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Problem-based Learning

Commentary: Generating Discussion during Examinations

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Problem-based learning (PBL)[1] recognizes the social context of learning and emphasizes individual responsibility for learning. While working on complex problems, students share what they know and define what they do not know. They work actively to fill their knowledge gaps and use their new knowledge to cooperatively resolve problems. The classroom format and expectations emphasize understanding something well enough to explain it to others.

Relatively few instructors have embraced PBL. The lecture format still dominates courses in biochemistry and molecular biology. To move from a conventional format to a PBL format involves risk and uncertainty. Those who contemplate this change often ask, "How do you assess students?" recognizing that when you teach differently, you need to test differently. If students work hard to adjust to a PBL format and then encounter a multiple choice test that requires little conceptual understanding, lots of memorization, and no new material, they may justifiably conclude it is business as usual, revert to old study habits, and cease to be effective PBL participants.

Before I adopted PBL, I used to design challenging multiple choice questions that probed conceptual understanding. I would try to tap into student misunderstandings so that the selection of incorrect answers seemed plausible. I became a connoisseur of good multiple choice questions. However, I eventually became disillusioned. Students could get the right answer by guessing, and students who had a good understanding could make a simple mistake and get no credit. While such questions were easy to grade and served the purpose of ranking students, they seemed inappropriate for assessment of learning when I adopted PBL where open-ended questions anticipate nuanced answers. Consequently, my file card boxes filled with multiple choice questions have gathered dust for almost 15 years.

My aversion to multiple choice questions in PBL took a sudden turn recently while attending a workshop on course design by Dee Fink [1]. He demonstrated how multiple choice questions can be used in a way that is fully in the spirit of PBL. A new type of answer sheets based on lottery ticket technology is the key. These commercially available sheets (IFAT®; www.epsteineducation.com) accommodate up to 50 multiple choice questions with four scratch-off choices each. Questions need to be written to accommodate the predetermined location of correct answers, a star under one of the choices.

I have used these answer sheets for quizzes. Within a group of four students, each student has about 5 min to answer several multiple choices questions printed on a sheet of paper. When each group member has an answer for all of the questions, group members compare answers and decide what answer the group will choose on the scratch off sheet. Well constructed challenging questions usually lead to competing answers that require discussion and consensus building. If the correct answer is selected, it is worth 4 points. If an incorrect answer is selected, the group must reconsider the remaining answers and select one. If it is correct, the answer is worth 2 points. If the answer is not correct, the process can be repeated one more time for a correct answer on the third try worth 1 point.

Several aspects of this structured approach attracted me. Most importantly, students receive immediate feedback. They know whether their answer is right or wrong. If it is wrong, they have a chance to discuss the remaining answers and try again for partial credit. In any case, they leave the classroom knowing the correct answer and knowing how well they did.

One might think that the vigorous discussions that evolve as groups seek consensus would influence neighboring groups. While that could occur on occasion, in practice the groups become quite focused on their own answers, and they quickly get out of phase with each other. Furthermore, because the quiz grades contribute only a small portion of the final grade, the impact of espionage, if it occurs, is minimal. The quizzes serve primarily as learning experiences and secondarily for grading.

The classroom atmosphere during these quizzes contrasts strikingly with the silence normally associated with testing. There is laughing. The occasional "Yes!" or a "high five" hand slap signal a correct answer. After the first quiz, several students independently referred to the quiz as "fun." Usually, the discussions continue after class as students from different groups compare their responses.

Some interesting group dynamics also emerge when

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Disclaimer: The author does not know nor has communicated with the people who developed the IFAT® answer sheets other than obtain permission to publish the figure. The author has no financial interests in the product.

[1] The abbreviation used is: PBL, problem-based learning.

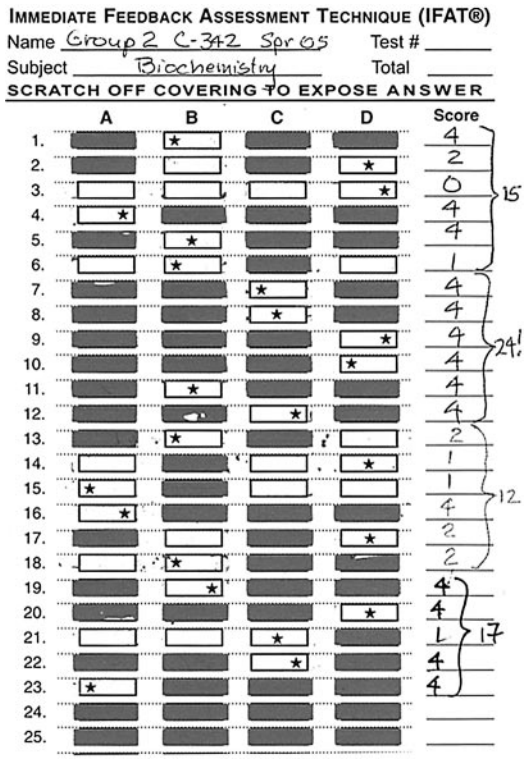

FIG. 1. **Scoring of an IFAT® answer sheet used by a single PBL group for four successive quizzes.** Note that the position of the star indicating the correct answer varies to discourage "peeking" that may have occurred with answer 12B.

dominating students convince their group of an answer that turns out to be wrong while a less assertive member was right. In other instances, the poor social skills of bright students interfere with group consensus building. These situations contribute to important learning that has little to do with the subject matter.

For these quizzes to work well in a PBL setting, the questions need to involve conceptual understanding rather than memorization of facts. Otherwise they would not generate discussions. An example of such a question (Question 21, Fig. 1) follows.

Ingram digested hemoglobin at pH 8.0, near the pH optimum for trypsin, and he followed the reaction by titrating the generated protons, H^+, and maintained the pH with NaOH. If Ingram had done the digestion at pH 7.0 instead, how would it have changed the rate and amount of protons generated? Note: pK_a α-COOH $\sim$2; pK_a α-NH_3^+ $\geq$ 9.

A. More protons would be produced at a slower rate.
B. More protons would be produced at a faster rate.
C. Fewer protons would be produced at a slower rate.
D. Fewer protons would be produced at a faster rate.

How many questions and how much time do students need to complete a group quiz with questions of this type? While the answer will vary with the difficulty of the questions and the ability of the students, 20–25 min has proved to be adequate for a quiz with five or six questions where the average score has been around 70%. This means one group can use a single IFAT® answer sheet for up to 10 quizzes in a semester.

It seems ironic having abandoned multiple choice questions and having never bought a lottery ticket that the combination would yield a product I find so useful for learning and assessing in the PBL classroom. Certainly, these answer sheets can be used for individual testing on conventional examinations with the added partial credit feature. However, they really reach their full potential when they generate discussion in group assessments.

REFERENCES

[1] L. D. Fink (2003) *Creating Significant Learning Experiences*, Josey-Bass, San Francisco, CA.