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'Other' Reasons to Invert a Class

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"Other" Reasons to Invert a Class

Abstract

Some one-to-one comparisons of the inverted mode of course material delivery versus conventional, in-person lecture mode have shown no significant difference in student learning between the two (Canino[1]). Experience shows that inverting a course is a time-consuming process. To justify the additional work required to invert courses, the present study looks beyond a direct comparison. Some of the reasons are predicated on the fact that video lectures used for inverted courses tend to be significantly shorter in duration than the associated class time. Others are due to class time being freed up for uses other than lecture. Among other things, these facts present opportunities to cover course material more completely and to better assess student learning compared to conventional lecturer mode.

Introduction

The inverted or "flipped" mode of course-material delivery usually comprises arranging for students to view video lectures outside class. As Swartz et al.[2] report, activities during class time may include guest speakers, field trips, taking quizzes, presenting problems to the class, etc.

Conventional course-material delivery will be defined for the purposes of this report to include in-class lecturing with more or less student interaction, and students working problems outside class. The problems may be handed in or practice problems for student learning but not graded.

The inverted mode of instruction has enjoyed significant press lately (e.g. Canino[1], Swartz et al.[2], Lape and Levy[3]). At least some of these studies were intended to compare, directly, the inverted mode with the conventional mode of course material delivery. In other words, attempts were made to keep as much of the course experiences the same, while only inverting the mode of delivery. Results have varied somewhat, but many who have tried this mode have discovered:

1. Students like it;
2. Students do not perform significantly better or worse than in conventionally taught courses.

In perhaps oversimplified terms, the only reason to invert a course based on the results of these direct comparisons appears to be because students like the inverted classroom. Inverting a class can represent a very notable time investment. From this oversimplification, if student performance is not a reason to invert a class, Why would an instructor choose to do so?

The above results have been well advertised. The need for these kinds of studies, exploring if course inversion alone improved student performance, were necessary, instructive, and have guided many of us in our own efforts in pedagogical improvement. The instant objective is to go beyond a simple one-to-one comparison of instruction and report several *other* reasons (other than because students like it) for an instructor to consider inverting a classroom. Typically, a full video lecture is noticeably shorter than a class period. Additionally, class time is freed up for extra learning activities. Several of the "other" reasons described herein are predicated on these facts.

The other reasons described herein include those intended to increase student learning and improve student performance. However, valid other reasons may not directly accomplish those worthy goals. Enhanced student assessment and flexibility in scheduling may be valid other reasons without direct impact on student learning. This work recognizes value in reasons not expressly intended to produce improvement in student performance.

The present work is a list and description of advantages discovered from experience teaching courses using both conventional and inverted modes of instruction. It is intended to help others determine if expending time and effort inverting a class might be advantageous. It is not an inverted classroom tutorial or a list of best practices. Other literature is available addressing those needs.

Student comments quoted herein are taken from several anonymous questionnaires administered at various times during the semester, and from anonymous course evaluations students completed near the end of the semester.

Background

This work is based on experience gained from inverting three courses: two levels of thermodynamics and a fluid mechanics course taken by all undergraduate mechanical engineering students at Trine University. The author has taught each of these courses in both conventional and inverted modes.

Each lecture for these inverted courses is posted as a single video. Students view lecture videos on their own time. If students wish to break the video into shorter segments, they have the opportunity to stop and start at their discretion. Multiple viewings of any lecture or any part of a lecture is an option.

Lectures are created using a tablet computer, PowerPoint, and screen-capture software. Blanks left in the PowerPoint slides are filled in during the lecture while the audio compliments the video, filling in details and adding explanation.

Notes are provided to the students. These notes parallel the videos exactly. The blanks filled in on the PowerPoint slides during the video are present in the notes as well, and the students fill those in while watching the video. Sketches made in the videos are preferably drawn by the students in the notes. The purpose for the pre-prepared notes is to keep students on-task. A student is less likely to view a video as he would a movie if he has notes to complete.

Students are quizzed each class period. One or two example problems per week are presented by the instructor during class time. Students work on practice problems that are not handed in during the remainder of the class period. They are encouraged, but not required, to collaborate while working these problems.

One quiz each week is directly based on a practice problem, or occasionally, more than one practice problem. A quiz problem may be identical to a practice problem, or slight modifications might be made to the practice problem. The purposes of this kind of quiz are to encourage students to work the practice problems in a timely fashion and to assess student learning.

