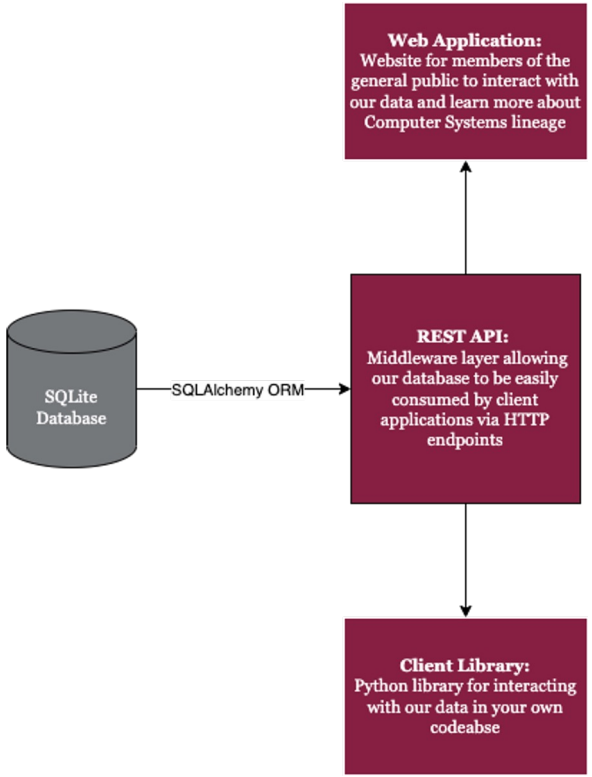
Integrating DevOps to Enhance Student Experience in an Undergraduate Research Project

Ryan Gniadek, Godmar Back, Kirk Cameron, Margaret Ellis

ASEE 2022 Annual Conference - Software Engineering Division

What is the CS Genome project?

“Since the dawn of computing, the world has tracked system performance. Yet, computer system performance data is still primarily siloed by benchmark, system, or system component. The Mission of the Computer Systems Genome Project (CSGenome) is to conduct the first scientific effort to catalog the lineage of computer system performance over time to enable knowledge discovery and further understanding of the impact of computing innovations on transformative technologies, the knowledge-based economy, and societal change.”



What is DevOps?

- The concept of “DevOps” first emerged within large software companies to bridge the gap between the development of software and the deployment of that same software [6]
- In effect, this typically means using tools like Continuous Integration, Continuous Delivery, and microservices to support an agile workflow [6]
- DevOps has become a bit of a “buzzword” lacking a consistent definition [7]
    - Most definitions converge on the idea that by giving developers deeper exposure into their system, iteration happens more frequently and with higher quality [6]

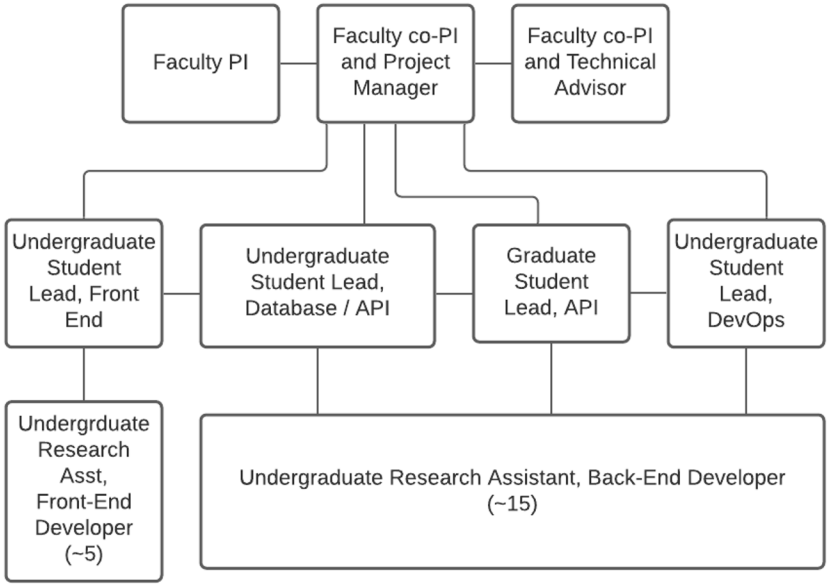
Context

Project Organization

In the Fall 2021 semester, we had a large group of inexperienced students with a small group of experienced student leaders

