Beating the Lecture-Textbook Trap with Active Learning and Rewards for All

David Pengelley

My active-learning journey was sparked decades ago, when I realized I could best help students work on extensive calculus projects by doing so inside, not just outside, the classroom. Thus I needed to reduce lecturing. But with less lecturing, how would I cover the syllabus? And how would students first be exposed to new material? I faced what I call the “lecture-textbook trap.” In this vicious circle, students don’t seriously study text material in preparation for class because they know I will lecture on it. In turn, I must lecture on it because they don’t study it first. Escaping this trap is the hardest thing I ever did in teaching. But liberation opened unimagined pedagogical doors, through which I discovered transformative rewards for both student and teacher.

Concomitantly, I began to question lecture’s overall purpose, efficacy, and necessity. Countless times as a lecturer, students had tellingly told me “I understand perfectly when you lecture, but then I can’t do problems at home.” I slowly realized that while a lecture may feel extremely comfortable to teacher and student alike, and sometimes be inspirational, it accomplishes precious little to help students successfully do mathematics themselves.

The many benefits of shifting from lecture toward active learning are now widely confirmed by scientific evidence, as amply elucidated and referenced in the February Notices [1], which also gives several examples of active learning paradigms (see too [2, 4, 5]). Here I will describe a different paradigm that integrates in and out of class active learning, and I will discuss its rewards for both teachers and students.

As I progressed from lecture toward in-class active learning built upon before-class preparatory work, I saw students increasingly gain confidence, satisfaction, and achievement in their own learning. The paradigm that evolved from this progression has three integrated parts.

Part A resolves the lecture-textbook trap by realizing this motto: Never lecture on something students can instead read and write about. I give students high quality reading on new material, and they write about it, to promote far deeper engagement than mere reading. I do not require much writing, but I expect all students to pose good questions about the mathematics, and describe what they did and did not understand. I also ask lower division students to respond to a couple of reading questions I pose. The overall goal is for students to think meaningfully about new material before class, and to leave no conceivable reason for me to lecture.

A critical feature is that I must receive their writing before I prepare for class. I can then prepare to lead a brief initial class discussion of a few questions I select from

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their written responses, narrowly focused only on what
their writing shows is really needed. This never occupies
more than 15% of class time.

For Part B students prepare easy-to-medium-difficulty
“warm-up problems” on the new material before class,
and bring this work to compare, discuss, present, and
perfect with others, with my help and guidance. When
class begins, students usually do not even notice my
arrival, since they are already engrossed comparing their
prepared work. The goal of class time is for students to
exhaustively resolve these warm-up problems. In class, I
continually circulate to interact with groups of students.
I often select solutions to go on the board, and choose
which students will write them there. We then end with
a whole class discussion of some of their solutions.

Thus the entire classroom experience starts on a higher
plane than first engagement, ends with a satisfying res-
olution of problems, and students both feel and are well
prepared for a few harder homework problems afterward.
The experience incorporates what I consider the essence
of active learning: Reduce or eliminate lecture, and de-
vote substantial classroom time to student involvement
in mathematical work that receives immediate feedback
from other students and from the instructor.

Only once did I make the mistake of lecturing, on a
hard topic, when my students were instead expecting to
work together on their preparatory homework. Rather
than appreciating my lecture, they became frustrated that
I was stealing their collaborative work time! How delight-
ful—they had taken ownership of their learning.

Part C is “final homework” to be completed after class,
just two harder problems that build on the warm-ups
completed in class. These I mark carefully for students,
and I sometimes request reworking to attain top quality.
They represent each student’s highest degree of achieve-
ment on that day’s mathematics. They are not normally
discussed in class.

While the traditional lecture paradigm could be called
“I-You” for “I lecture, then you do homework after class,”
what I describe can be labeled “You-You-We-You” for “You
read and write, you prepare warm-up problems to bring to
class, we master these together in class, and you do final
homework after class.” Observe the shift from “I” to “You,”
along with integration of before-, during-, and after-class
student work. And the answer to the earlier question,
“With less lecture, how will I cover the syllabus?” is that the
syllabus is inherently covered by the learning community
of students and teacher actively working together both in
and out of the classroom, especially now that class time
is devoted to actual work.

You may be wondering whether students will really do
what I expect, and whether I spend my whole life reading
student papers; the answers are yes and no, respectively.

Students do the three-part daily work because I con-
fidently and repeatedly emphasize what to do and the
benefits it will bring them, because there is considerable
peer pressure from group members and the board pre-
sentations I demand, and because they quickly experience
success and confidence. Crucially, too, this daily home-
work is the majority (at least 60%) of the course grade,
with exams minimized, reinforcing the message that the
daily work is the fundament of learning.

Regarding grading, the reading/writing is marked in
literally 5–10 seconds with a +, − only for effort and dili-
gence, and an occasional quick note for them or for my
own class preparation. The warm-up problems are also
assigned a single overall +, − solely for diligence at pre-
paring before class, since they were fully worked through
in class and need no appraisal; this takes even less time,
perhaps 3 seconds. The final daily homework of
just two problems is all that I mark closely, and
it receives a single uni-
fied letter grade, using
no time-consuming,
distracting numerical
points. The course grade
is a holistic evaluation,
with the letter grades
on final homework gen-
erally predominant,
so that evaluation and
learning are in harmony. Overall the amount of time I
spend teaching, including grading and otherwise, is no
greater than when I used to lecture.

The benefits for me as a teacher include rich and satis-
fying interactions with students. There are fewer exams to
grade, an elevated intellectual level of homework evalu-
ation, and a far steadier schedule of time demands for all.
A big difference in the classroom is that its direction now
involves continual unknowns, depending on what arises
from student work, thoughts, and questions, unlike lec-
ture, which is entirely predictable and controlled. This may
be unsettling to some faculty, but I have come to embrace
it. All these features keep me fresh and avoid burnout.

Here are three illuminating student responses: Often, if

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Students often ask why all mathematics classes aren’t taught this way. And students will comment that this approach provides lower stress with more learning, reducing both uneven time demands and the cram-exam-forget phenomenon.

In what courses and of what sizes can this be carried out? I have implemented this, with minor variation, over twenty years of multiple incarnations of sixteen different courses at all university levels from mathematics appreciation and calculus through PhD qualifying exam courses. Some courses have had up to 45 students, taught without any form of assistance. If I were faced with larger courses, I would not hesitate to train graduate or undergraduate assistants to serve both in and out of class, and adapt the paradigm (see [3]). The challenges would be institutional commitment and constraints for supporting an active learning course structure. I would never retreat from melding active learning both in and out of the classroom, since I have experienced its transformative rewards for all.2

References

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2A longer version of this article, with more detail, references, and provocation, as well as guidelines for students, grading, logistics, sample assignments, etc. is at https://www.math.nmsu.edu/~davidp/