Active learning strategies for improving student engagement and learning

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An important goal for teachers is to help students engage in learning. We often attempt techniques such as connecting topics to real-world contexts, using historical anecdotes as motivation, showing videos, asking questions, and even telling jokes in the classroom. While each of these may play some role in triggering students' engagement, they fall short of maintaining *cognitive engagement*, which is learners' focused effort to understand what is being taught. Using real-world contexts and historical anecdotes may be effective in getting students' initial attention, but they can only be used occasionally. Similarly, showing videos and demonstrations may be useful, but they are not sufficient. Asking questions elicits responses from motivated students while others may have a barrier to respond. Hence it is difficult to ensure that all students participate. What is required are techniques which are known to promote and sustain cognitive engagement for the majority of students.

One such approach recommended by educational researchers is the use of *active learning* techniques in the classroom. Active learning engages students in the process of learning through activities and/or discussion in class, as opposed to merely listening to an expert [1]. The main requirement of active learning is that students go beyond listening, taking notes and executing prescribed procedures. The role of the instructor is to go beyond transmitting information and clarifying doubts. Instead, the instructor designs activities that require students to talk, write, reflect and express their thinking. In addition, active learning strategies are explicitly based on theories of learning and have been evaluated repeatedly through empirical research. Some key features of active learning strategies are [2]:

- Students engage in problem-solving activities *during* lecture.
- Students work collaboratively.
- Students are asked to "figure things out for themselves."
- Students are asked to express their reasoning explicitly.
- Qualitative reasoning, conceptual thinking are emphasized.
- Specific student ideas are elicited and addressed.
- Students receive rapid feedback on their work.

There is significant research evidence for the effectiveness of active learning strategies. A recent meta-analysis of 225 studies [1] showed that active learning improved exam scores and reduced failure rates in a variety of disciplines and across all levels of undergraduate courses.

A wide array of classroom active learning strategies exist: structured group learning activities, problem-based learning, role-play, in-class worksheets, just-in-time-teaching, etc. We provide details of one active learning technique, Peer-Instruction, which has been established to be effective even for a set of diverse learners. Research studies on Peer-Instruction have reported benefits related to improved conceptual understanding, problem solving, attendance, motivation, learning from peers and student perceptions.

Peer-Instruction is also popularly known as clickers-activity, but clicker technology is not essential. This activity has the following main steps:

- Step 1: The instructor poses a conceptual multiple choice question. The question should not be 'trivial' and should involve conceptual reasoning (rather than a calculation).
- Step 2: (~ 1 minute). Students vote for their choice individually, using clickers, flashcards or a discreet show of fingers for the instructor's view alone (hold hands next to chest).
- Step 3: (2-4 minutes). This is the important phase of peer-discussion – wherein students turn to their neighbors, form informal groups of 3-4 and discuss their choices. In this phase, the goal for each student is to convince their group of the correctness of their answer using concepts, reasoning and analysis. Students are encouraged to converge on an answer within their group before the next phase.
- Step 4: (30 seconds -1minute). There is a second round of voting.
- Step 5: (1-3 minutes). The instructor leads a class-wide discussion in which the correct/wrong answers are mentioned, but more importantly the conceptual reasoning is discussed in context of the topic.

In most cases, the percentage of correct answers has been found to increase after the second round of voting. If answers to these questions tend to diverge even after the second round, the instructor can go into deeper discussion of the topic to clarify doubts. Thus the activity produces useful feedback for the instructor on how well students have understood a topic. It is recommended that this activity not be graded for the correct answer.

Figure 1 shows an example of an effective peer-instruction question, i.e. one that is known to generate productive discussion. Several resources for implementing peer instruction, examples from different topics and research articles are available in [3].

Another active learning strategy is Think-Pair-Share, which we implemented in a large-enrollment (250+) 1st year CS programming course at IIT Bombay. Our research showed that Think-Pair-Share led to 83% sustained engagement [4] and improved learning [5]. Videos and slides on the what-why-how of Think-Pair-Share and Peer-Instruction, as well as 'activity constructors' for instructors are available [6].

To conclude, there are various benefits when an instructor creates structured active learning activities for the classroom. Implementing research-based active learning strategies could lead to improved engagement and conceptual understanding. Such activities also provide the instructor with valuable and authentic feedback on the effectiveness of their teaching.

