



2025 CAE Community Symposium

Changing Undergraduate Cybersecurity Instruction

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ANECDOTAL HISTORY

15 Years ago – Certs

7 Years ago – Degrees

2024 – need to *do*



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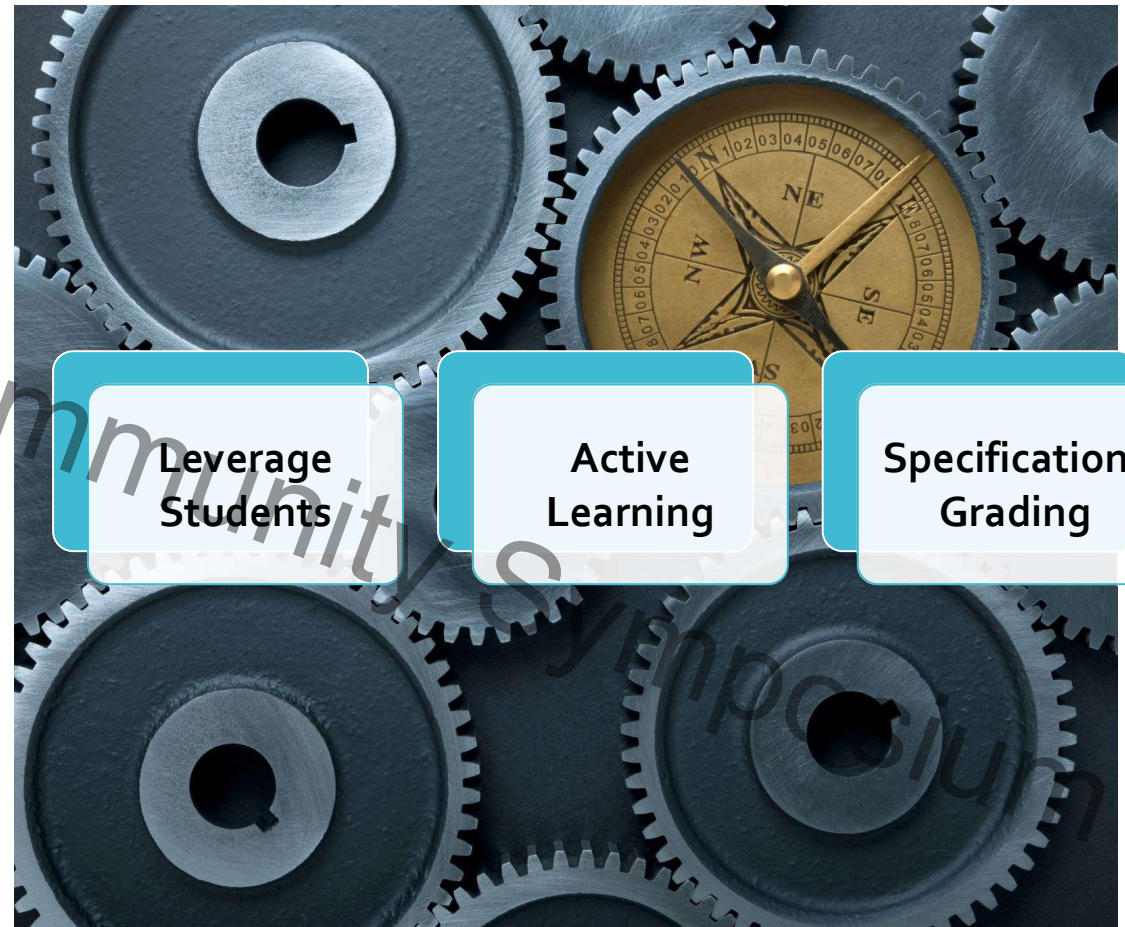
My undergraduates are asked to demonstrate knowledge at interviews

Certs seem to be following the trend

- DoDD 8140
 - Demonstration of Knowledge
- CompTIA
 - Adding performance-based questions
- (ISC)²
 - Multiple Choice
 - Hands-on experience

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Investigate
three
mechanisms
to change
teaching



Mechanism 1

Leverage
Students

- Job Fairs
- Internships/Jobs
- New Thinking
- Energy
- Open to Learning

Mechanism 1

Students write
the textbook
and update it
annually

Mastering Enterprise Networks

Step-by-step labs to create, attack, and defend enterprise networks



Mechanism 1

Textbook

- Student led
- What they wish they had learned
- 50 Chapters of hands-on labs
 - Build Enterprise Networks
 - Attack
 - Defend
- All FREE
- Doable on a modest laptop