In the other class periods during the week, a "lecture quiz" is taken. Lecture quizzes are open-note quizzes on which the students simply copy what they wrote in one or more blanks in their notes when they watched the lecture video. The purpose for this type of quiz is to encourage students to view the lecture videos before the class period on the date they are scheduled.

Class section sizes for both inverted and conventional classrooms have varied from 15 to 25 students, with an average of 18. Most classes have been held in conventional classrooms, with desks or tables lined up so the students all face the same direction. A few sections have spent part of a semester in a classroom with tables arranged to better facilitate collaboration.

"OTHER" REASONS

Update Class Notes

Traditionally, instructor lecture notes were hand-written, including hand-sketches. This was due, of course, to a lack of alternatives before the advent of the personal computer and convenient software. Many instructors still work from such notes.

Inverting a class is an impetus to revamp and revitalize hand-written notes, and place them in digital form, easily amended later. Artwork created by the instructor can, likewise, be improved easily at a later time.

When the decision is made to change texts for a course, notes in electronic form may more readily be adapted to new nomenclature and order of presentation than handwritten notes.

Probably student learning is not significantly enhanced by revamping and modernizing lecture notes.

Missed Classes

The first semester I inverted a course, classes were canceled the first week of the semester due to snow. Classes were canceled again later the same semester for the same reason. The students in the inverted class were still able to view the lectures on schedule, and they had time on their hands to work the practice problems – albeit without instructor presence. With a minor adjustment, permitting the students an opportunity to catch up with the practice problem schedule before the first quiz, the course went smoothly. Students related there was noticeably less pressure to make up time in their inverted course compared to their conventionally taught courses. Reducing stress may be beneficial to student learning, but this other reason is not necessarily directly related to improved student performance.

Other reasons for missed class time, such as illness of the instructor, an impromptu guest speaker, or an unexpected opportunity for a field trip can be handled with much less difficulty.

Work More and Better Examples

Due to time pressure in a conventional lecture, common items dropped to mitigate that pressure are example problems. While I have been guilty of this many times in a conventional classroom setting, my experience shows that I can cover all the examples I wish to present during a recorded lecture, while still averaging 30–35 minutes per lecture for a 50-minute class period.

When polled, students of an inverted course expressed a desire to have examples presented during class time. The reason given was for a more interactive opportunity. That is, they wished to be able to ask questions while the example was worked. In presenting one example problem per week in class, about two-thirds of the class was satisfied. The other third wished to have more examples presented in class. A common comment in questionnaires and course evaluations is the in-class examples are a benefit:

- Enjoyed in class examples, they helped me understand the lecture notes more in detail.
- The in class practice problems were helpful.

Between introducing more examples during lecture videos, working additional examples during class, and presenting solutions to the quizzes, an inverted class can include a significantly larger number of examples compared to conventionally taught courses. Some students recognize this:

- I enjoyed going over the solutions to the exams and quizzes. Also, in class examples were helpful.

Additionally, when time is not an issue, example problems presented in video lectures and in class may be worked much more formally. If a homework format is required for students, example problems worked for them can be a good reinforcement of this requirement. I have found students tend to mimic my delivery whether I work examples carefully or sloppily. Many faculty believe a formal homework format is helpful to student learning. Setting a good example encourages the students to use that format even when work is not handed in.

Some courses, particularly early in the curriculum (such as freshman classes), suggest instruction on the process of working problems would benefit students. Before gaining much academic maturity, students frequently have difficulty working problems in a clear, logical fashion, even when required to follow a format intended to direct them in this. For instance, it is common for underclassmen to work problems entirely with numbers, despite the requirement to work symbolically. Even when students begin a solution symbolically, a common tendency is to insert values much earlier than practical.

A format for in-class activities, then, can be heavily weighted toward formal problem solving. Such a format can be entirely instructor-led, or student groups may present solutions with class interaction. A combination of these activities, perhaps beginning with instructor-led solutions and evolving toward student group-led solutions as proficiency is gained, may be adopted. These kinds of activities are made possible because the lecture is exclusive of class time, hence providing great flexibility of the inverted classroom.

There is always a tradeoff between spending time working examples and having the students spend the same time working practice problems. If students work the same number of practice problems regardless of the number of examples provided, it seems reasonable to expect student learning to benefit from a greater number of examples.

