching

Implementing active or inquiry-based learning in your teaching can be as simple as stopping your lecture for a few minutes to ask students questions about the content you are teaching, breaking out into small discussion groups, and/or engaging students in interactive demonstrations. Here are a few simple techniques to try:

• Instead of asking "Any questions?," stop and ask students to define concepts or ideas in their own words throughout your lecture (Felder 1994). Ask your students specific open-ended questions structured to provoke curiosity, relate concepts to the real world, illustrate meaning, or trigger discussions and/or debate.

- Show rather than tell. Use interactive demonstrations and simulations to illustrate concepts and theories. Take this one step further and ask your students to predict behaviour and construct their own hypotheses before carrying out experiments or doing calculations. One way of doing this is to show your students a photograph, map, or diagram and ask them to make their own observations and interpretations (McConnell, Steer, & Owens 2003).
- When lecturing, encourage students (particularly first-years) to question concepts, ideas, and theories. Use examples from your own research to illustrate how the scientific process is carried out.
- Use case studies to illustrate contentious issues in science, such as genetically modified foods, or toxic waste disposal. When students start thinking about the importance and relevance of science and its impact on society, the learning benefits are amazing.
- Integrate current events into your lecture. For example, if you're teaching geology, how could you not talk about the tsunami that recently hit South Asia?
- Incorporate active learning exercises such as conceptests and Venn diagrams into your teaching (McConnell, Steer, & Owens 2003). Conceptests are short multiple-choice tests that faculty intersperse in their lecture to assess whether students are learning. Venn diagrams add a visual (graphical) touch when comparing and contrasting characteristics (mathematical sets) and demonstrating relationships between phenomena (hurricanes vs tornadoes; igneous vs sedimentary vs metamorphic rocks; vertebrates vs invertebrates) (McConnell, Steer, & Owens 2003).
- Use concept maps to establish relevance and demonstrate how concepts are related to 1) one another; 2) the real world; and 3) other concepts in related scientific disciplines.
- Implement problem-based and cooperative learning in the field or lab. Problem-based learning involves incorporating exercises in which students work individually or together in teams to pose and/or solve problems related to specific scenarios or topics. Cooperative learning establishes community, better student-faculty interaction, and a more supportive and caring learning environment.

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> (Felder & Brent 1999).

References

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