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Chapter Structure

- Learning Objectives
- Prereqs
- Resources
- Content
- 2 Homeworks:
 - Easy
 - Challenging

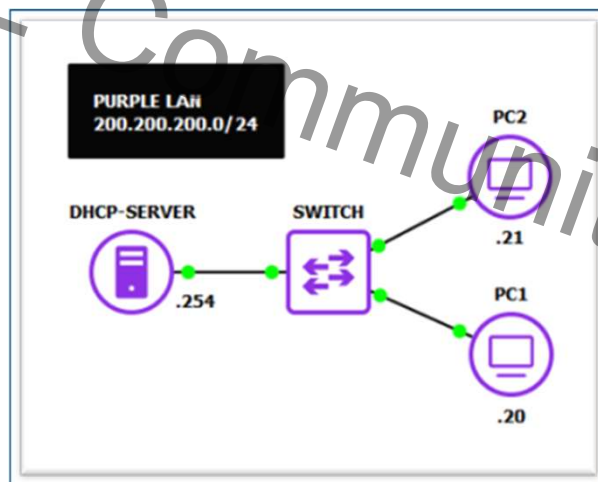


LEARNING OBJECTIVES
<ul style="list-style-type: none">• Create a working GNS3 Learning Environment on a PC or laptop
PREREQUISITES
<ul style="list-style-type: none">• Install Oracle VirtualBox
DELIVERABLES
<ul style="list-style-type: none">• None – This is for student needs
RESOURCES
<ul style="list-style-type: none">• GNS3 Documentation
CONTRIBUTORS AND TESTERS
Testers: <ul style="list-style-type: none">• Quinton D. Heath Van Horn, 7th Grade• David Reese, Mathematics Student, SUNY Brockport• Cody Shinkyu Park, Honeywell Software Engineer, ERAU-Prescott Alumni• Salvador Morales, Safety Management System Analyst, ERAU-Prescott Alumni• Evan Paddock, Cybersecurity Student, ERAU-Prescott• Dante Rocca, Cybersecurity Student, ERAU-Prescott• Sawyer Hansen, Cybersecurity Student, ERAU-Prescott• Bernard Correa, Cybersecurity Student, ERAU-Prescott
NOTES
This lab has been tested on various Intel CPUs running Windows 10 or Windows 11
Phase I – Install GNS3 Environment
GNS3 comes in two parts: the GNS3 working environment and the GNS3 Virtual Machine (VM). This section covers the installation of the GNS3 environment.

