Improving Undergraduate STEM Education Initiative

Enhancing the Learning Experience: Implementable and Adjustable Learning Models for Educators

Dr. Martene Stanberry
Dr. Sheila Tabanli
Dr. Sheryl Burgstahler

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AAAS IUSE Initiative

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WORKSHOP

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WORKSHOP

First-year Achievement by Supporting Students Transitions in Engineering Implications for Academic and Career Development in Undergraduate STEM Education

May 22, 2025

Martene L. Stanberry, Ph.D.
stEm PEER Leader
Professor of Mathematics
College of Life and Physical Sciences
www.tnstate.edu

TENNESSEE STATE UNIVERSITY
"Think. Work. Serve."

Overview of Presentation

- Introduction
- Review of Related Literature
- Methods
- Results
- Conclusion

Introduction

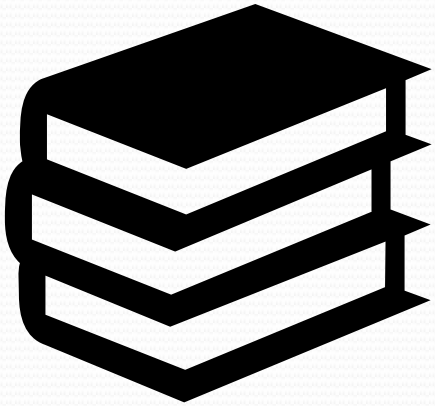
Tennessee State University

- A public, coeducational, urban Historically Black University founded in 1912
- Offers associates, bachelors, masters, and doctoral degrees
- In Fall 2024 the undergraduate enrollment was 5,057 with 65% female and 35% male students
- In Fall 2024 the enrollment in architectural, civil, electrical, and mechanical engineering, and computer science was 602 students (11% of the undergraduate population)

First-year Achievement by Supporting Students Transitions in Engineering (FASST in ENGR)

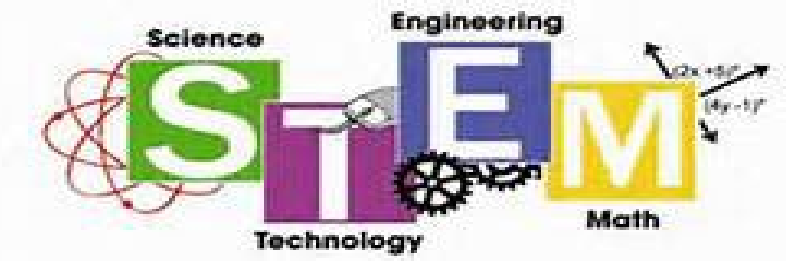
FASST in ENGR

- Funded project with support from Department of Homeland Security through Northeastern University
- Two cohorts of undergraduate engineering students at Tennessee State University were engaged in *academic and career development* activities to augment their academic experiences



FASST in ENGR Project Goals

1. To increase science, technology, engineering, and mathematics (STEM) student learning and engagement
2. To retain more underrepresented minority (URM) students in the engineering disciplines
3. To improve the graduation rate of engineering students



FASST in ENGR Expected Outcomes

To enhance undergraduate STEM student awareness of academic and career opportunities in STEM

To increase the number of engineering students prepared to engage in research

To develop a culture of undergraduate engineering student success

Review of Related Literature

Cohort Learning Model

O'Neil et al., 2019

A *cohort* shares five characteristics:

- defined, long-term membership
- common goal
- common series of learning experiences
- structured meeting schedule
- network of synergistic learning relationships.

Hansen et al., 2023

Cohort-based interventions have been effective in helping low-income and underrepresented students buffer against feelings of low sense of belonging, isolation, and alienation in competitive STEM majors.

Professional Development

Blunstein et al., 2022

STEM student *professional development* refers to specific interventions, programs, research, and other efforts designed to enhance STEM students' interest, self-efficacy, identity exploration, STEM skills, and their intention to pursue STEM careers.

Belser et al., 2018

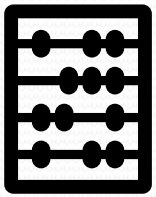
Career development activities have shown efficacy with general undergraduate populations, but have been studied less commonly with STEM-specific undergraduate populations.

