Teaching HPC: Lessons from a Flipped Classroom, Project-Based Course on Finite Element Methods

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Background

High Performance Computing (HPC) is an integrative field

- “Computer literacy”
- Programming, parallel computing
- Version control, debugging, IDEs
- Basic numerical methods
- Iterative methods (Newton, Gauss-Seidel, CG, …)
- Finite elements, finite differences, finite volumes
- FFT, Fast Multipole Method

Key Observations

- Teaching many disconnected areas is difficult
- Students learn best via projects with individual feedback
Motivation

Concrete Case:
Finite Element Methods in Scientific Computing (MATH 676)

Course Goals
• Teach graduate students FEM (using *deal.II* library)
• Complete projects useful for students’ research

Challenges
• Insufficient time for individualized project feedback
• Too many students
• Multiple disciplines

Approach
• Record videos, flip classroom
• Journals & reflective writing
Videos

Similar Existing Efforts
• Khan Academy
• MIT OpenCourseware, Coursera, iTunesU
• Linear algebra lectures (Gil Strang)
• HPC (Randy LeVeque)
• Direct solvers (Tim Davis)

Our Videos
• 48 lectures (~35 hours)
• Covers FEM, general HPC methods
• Hands-on demonstrations
• Recorded in a professional TV studio
• Hosted on YouTube (~1000 views/month)

http://www.math.tamu.edu/~bangerth/videos.html
How do we know students watch the videos?

Class Discussion

Individual Feedback & Interaction

Research Journals
In the form of GoogleDocs and shared with the instructor
  • Simultaneous editing
  • Close monitoring of student progress and learning

Containing:
  • Table of contents
  • Record of videos watched
  • Project log with dated entries
What else can we do with journals?

Reflective Writing

Goals

• Help students identify (and adjust, if needed) patterns of behavior
• Engage with the big picture of the research process

Structure

• Write periodic meta-reflection essays in learning journal based on reviewing the regular entries to date
“Video lectures was one of the important aspects for the course like this. I have gone back many time to the previous lectures in case of some doubts. Also I can refer them in the future.”

“[A]s far as class structure, I found it very useful that we got one-on-one time with the professor to give guidance with our projects during the class period, so I completely agree with the decision to have most lectures done as video lectures outside of class. Also, I like video lectures because we can re-watch them when we need them. This is especially helpful in a class like this because some of the lectures demonstrate how to use software, so the visual component is useful, as opposed to just writing notes to read later.”
“[T]he most helpful tool for my learning was by asking questions and receiving answers [...]. This is extremely useful because when having a face-to-face class, it was difficult for me to ask questions due to cultural differences. I tend to be shy when asking questions in front of other classmates. However, this journal entries allowed me to ask as many questions I can without a fear.”
“Keeping journal of learning is one good experience I have had for this course. Initially it felt like berdon but then gradually, mainly after spring break I got into the habit that whenever I worked for the project I kept my journal open so that I can record what I am doing. Also the responses, I got [...] was very helpful and quicker way, I would say, to get my doubt answered. Also, when I watched the lecture video, I thought I understood everything and then I sat to write the summary for that made me think what I really have learn and what was the most important points in the same. Some time I have seen lectures twice or thrice to write it down.”
“From taking this course and participating in a reflective exercise, I found what I was missing: To really understand the material at a deep and intuitive level the student needs to think very hard about "why" questions. I feel like this exercise [...] helped me to gather my thoughts [...] and really understand the processes that lie deeper than the surface. I plan to continue using a reflective journal through my PhD study and have found a nice tool that will help me do this.”

“Enroling in this course has exposed me to much more material than I expected. Most of all, the instructor has changed the way I approach problems. His exercises of self-reflection have made me become a more thoughtful student.”
“This semester has been a unique experience for me. I have often wondered what education is going to look like in a few years. I see all these online education classes popping up at many schools and have a hard time seeing how they can compete with the classes on campus. I have had to work with students in those types of classes before and have found that learning was not really happening at all. I don’t see them lasting very long. I really enjoyed this semester and found myself wishing more classes were structured in a similar pattern. I liked having the lectures available online and then having class where we could practice and get our hands into the material. It fit my learning patterns perfectly. I could see many more classes successfully patterned in this manner.”
Challenges, Opportunities, and Conclusions

Challenges

• Reflective writing is difficult for students!
  • STEM discounts personal opinions and experiences
  • Cultural influences
• Flipped courses have a high barrier to entry

Successes

• Achieved goal of increased interaction with students; more time for individual project work
• Students seemed to genuinely appreciate the format

Conclusions

• Worth the effort!
Thank You!

For More Information

• See the conference paper

• Contact us
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• Videos: www.math.tamu.edu/~bangerth/videos.html
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