Example

Build a DHCP server and observe its functions on a sample network

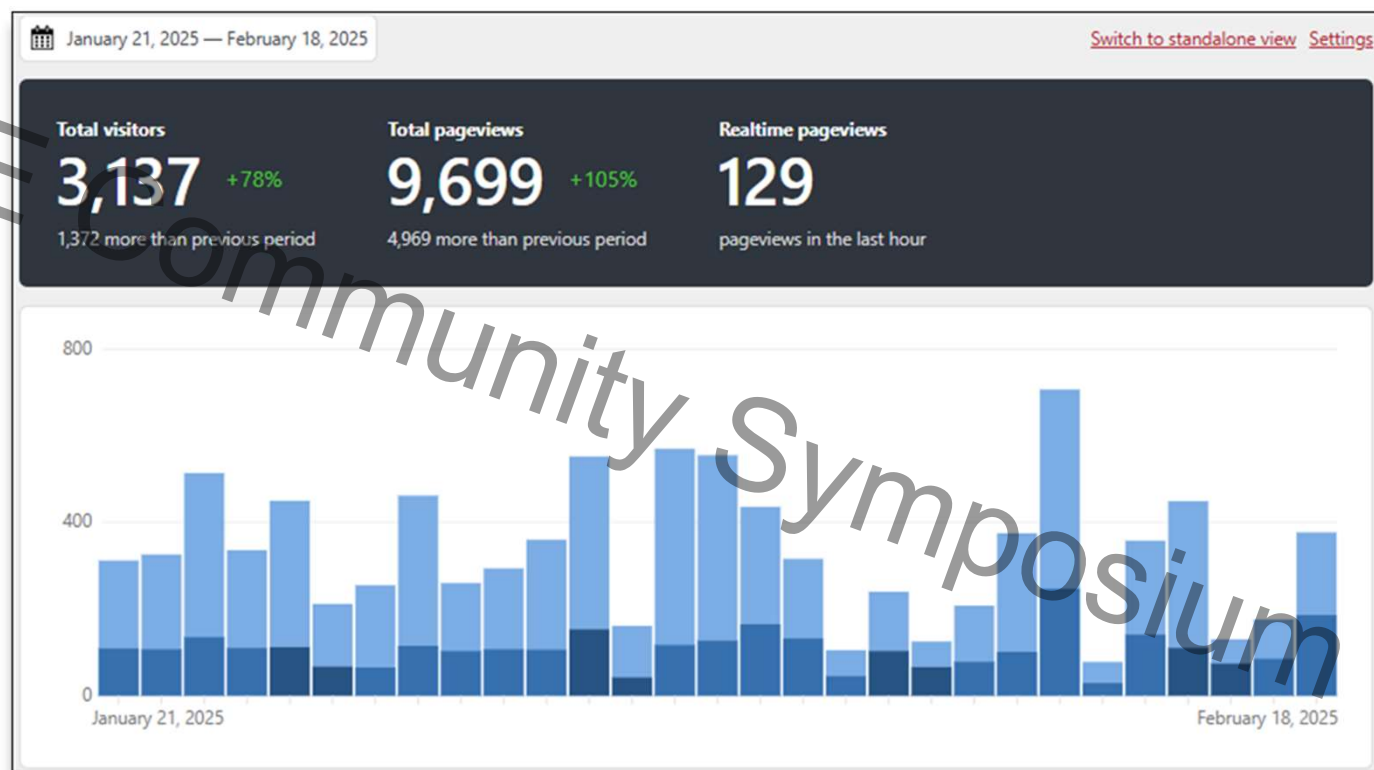
Reinforces lecture, readings, and assessments



Deliverables
<p>5 screenshots are needed to receive credit for this exercise:</p> <ul style="list-style-type: none"> Wireshark - DHCP Packets for PC2 Wireshark - DHCP Packets for PC3 Wireshark - ARP Packets for router GNS3 Workspace with 3 PCs, switch, router, and DHCP server - all devices labeled with their IP addresses Configuration settings of Windows Server DHCP
Homework
<p>Assignment 1 - Combined network traffic watching</p> <ul style="list-style-type: none"> Turn off all devices Replace the switch with a hub and reconnect all devices Monitor any of the PCs with Wireshark and capture ARP, DHCP, and ICMP packets for all three PC's as you turn devices back on <p>RECOMMENDED GRADING CRITERIA</p> <ul style="list-style-type: none"> Screenshot of GNS3 environment with everything labeled Screenshot of server-router ARP Screenshot of DHCP for one PC Screenshot of ICMP for one PC <p>Assignment 2 - Reconfigure the DHCP server</p> <ul style="list-style-type: none"> Figure out the number of devices that can be attached to the switch Generate a random IP address and choose a subnet that will allow the use of all the switch connections with as few wasted IP addresses as possible Reconfigure the network to use these new network addresses Reconfigure the DHCP settings to issue IPv4 address in this new space <p>RECOMMENDED GRADING CRITERIA</p> <ul style="list-style-type: none"> Screenshot of the DHCP configuration Screenshot of the GNS3 workspace Screenshot of server-router ARP Screenshot of DHCP of one PC Screenshot of ICMP of one PC

After 7 months...

“My 20-minute interview turned into an hour because they wanted to speak about my work on the textbook. When they made the job offer, it was not for the entry-level position I applied for.” - Jake



ERAU – University of Minnesota – Pima Comm College – NSA’s CLARK

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Mechanism 2

Prioritize Active Learning

- Lecture vs Hands-on
 - Typical 80/20
 - Changed to 20/80
- 1 day lecture – 2 days labs
 - Monkey see, monkey do
 - Homework and exploration
- Students *want* to complete readings because it makes the labs much easier.



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Student
Quotes From
Fall 2024



Really loved the hands-on work, especially since we'll be doing more of this in industry.

Professor Mathew Heath Van Horn prioritizes hands-on learning, which I believe is one of the best ways to teach students and keep them engaged.