Numerous challenges:

- Onboarding / acclimating to a large code repository
- Making collaboration a positive experience
- Giving students skills that are relevant not just in academia but also in industry



Existing Cultural Practices

- Students work in subgroups with peers and student mentors
- Daily working sessions and weekly all-hands meetings / stand-ups
- Technical demos / presentations and code-reviews
- Instant messaging via Discord
- GitLab issue tracking

Building off these existing practices, we started applying tooling we learned from industry to our project

Implementation of DevOps

- GitLab issue tracking / milestones to track progress
- Continuous Integration pipeline using Gitlab CI/CD suite

Implementation of DevOps

Initial use case is relatively trivial with only build and test stage

The build-job has three basic tasks:

- Install and activate the python virtual environment
- Install the python dependencies into that environment
- Create a new copy of the database for the purpose of testing

After the build-job succeeds in preparing the test environment, the test-harness-job simply activates the python virtual environment and then runs the test harness using pytest.

With DevOps, we were hoping to give all project members a better experience on our project

Motivation

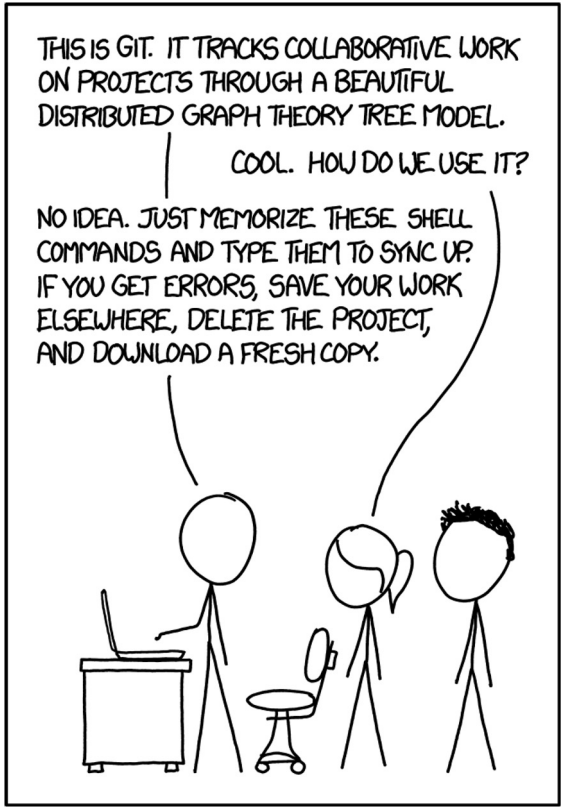
Incorporating Industry Practices into Coursework

- Students generally appreciate courses that are taught in coordination with industry professionals, that incorporate industry tooling [1]
- More specifically, tooling that provides automated feedback has been shown to improve student outcomes [2]
  - Less time “blocked” waiting for a student mentor or professor to give feedback
- Involving students in the creation of a test harness used to provide such feedback further reinforces the benefits of testing
  - Test driven development is also a popular practice in industry

Practical Computing Skills

- Virginia Tech Computer Science has recently begun to teach foundational skills like Git and shell scripting as part of first year experience courses [13]
- Eddy et al. learned by introducing CI/CD into software engineering courses that not only did it increase student understanding of CI/CD but also reinforced more basic concepts like Git [9]

And yet, our research project relied on self learning to reinforce these skills



Project Management Skills

- DevOps enables the quicker delivery of software features [6][8] and often goes hand-in-hand with agile workflow
- Agile in education has become popular supporting capstone experiences [10] or other self-guided student projects [11]
- Similar research groups have also successfully used Agile to overcome a large student to faculty ratio [12]

While Agile has become very popular in the classroom and research settings, CI/CD and accompanying DevOps technologies are not as commonly used in research settings

