The flipped exam: creating an environment in which students discover for themselves the concepts and principles we want them to learn

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Lujan HL, DiCarlo SE. The flipped exam: creating an environment in which students discover for themselves the concepts and principles we want them to learn. Adv Physiol Educ 38: 339–342, 2014; doi:10.1152/advan.00081.2014.—Students are naturally curious and inquisitive with powerful intrinsic motives to probe, learn, and understand their world. Accordingly, class activities must capitalize on this inherently energetic and curious nature so that learning becomes a lifelong activity where students take initiative for learning, are skilled in learning, and want to learn new things. This report describes a student-centered class activity, the “flipped exam,” designed to achieve this goal. The flipped exam was a collaborative, group effort, and learning was interactive. It included a significant proportion (~30–35%) of material not covered in class. This required students to actively search for content and context, dynamically making connections between what they knew and what they learned, grappling with complexity, uncertainty, and ambiguity, and finally discovering answers to important questions. Accordingly, the need or desire to know was the catalyst for meaningful learning. Student assessment was determined by behavioral noncognitive parameters that were based on the observation of the student and the student’s work as well as cognitive parameters (i.e., the student’s score on the examination). It is our view that the flipped exam provided a student-centered activity in which students discovered, because of the need to know and opportunities for discussion, the important concepts and principles we wanted them to learn.

motivation; learning; collaboration

Tell me, and I will forget.
Show me and I may remember.
Involve me, and I will understand.

Xunzi, Chinese Confucian philosopher

We learn by actively constructing knowledge as we search for answers. That is, we most often start with a question or problem and actively search for answers and solutions. During this process, we broaden the focus and expand the possibilities, and meaningful learning occurs. As an example, we learn through addressing tentative and evolving problems as they arise. This involves actively searching for content and context, dynamically making connections between what we know and what we learned, grappling with complexity, uncertainty, and ambiguity, and finally discovering answers to important questions. Accordingly, our need or desire to know is the catalyst for meaningful learning.

Talking to learn. We also learn by talking in the classroom (1, 4, 5, 16, 30). In fact, discussion enhances student understanding even when none of the students initially know the correct answer (9, 24). Furthermore, discussion enriches the learning experience by increasing engagement and interest while promoting thinking about what is understood and what remains to be understood (27). The following statement by Canadian teacher Stephen Leacock (1869–1944) (15):

If I were founding a university I would found first a smoking room; then when I had a little more money in hand I would found a dormitory; then after that, or more probably with it, a decent reading room and a library. After that, if I still had more money that I couldn’t use, I would hire a professor and get some textbooks.

suggests that this renowned educator understood the importance of student discussion since his first priority for a university was creating a place for dialogue. He also seemed to understand that teachers often do too much telling since his last priority was hiring professors!

The “flipped examination.” The “flipped classroom” is an example of a student-centered environment where the teacher tells less and discussion and problem solving become more important. The flipped classroom promotes discovery and occurs when students prepare for discussion and/or problem-solving activities during traditional class time with preclass homework including watching recorded lectures and reviewing relevant topics (19). We extended this concept to the “flipped exam,” when students, during the traditional examination time and while working in one large collaborative group, actively construct knowledge as they search for answers using their notes and other resources and discuss questions during the exam.

METHODS

The flipped exam, student-centered activity was implemented with students enrolled in the Post-Baccalaureate Program at Wayne State University School of Medicine. The Post-Baccalaureate Program is a structured, 10-mo (September-July), intense academic program. The program identifies students from underrepresented backgrounds (racial, socioeconomic, and rural) who had originally applied to the medical program but were not selected by the school’s admission committee. These students, however, have shown potential to succeed in medical school.

The program is designed to help students improve their scientific knowledge, academic skills, and personal adjustment. Efforts to improve students’ scientific knowledge involve three basic components: 1) structured courses, 2) subject supplements, and 3) Kaplan Preparation for the Medical College Admission Test.

Structured course work involves six different subjects: biochemistry, chemistry, embryology, histology, gross anatomy, and physiology. Courses were evenly distributed among three semesters: fall (chemistry and histology), winter (biochemistry and embryology), and spring-summer (gross anatomy and physiology). Gross anatomy and physiology were 6- and 8-wk courses, respectively.

The cardiopulmonary component of the physiology course presented to 8 postbaccalaureate students consisted of 20 classes of 3 h each. Before the first class, students received a course pack containing...
306 pages of cardiopulmonary physiology content. Students were told that although we would not cover all of the content in the course pack, they would be tested on all of the material. Students were also told that the exam would be collaborative and, in fact, discussion with all members of the class (8 total students) was highly encouraged. Thus, on Tuesday of the first week, the professor began a typical class covering the material in the course pack and this continued on Wednesday and Thursday. On Friday, students sat for a collaborative exam covering the first 25% of the material and the pedagogical value of the flipped exam was high as the students understood the correct answer why answers were correct as well as incorrect while understanding learning as the students and professor deconstructed each question and understanding the student’s work (50%) as well as cognitive parameters (i.e., the student’s score on the examination (50%); Fig. 1). Specifically, we assessed communication, collaboration and problem-solving skills, decision making, and interactive, critical integration of knowledge, professional attitudes, and effort as well as engaging with the material because this approach has been shown to stimulate student interest in improvement (26). Our attempt was to reward effort and participation and avoid some of the documented negative consequences of exams.