This class was very informational and had key ideas that will 100% help me in my career.

Hands-on learning

Data collection
underway

Longitudinal study of biology hands-on learners
after 2 years:

- Improved work quality and knowledge retention
- High favorability of hands-on learning

Using Ji et al.'s attitude instrument, do
cybersecurity students have favorable
views of hands-on learning?

• Ji, Q., Zhang, R., Duan, X., Tripp, J. N., Liu, X., & Cheng, C. (2024). Using hands-on learning video assignments in online and in-person contexts: A longitudinal study. *Eurasia Journal of Mathematics, Science and Technology Education*, 20(7), em2466. <https://doi.org/10.29333/ejmste/14706>

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Mechanism 3

Specifications Grading

- AKA Mastery Grading (competency-based assessments)
- Students meet standards or not
- Clear expectations for grades on Day 1

Specs Grading is like Climbing a Mountain

A Students - Create, Evaluate

B Students - Analyze, Apply

C Students – Apply, Understand

D Students – Remember

Specifications Grading (CI 311)

A Students (create, evaluate, analyze)

Complete Requirements for B, C, and D students PLUS:

- ✓ Create a Defensive Lab
- ✓ Evaluate 2 defensive labs using the weekly lab report format
- ✓ Self-Assessment Report (Weeks 8-14)
- ✓ Must pass all three exams (Mid-term, Final, Hands-on Final)

B Students (analyze/apply)

Complete Requirements for C and D students PLUS:

- ✓ Complete all but one Homework Assignments* (e.g. N-1)
- ✓ Must pass two exams (Mid-term, Final, Hands-on Final)
- ✓ Complete the Group Project (SEED LAB)

C Students (apply/understand)

Complete Requirements for D students PLUS:

- ✓ Complete 9 Homework Assignments
- ✓ Complete the Secure Your Data Fortress
- ✓ Self-Assessment Report (Weeks 1-7)
- ✓ Must pass one exam (Mid-term, Final, Hands-on Final)

D Students (understand/remember)

- ✓ Complete all 5 preparatory lab HW
- ✓ Complete 4 of 5 pre-midterm HW†
- ✓ Complete 5 of 6 post-midterm HW†
- ✓ Complete mid-term and final exams (passing is not required)

Tokens

3 Tokens: Can be used to retake the mid-term exam and/or resubmit a report, project, or homework. No retakes are allowed on the final exams. The deadline to use tokens is prior to the start of Week 13.