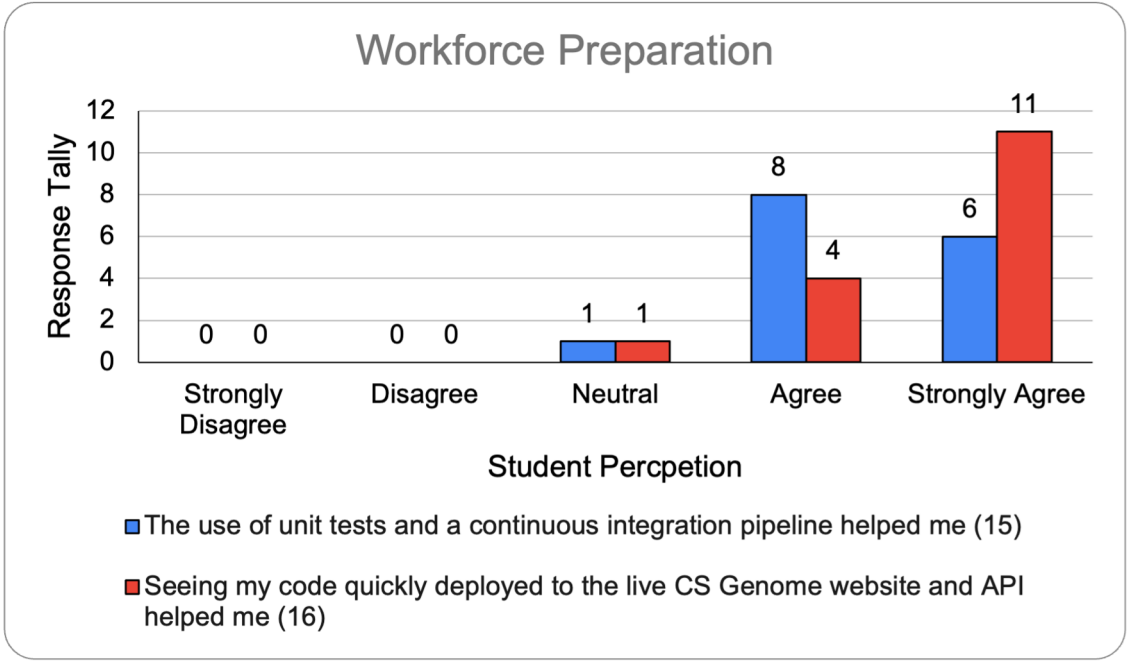
Results

Survey Methodology

- We anonymously surveyed students in our group to:
  - Determine their pre-existing exposure to Continuous Integration and Continuous Delivery
  - Ask how much they feel they learned about CI/CD since it was introduced to the project
  - Share perceptions on how working in groups on our project has compared to group work they've done as part of class projects (which are often less structured)
- Categorized respondents into two groups
  - 6 students joined before Fall 2021 vs. 10 students joined in Fall 2021

Semester Started in Project	Fall 2019	Spring 2020	Summer 2020	Fall 2020	Spring 2021	Fall 2021	Total
Number of Respondents	1	1	1	1	2	10	16