Accordingly, with the flipped exam, the process of gaining knowledge was as important than the answer. This concept is consistent with constructivist teaching, which states that students learn best when they actively construct a personal understanding of the question and answers. This success engendered an enormous sense of accomplishment and confidence as students discovered the skill of learning on their own. Students were also required to construct notes on material that was less well understood, and these concepts were discussed with the professor on Monday.

The Monday postexam review session promoted deep, meaningful learning as the students and professor deconstructed each question and the corresponding answer choices, exposing misconceptions, inconsistencies, and biases (often what we think we know prevents us from learning what we do not know). In this way, the students explored why answers were correct as well as incorrect while understanding principles and concepts. Therefore, the pedagogical value of the flipped exam was high as the students understood the correct answer and whether the thought process behind the answer was adequate. This process promoted the discovery of the scope and depth of their knowledge.

RESULTS

Each exam (4 exams total) consisted of 45 questions and was designed to be completed within 60 min to stay within the guidelines of 1.5 min/question established by the United States Medical Licensing Examination (28). Remarkably, the average time to completion of each of the four exams in the flipped format was significantly (>4 h, documenting the team effort and commitment students invested in their learning. This team approach is essential to promote and nurture because healthcare is now recognized as a team sport, with physicians functioning as members of a complex group that includes other physicians, nurses, physician assistants, pharmacists, social workers, dieticians, allied healthcare providers, administrators, and many additional team members. This team effort is essential given the complexity of information and interpersonal connections as well as the fact that it is impossible for one individual to provide care in isolation and it is also potentially dangerous. Accordingly, each clinician relies on information and action from other members of the team. The flipped exam cultivates and advances these skills.

Student assessment was determined by behavioral, noncognitive parameters that were based on observations of the student and the student’s work (50%) as well as cognitive parameters (i.e., the student’s score on the examination (50%); Fig. 1). Specifically, we assessed communication, collaboration and problem-solving skills, decision making, and initiative, critical integration of knowledge, professional attitudes, and effort for overcoming the obstacles and challenges associated with the exam, motivation to learn (as opposed to getting the correct answer), and ethics. This assessment approach was chosen because student performance (grades) on examinations is highly overrated as the value of grades as an objective evaluation of student performance or a reliable indicator of student learning is under deep scrutiny and challenge (23). Furthermore, traditional forms of assessment have the potential to incorrectly indicate student understanding, hinder critical thinking, and display bias (based on language proficiency, cultural background, or skills in test taking) against certain groups of students (23). Accordingly, the final grade on the flipped exam was based on the performance on the exam (50%) and on behavioral parameters (50%). We did not want the entire grade to be based on work that rewards only correct answers. We chose to reward students for participation and effort as well as engaging with the material because this approach has been shown to stimulate student interest in improvement (26). Our attempt was to reward effort and participation and avoid some of the documented negative consequences of exams.

Accordingly, with the flipped exam, the process of gaining knowledge was as important than the answer. This concept is consistent with constructivist teaching, which states that students learn best when they actively construct a personal understanding of concepts based on finding solutions and reflecting on those experiences (18). The focus is on social and communication skills and critical thinking and the exchange of ideas.

Finally, we also assessed the student’s performance on the exams and compared the scores of the content covered with the scores of the content not covered (Fig. 1). The average score for the four exams on the material covered was significantly higher than the average score for the four exams on the material not covered. However, importantly, the score on the material not covered was high and suggests that we do not need to cover the material for students to learn.

DISCUSSION

We implemented a student-centered activity where collaboration and discussion became important for finding answers and solving problems. With collaborative group learning, students were responsible for and facilitated individual success by working together to solve problems and find solutions. Collaborative interactions promoted the exchange of ideas that en-
hanced connections between present and past learning. When the students disagreed over answers, the issues were resolved by group consensus and the understanding of concepts. This was a difficult but important process because students must be convinced of an answer they initially disagreed with. Furthermore, by discussing each exam question and answer choices, students develop a better understanding of the material and, in the process, gain more self-confidence. Studies have also shown that groups are more than the sum of their parts and that students perform higher when they work in groups (6, 10, 11, 21).

Collaborative group learning has the additional advantage that students learn course content as well as the interpersonal skills required to work together effectively. This is important because employment opportunities in the future will require employees to work cooperatively to solve problems and develop solutions.