*Max total can sometimes change

‡ Demonstrates mastery of learning objectives without exam stress



Longitudinal study of 900+ chemistry students

- Student learning improved
- Students didn't believe their learning improved

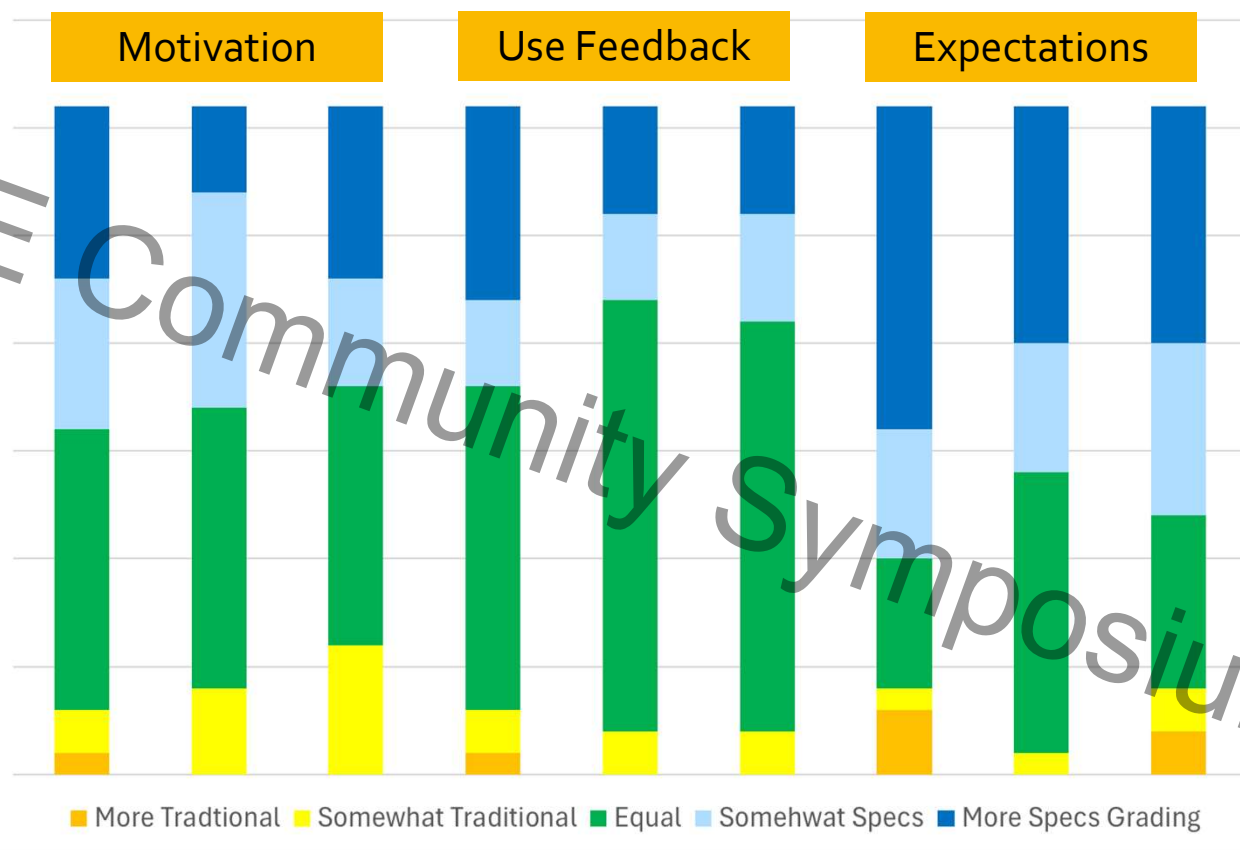
Using Yik et al.'s instrument, do cybersecurity students appreciate specifications grading?

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Specs Grading

Data collection
underway

• Yik, B. J., Machost, H., Streifer, A. C., Palmer, M. S., Morkowchuk, L., and Stains, M., "Students' Perceptions of Specifications Grading: Development and Evaluation of the Perceptions of Grading Schemes (PGS) Instrument", *Journal of Chemical Education*, vol. 101, no. 9, pp. 3723–3738, 2024. doi:10.1021/acs.jchemed.4c00698.

Preliminary Data N=29



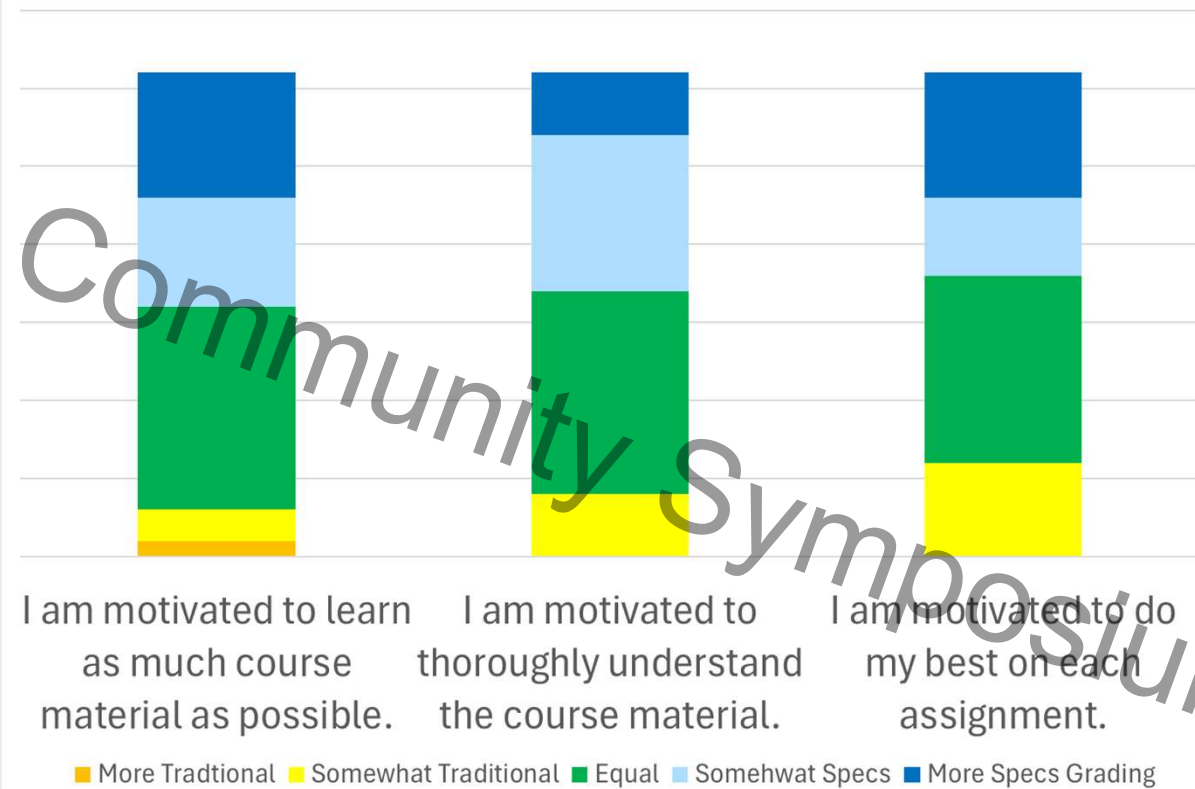
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Data is
Collected

