Multiple-Choice Exams: An Obstacle for Higher-Level Thinking in Introductory Science Classes Kathrin F. Stanger-Hall Department of Plant Biology, University of Georgia, Athens (2012)

Note:

MC = multiple choice

SA = short answer

CR = critical response

Method

"During Spring 2009, two sections of this introductory biology class were offered, both taught by the same instructor. Instruction, assignments, and study tips were identical for both classes. The larger section (N = 282 consenting students) was assessed using the traditional MC-only exam format, and the smaller section (N = 192 consenting students) was assessed using a combination of MC, SA, and other CR questions (denoted by MC+SA hereafter). Students were not aware of the assessment format when signing up for one of the two class sections."

"Student performance on the cumulative final exam was used to assess whether exam format affected student learning (final exams are not returned in this class, and none of the final exam questions had appeared on previous exams). For the final exam comparison between the two sections, I used the 90 identical MC questions (29 higher-level and 61 lower-level thinking questions: categorized based on class content and activities, assignments, and assigned reading) and one common higher-level short essay question (extra credit for the MC class and part of the exam for the MC+SA class)."

Table 1. List of cognitively passive and active learning behaviors that students reported in their study surveys

Cognitively passive learning behaviors	Cognitively active learning behaviors
I previewed the reading before class.	I asked myself: "How does it work?" and "Why does it work this way?"
I came to class.	I drew my own flowcharts or diagrams.
I read the assigned text.	I broke down complex processes step-by-step.
I reviewed my class notes.	I wrote my own study questions.
I rewrote my notes.	I reorganized the class information.
I made index cards.	I compared and contrasted.
I highlighted the text.	I fit all the facts into a bigger picture.
I looked up information.	I tried to figure out the answer before looking it up.
I asked a classmate or tutor to explain the material to me.	I closed my notes and tested how much I remembered.
	I asked myself: "How are individual steps connected?" and "Why are they connected?"
	I drew and labeled diagrams from memory and figured out missing pieces.
	I asked myself: "How does this impact my life?" and "What does it tell me about my body?"
	I used Bloom's taxonomy to write my own study questions

Findings: amount of study time, amount of passive versus active study time

"The students in the two sections did not differ in their reported study times for a science class in general. At the beginning of the semester, students in the MC section reported an average of 3.93 (± 0.84) hours cognitively passive learning behaviors (of nine options), while the students in the MC+SA

section reported an average of 3.91 (±0.17) cognitively passive learning behaviors during studying for this class (non–exam week; Table 2); this was not significantly different."

"Interestingly, students in the MC + SA section did not study more than the students in the MC-only section. Students in both sections spent on average considerably less time studying (3 h per non–exam week) than was recommended by the instructor (2 h per hour class time or 6 h/wk). This is in line with national data: college students spend on average a total of 15 h/wk on studying, or about 7% of their time in a 5-d week (Arum and Roksa, 2011). These data also reflect national trends of declining study times in college students (Babcock and Marks, 2011): full-time college students in 1961 allocated on average 24.4 h/wk to studying, while in 2003 students spent on average 14.4 h/wk (10 h fewer)."

"Students in the MC+SA section reported significantly more cognitively active learning behaviors than the students in the MC section in three of the four surveys. Instead of studying more, the students in the MC + SA section used their study time more effectively for practicing higher-level thinking. Students in both sections reported a similar number of cognitively passive (surface) learning behaviors (∼3.5) during studying, and the average number of reported cognitively active (deep) learning behaviors increased in both sections in response to their exams. This shows that students will respond with more active learning if challenged, even in the MC-only format."

"However, the students in the MC + SA section consistently reported more cognitively active learning behaviors in non– exam weeks than the students in the MC-only section, and this difference in study behavior translated into significantly better student performance on the cumulative final exam."

Findings: common multiple choice questions

"Students in the MC and MC+SA sections answered 90 identical MC questions on their final exams. The students in the MC+SA section (who used more cognitively active learning behaviours) scored significantly higher (67.35%) on these 90 MC questions than the students in the MC section (64.23%)"

Findings: higher-level multiple choice questions

"Students in the MC+SA section scored significantly higher (64.4%) on the higher-level questions than the students in the MC section (59.54%.)"

Findings; lower-level multiple choice questions

"The difference between the two sections on lower level MC questions (68.76% vs. 66.46%) was marginally significant. All differences remained significant after adjustment for multiple comparisons."

Findings: student perceptions of the value of learning

"In the MC section, 57.3% of students agreed or strongly agreed that they saw the value of learning on all learning levels and 11.1% of students disagreed or strongly disagreed with the statement.

In the MC + SA section, 72.1% of students agreed or strongly agreed that they saw the value of learning on all learning levels, and 7.4% of students disagreed or strongly disagreed."

Findings: student perceptions of challenge

"Even though students in the MC + SA section learned significantly more than students in the MC section, they did not like being assessed with CR questions. The clear student preference for

assessment with MC questions (and student perception of MC questions being easier to answer and thus less effort to prepare for) is reflected in the assessment literature (Simkin and Kuechler, 2005). Due to the mixed exam format, mistakes in reasoning were more obvious for the students in the MC + SA section and likely contributed to their less-favorable student evaluations of both the class and the instructor at the end of the semester (Kearney and Plax, 1992; Keeley et al., 1995). But even though many students in the MC + SA section disliked the experience, they learned significantly more, including critical-thinking skills, than the students in the MC-only section. This illustrates the limited use of student evaluations as a measure of actual student learning, and suggests that student ratings should not be overinterpreted, especially if students are asked to practice new thinking skills (McKeachy, 1997)."

"Given the increased learning gains with the mixed exam format, an important question for both instructors and students is how to overcome student misgivings (e.g., Kearney and Plax, 1992) about the learning process to further maximize learning gains. In the present study, possible sources for student resistance included: 1) different exam formats in different sections, 2) expectation to practice unfamiliar thinking skills, and 3) overestimation of own critical-thinking ability. To reduce these influences, ideally all introductory science classes should implement a mixed exam format. This would not only improve student learning, but would also reduce student resistance associated with the perception of unfairness in grading due to different exam formats."