Some educators may be concerned that the less-prepared students will simply defer to better-prepared students and/or that the high-performing students may “carry” low-performing students during group testing. However, it became clear to the professor, based on the >4 h of observation during each of the four flipped exams as well as in previous studies (6, 10, 11, 21), that this seldom happens. Observation during each of the flipped exams also made it clear whether or not students understood the complex principles. Earlier work demonstrated that both high- and low-performing students, when they are correct, can generally convince their peers with incorrect responses to change to correct answers. Accordingly, during student discussions, it is more important to have the correct answer than to be the high-performing student of the group. Thus, educators should not be concerned that low-performing students are “carried” by their high-performing peers or defer to their high-performing partners. It is clear that collaboration is critical for determining the correct answer independent of the previous performance of the students. Furthermore, collaborative testing is beneficial for all students (high performing and low performing) since the student with the correct answer prevails most of the time and the changes in responses after the discussions mostly go to the correct answer (11).

This is consistent with the professor’s impressions and student comments that indicated that the flipped exam was fun, challenging, and enhanced learning as well as noncognitive skills. It is our view that the flipped exam facilitated active learning, enhanced problem-solving skills, and encouraged group discussions. Because the flipped exam also increased student involvement, motivation, and interest in the material, we recommend its use for enhancing and supplementing the traditional examination format. Although not investigated in this study, it is likely that the flipped exam has merit with other groups of students and class sizes. The time and stress associated with traditional exams distract instructors from other more meaningful aspects of teaching and learning. Accordingly, it is time to scrutinize our methods and assumptions regarding the traditional exam. Of particular concern is that the motivation to study for a traditional exam is to avoid receiving bad grades. The flipped exam transforms students’ test taking motivations from avoiding receiving bad grades (2, 3, 7, 13, 20) to actually learning the material.

**Limitations.** The major limitation we encountered using the flipped exam was overcoming the resistance and unwillingness of many educators to accept this paradigm shift. Most of our colleagues consider exams as measures of individual competence and the sharing of information during the examination as cheating. However, this attitude places students in competition with one another for grades and negatively impacts student learning (31). Traditional exams also place an emphasis on numeric aspects of learning, which fosters a fear of failure and increases anxiety, undercuts interest, reduces intrinsic motivation, heightens competitiveness, and depresses creativity (2, 3, 4, 7, 20). In fact, rather than stimulating an interest in learning, a traditional exam primarily enhances students’ motivation to avoid receiving bad grades (2, 3, 7, 13, 20). Furthermore, with this approach, students do not remember or, more importantly, understand much of what they learned. It has been reported that students forget much of what they learned in anatomy and biochemistry courses before they graduated (17). In addition, after a short time, students who had high grades in a subject knew no more about that subject than students who had lower grades (17). Similarly, students have very low retention of basic science information by the fourth-year of medical school (25). Furthermore, compared with naive students, experienced students who completed an elementary physiology course did not have a greater knowledge level of physiology or perform better in an upper-division physiology course (22). It is also well documented that science-based undergraduate education has no effect on academic performance by medical students (12). Finally, we documented that retention of acquired knowledge is short lived (6).

In contrast, the flipped exam provides an alternative to the traditional summative assessment and provides an occasion to determine how well students perform when they have an opportunity to collaborate with and learn from peers. This is an important consideration because it has long been known that students learn better by collaborating with others within a social context rather than in isolation (8, 29). Students learn better because the flipped exam provides opportunities for students to construct, articulate, and defend logical responses to complex questions or problems, provides immediate feedback to students about their knowledge and understanding of content, and provides the opportunity for the utilization of this feedback to improve their performance (14). Thus, the flipped exam is an example of formative assessment, or an assessment for learning.

It would be very educational to determine if the flipped exam format improved student exam scores on traditional individual exams. This question merits future consideration. However, despite this limitation, we describe the implementation of a novel, student-centered classroom activity in which students worked together in a collaborative group to search for content and context and discover answers to important questions.

**Summary.** We educators often do too much telling rather than creating environments in which students discover, for themselves, the concepts and principles we want them to learn. However, teaching is not telling! In fact, telling seldom works for deeply understanding complex principles. In contrast, students learn best by discovering new concepts and relating them to what they already know. The flipped exam provides a student-centered examination in which students discover, because of the need to know and opportunities for discussion, the important concepts and principles we want them to learn. Finally, the flipped exam transforms students’ test-taking mo-
tivations from avoiding receiving bad grades to actually learning the material.

DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the author(s).

AUTHOR CONTRIBUTIONS

Author contributions: H.L.L. and S.E.D. performed experiments; H.L.L. and S.E.D. analyzed data; H.L.L. and S.E.D. interpreted results of experiments; H.L.L. and S.E.D. prepared figures; H.L.L. and S.E.D. drafted manuscript; H.L.L. and S.E.D. edited and revised manuscript; H.L.L. and S.E.D. approved final version of manuscript; S.E.D. conception and design of research.

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