Analysis is
Underway

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Motivation

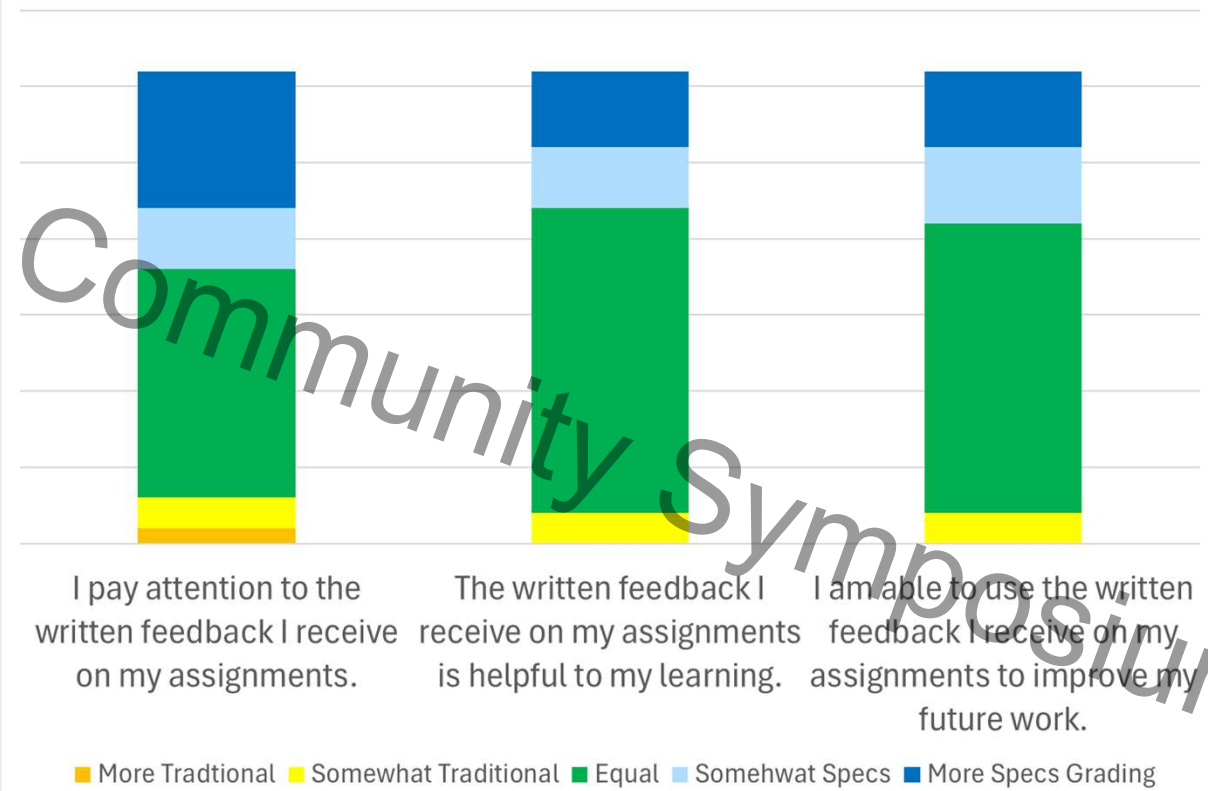
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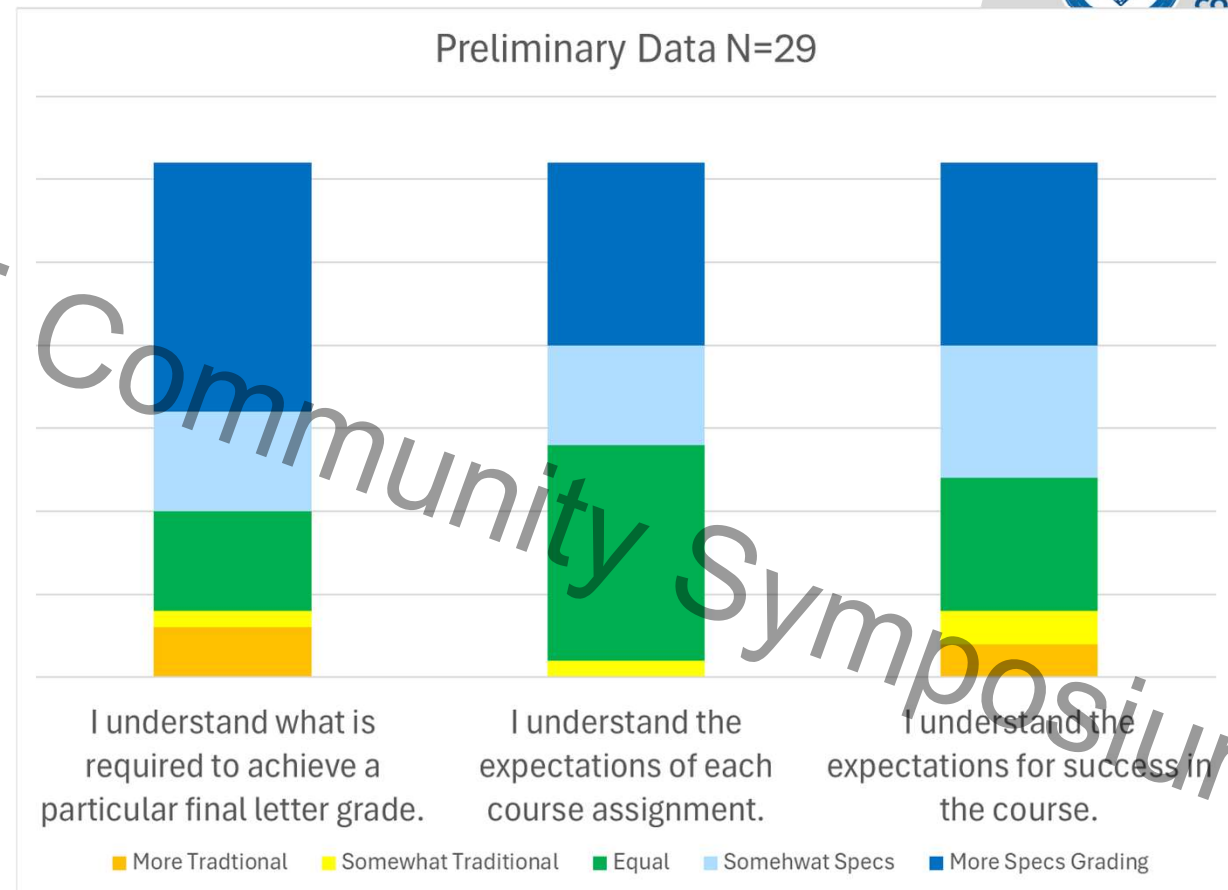
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Feedback

Preliminary Data N=29



2025 CAE Expectations





Quotes

Dr. HVH gave us immediate feedback on our briefs and essays, which was very helpful.

I like the structure of his course; however, it's very disheartening working so hard over the semester and, if you fail a part of the final exam, your grade drops so much.

The specs grading system can use some improvement, but it is definitely an improvement from the old systems.

Conclusion

- Having students develop coursework seems to benefit the students
- Hands-on learning is very well received
- Specifications grading needs some tweaks, but seems to enhance student learning



Way Ahead

- Pass textbook responsibilities to students
- Hands-on learning is ready to expand population
- Remeasure specifications grading after changes are implemented



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