Preparation for Workforce



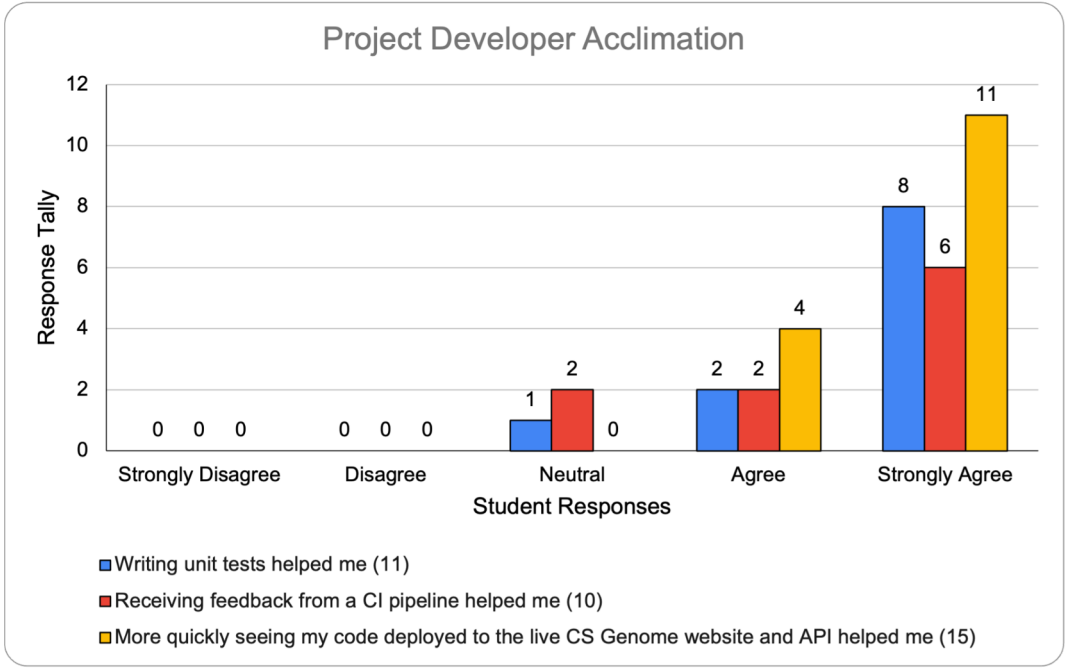
Preparation for Workforce

*"I loved the **exposure to version control software such as GitLab**, and the organization of our merge requests**.** I liked how the people who reviewed merge requests were very particular and thorough. I also appreciated the onboarding process as there were lots of documentation and tutorials that the leads provided, which helped me grow to the code. I believe **onboarding is always a big deal in joining any new project**, and by completing this, I have a better handle in future onboarding tasks. Finally, I appreciated our **focus on test-driven development and weekly stand-ups similar to Agile methodology that the industry uses.**"*

Preparation for Workforce

*"Thanks to CSG, I feel like **I now have an edge compared to my peers** when it comes to experience with the kinds of **systems prevalent in the workforce**."*