Review of Prerequisite Material

One of the main reasons for inverting the fluid mechanics course taken by Trine University mechanical engineering students was to review prerequisite mathematics. Experience had shown students' mathematics preparation was seriously lacking, and simply wishing it would improve was ineffective. The quantity of fluid mechanics material presented in this course disallowed including mathematics reviews during conventionally taught lectures.

Mathematics review materials were strategically inserted into the video lectures such that the math was reviewed and immediately used to derive fluid mechanics relations or work fluid mechanics problems.

The results prove this effort was very successful. The second exam in this course is mathematics intensive. As can be seen in Figure 1, before inverting this fluid mechanics course, average scores for Exam II were discouragingly low. After inverting this course and including the mathematics review sections, the second exam average has been equal to or even above the other exams' averages. Scores on the comprehensive final have also benefitted from course inversion and the mathematics review. (The lower score on the first exam may be attributed to a relatively large contingent of juniors whose first inverted course experience was fluid mechanics. Learning in an inverted setting requires some adjustment, and the first exam scores can reflect that.)

Scores for 41 conventionally-taught students and 86 students taught in inverted classes comprise the data shown in Figure 1.

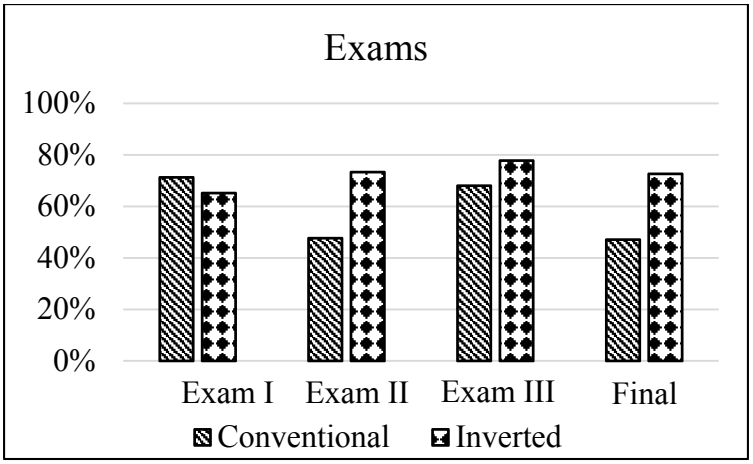

Figure 1. Exam Scores for Fluid Mechanics Students

Many students appreciated the math review. Anonymous student comments include:

- [The] math review was also very helpful getting the concepts back into our minds and thinking about math again.
- Dr. Batson has done a wonderful job with the math review and I found it to be very helpful.
- Math review and in class problems were very helpful.

Although the mathematics review material is not meant to *teach* students the mathematical content, the review obviously reminds students what they learned in their mathematics courses, and connects it with the use of the same methods in fluid mechanics. This has been one of my most successful results in inverting a course. Clearly, this other reason benefits student performance, and was the objective in its inclusion.

Student Assessment

In this age of the Internet, homework assignments to be handed in for credit cannot be taken from the problems in the text. Even when entirely made up by the instructor, these assignments are frequently a disappointment due to students copying one another. Instructors are faced with the options of giving credit to students who have not done their own work, or confronting them for cheating.

Because class periods do not include a lecture in an inverted class, time is available to quiz students regularly as a substitute to, or to supplement, handed-in homework for assessment. Students commonly express appreciation for frequent quizzes, stating that they keep on topic better when they know they will be answerable for their preparation.

Although students can still cheat on quizzes, in smaller class settings it becomes very difficult to do so with a vigilant instructor in the classroom. The instructor also has control of materials to be used by students, such as equation sheets, property data, etc.

At least two different measures can be evaluated using quizzes. One is the students' proper use of the lecture videos and lecture notes. Students may be given an open note "lecture quiz" requiring them to copy a portion of their notes onto the quiz paper. Students who have not viewed the lecture on time will receive a zero. Partial credit need not be given. Students tend to consider these quizzes as encouragement to view the lectures before the scheduled date for them, and as easy points. Full credit can be earned without any understanding of the material, so these quizzes should represent a small percentage of the students' overall grade.