[1] S. Freeman, S. L. Eddy, M. McDonough, M. K. Smith, N. Okoroafor, H. Jordt and M.P. Wenderoth. Active learning increases student performance in science, engineering, and mathematics. *Proc Natl Acad Sci*. 111(23), pp.8410-8415, 2014.

[2] D. E. Meltzer and R. K. Thornton. "Resource letter ALIP–1: active-learning instruction in physics." *Am. J. Phys*, 80(6), pp.478-496, 2012.

[3] Carl Wieman Science Education Initiative http://www.cwsei.ubc.ca/resources/clickers.htm

[4] A. Kothiyal, R. Majumdar, S. Murthy and S. Iyer. Effect of Think-Pair-Share in a large CS1 class: 83% sustained engagement. ACM Ninth International Computing Education Research conference, (ICER 2013), San Diego, USA, August 12-14, 2013.
[5] A. Kothiyal, S. Murthy and S. Iyer. Think-Pair-Share in a large CS1 class: Does learning really happen? 19th Annual ACM conference on Innovation and Technology in Computer Science Education (ITiCSE 2014), Uppsala, Sweden, June 23-25, 2014.
[6] Teaching Strategies on the webpage of the Inter-disciplinary program in Educational Technology, IIT Bombay. http://www.et.iitb.ac.in/TeachingStrategies.html

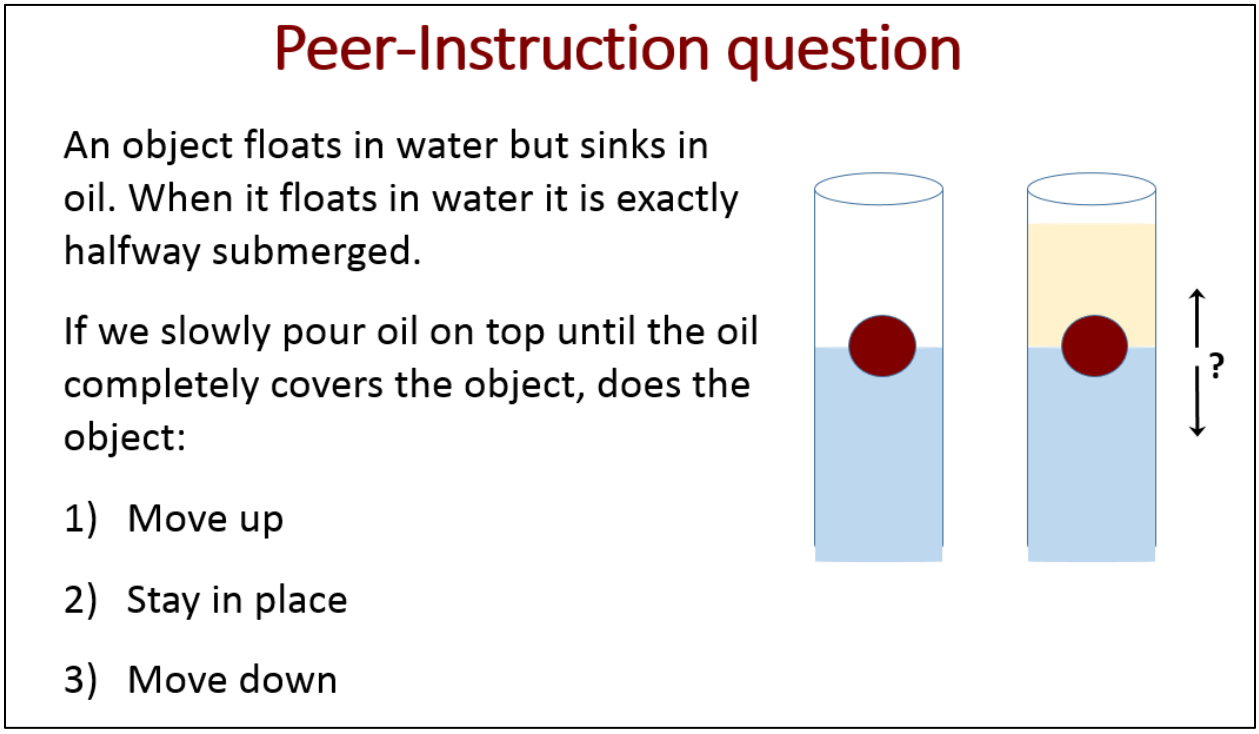

Fig. 1: An example of a Peer-Instruction question