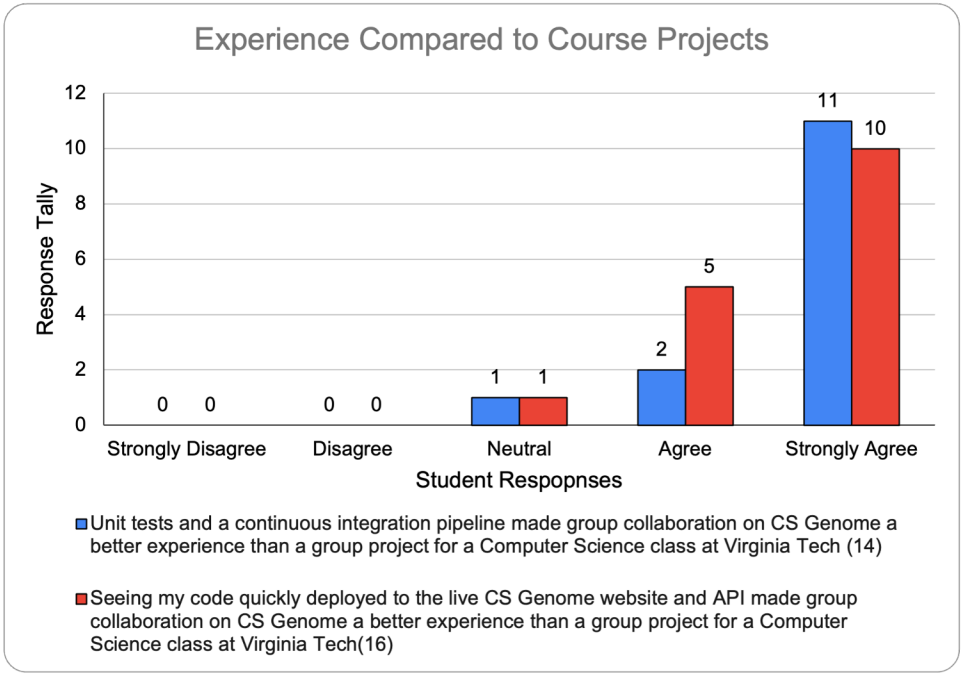
Research Project Onboarding



Research Project Onboarding

“There was a lot to learn in a very short period of time. This made it difficult, and the first few weeks I was definitely sprawling around trying to figure everything out. With the ***unit tests and CI pipeline, these really helped get acclimated*** *because we already had some experience with unit testing. I wouldn't say these necessarily helped the most in the onboarding process, but* ***later in the semester these REALLY helped with debugging and developing the endpoints****. Overall, just help from other students in CSG is what made the biggest difference in onboarding.”*

Comparing Research Experience to Coursework



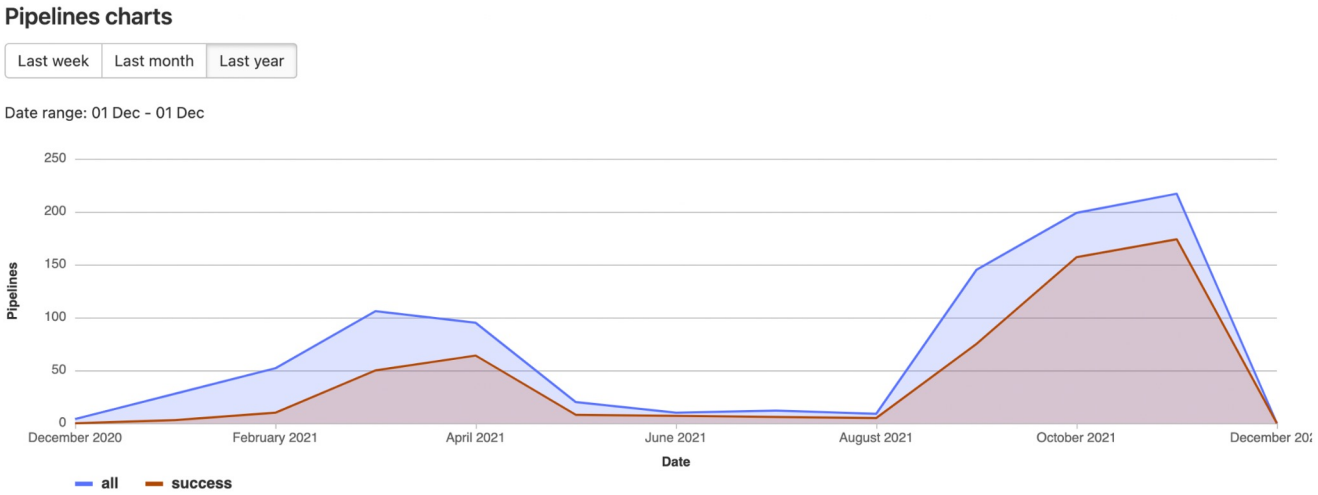
Comparing Research Experience to Coursework

*"I **loved working with my peers** as everyone was very responsive on Discord, and it seemed that the faculty and students were engaged with the project, which really **distinguishes this project from computer science classes** as in computer science classes, many students are just working for the grade. I also appreciated the **Agile methodology type meetings we had where we discussed our blockers, progress points, etc, which is heavily used in the industry.**"*

Comparing Research Experience to Coursework

*“I've done one group project in CS 2114 and **we did not know how to use Git**. In CSG, **I've learned how useful and efficient Git makes team work**.”*

Increased Iteration and Deployment



Future Work

- Additional CI checks such as front-end linting, back-end/front-end version compatibility checks, and database schema modification tracking
- Staging site to view codebase in production-clone/QA environment before deploying to our publicly available production server

Acknowledgements

This material is based upon work supported by the National Science Foundation under Grant Nos. CNS 1565314 and CNS 1939076. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

COLLEGE OF ENGINEERING

COMPUTER SCIENCE

VIRGINIA TECH™