In response to the question, "Are the lecture quizzes effective in encouraging you to view the lectures in a timely fashion?" in an anonymous questionnaire, 75% of students said the lecture quizzes were *very effective*, 17% reported they would have watched the videos, anyway. The remainder said the lecture quizzes were *effective*. Anonymous comments from students about lecture quizzes include:

- Lecture quizzes are always helpful in making sure you watch the lectures in a timely manner.
- The daily lecture quizzes. (Response to the question, "What should not be changed about the way this course is conducted?")

The second measure is associated with the practice problems. A quiz may be constructed to be exactly like a practice problem, or modifications may be made to assure quizzing the students on the same concepts as a practice problem without being identical. These quizzes may be closed book and notes, and thus represent a more significant fraction of the course grade than the lecture quizzes. Students view these quizzes as encouragement to keep up with the practice problems. They are also recognized as still another example after they are handed back and the solution worked out in class. These quizzes provide accurate and timely assessment of student learning.

In anonymous questionnaires, students were asked to provide comments about the inverted class. Comments about the quizzes over the practice problems included:

- I think if this class was *[sic]* not inverted, it would be helpful to still have quizzes every week over practice problems. That way it gives an extra reason to stay caught up and do all of the problems.
- The weekly quizzes help me stay on top of my ungraded assignments.
- I like the quizzes I felt like they helped me stay on top of the class.
- The notes and homework quizzes are VERY helpful in keeping me caught up with the lectures and homework problems.

Due to the frequency of the quizzes, adjustments and interventions based on the adaptive learning model may be made in near real time. These adjustments may be done on a group level, presenting examples, for instance, to strengthen weak areas of learning for the class as a whole. Interventions may also be made on an individual or very small group basis, as well. Because class time can be unstructured, an individual may be given specialized instruction without the need for – or in addition to – a visit to the instructor's office.

The use of homework for student learning and assessment is not precluded in an inverted course. In courses where computer programming or involved problems not suited in their entirety to quizzing, it may still be important for students to work and hand in homework. Fortunately, there is nothing about the inverted course mode disallowing this learning and assessment tool.

The methods used to improve assessment in the inverted classroom appear also to be effective motivators for students. It seems reasonable to conclude student learning and performance benefit from this other reason. Possibly less directly, adjustments and interventions made based on the results of student assessment should also improve student performance.

Review for the Final Exam

For those who have corrected final exams, it can be easy to conclude that many students do not take studying for final exams seriously. There is little instructors can do to force students to prepare for final exams. Because video lectures are shorter than the class period, all the course material can be compressed to free a few class periods of new course material just before final exams. Lecture videos reviewing material in the course may be produced and viewed by the students for these last periods. Practice problems may be chosen to persuade students to review material commonly missed on the final exam. Students may be quizzed over those practice problems just as they are quizzed over other practice problem, hence encouraging them to complete all the review problems.

The express purpose of this other reason was to improve student performance on the final exam. Although it is hoped the effort is valuable in this way, no attempt at quantifying the benefit has been made to date.

Student Collaboration

Presently, students are only encouraged to collaborate as they work practice problems. This semester, a study using two sections of Thermodynamics I will be conducted to determine the value, if any, of structured collaboration. Results are, of course, pending.

Class time may be used in a variety of ways. Indications are students who collaborate most effectively tend to be more successful than those who do not collaborate or those whose collaboration consists of copying from a classmate. Activities encouraging or requiring productive collaboration may be included. Groups of students may be selected by the instructor and changed regularly to expose students to their fellow classmates, and to give them experience working with a broad cross section of people, such as they are likely to find in their occupations. Groups may also be chosen by the students. Group size may be specified or limited by the instructor.

Examples of collaborative activities possible during class time are group quizzes, group presentation of problem solutions, and think-pair-share.

This other reason is also intended to improve student performance.

Summary

Course inversion contributes significant flexibility in course layout and scheduling. Because class time is freed from lectures, student assessment and collaborative activities may be performed then.

"Lost" class time, due to guest speakers, field trips, and snow days are more easily accommodated in the inverted course format.

Since video lectures are shorter than in-class lectures, remedial topics may be presented to bolster student understanding and performance. Additionally, class periods may be freed from new material just before final exams are proctored. Exercises encouraging productive studying for the final exam can be included during this time.

Early findings are that these "other" reasons for inverting a course have successfully increased student learning and improved student assessment.

References

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