Experiential Learning

- According to the Association for Experiential Education (AEE), the hallmark of *experiential education* is “challenge and experience followed by reflection, leading to learning and growth.”

- This approach to learning emphasizes *student engagement* through direct experience and deep *reflection* to increase knowledge, develop skills, and define values (AEE).

- Throughout the *experiential learning* process, the student is actively engaged in posing questions, investigating, experimenting, being curious, solving problems, assuming responsibility, being creative, and constructing meaning, and is challenged to take initiative, make decisions and be accountable for results.



Methods

Overall Goal:

- To put students on a pathway to persistence and graduation in engineering disciplines as well as prepare them for internships and post-graduation opportunities.

Methodology:

- Data was collected through multiple means

Timeline of Project:

- 2024-2025

Program Design

- Two major components:
  - *Academic development*
    - Academic success modules
    - Goal setting
    - Research paper
  - *Career development*
    - Experiential learning
    - Seminar series
    - Reflective journaling
    - Presentations by Career Center

Student Selection

- Enrolled in multivariable calculus
- Demonstrated potential to benefit from the program
- Total of 16 scholars
  - Fall 2024 Cohort
    - 3 sophomores
    - 5 juniors
  - Spring 2025 Cohort
    - 2 freshmen
    - 1 sophomore
    - 4 juniors
    - 1 graduating senior
- Majors:
  - Architectural engineering
  - Civil engineering
  - Computer science
  - Electrical engineering
  - Mechanical engineering

Results

Data

- This model engaged participants in independent and collaborative activities with an emphasis on strengthening academic skills, offering exposure to engineering careers, and building career readiness.

- Data were collected through unstructured interviews, surveys, reflective journaling, experiential learning, and observations to explore experiences, opinions, characteristics, and preferences of participants.

Question 1

What motivates you most to succeed in engineering? Select up to 2 choices.	
Good job opportunities	91%
Passion for engineering	58%
Hands-on projects	33%
Scholarships and financial incentives	25%
Faculty/peer support	17%

Question 2

As an engineering student, what challenges make it harder for you to stay motivated? Select all that apply.	
Course difficulty	58%
Time management/workload	50%
Lack of hands-on learning	33%
Unclear career opportunities	33%
Feeling disconnected from peers and faculty	33%

Question 3

What additional resources or support would help you feel more academically and professionally prepared? Select all that apply.	
More tutoring/academic support	33%
Career counseling/job placement assistance	42%
Networking events with industry professionals	58%
More hands-on projects and labs	67%
Internship/Co-op	67%

Question 4

What academic or professional skills have you developed or enhanced as a FASST in ENGR Scholar?

word cloud of responses

Question 5

Using a word or phrase how would you describe your experience in the FASST in ENGR Program?

word cloud of responses

Conclusion

Key Takeaways

1. A *cohort learning* model benefits students by providing increased accountability, enhanced motivation from shared goals, more engagement due to peer interactions, and building a sense of community.
2. *Professional identity* can be developed through personal values, goal setting, participation in professional organizations, continuous learning, reflection, mentorship, networking, and building a reputation within the chosen career path beginning with an internship, co-op experience, or undergraduate research.

Implications of the Research

Significant Findings

- FASST in ENGR Scholars had the ability to connect with each other, faculty, and recent STEM graduates outside of the classroom setting.
- The average GPA for all Scholars was 3.52, so these are high-achieving students.

Interpretation of Findings

- This allowed Scholars to develop a rapport with peers, faculty, and STEM professionals.
- For this student population there seemed to be a desire to strengthen career knowledge and skills through internships, hands-on projects/labs, and networking with prospective companies.

Implications of the Research

Significant Findings

- During the seminar series Scholars interacted with representatives from DHS Center for Accelerating Operational Efficiency and recent TSU graduates who are early career STEM professionals. The Scholars reported the seminars were insightful and inspiring.
- It is important for engineering students to build a sense of belonging and self-efficacy.

Interpretation of Findings

- The seminars provided the Scholars with insights about successfully navigating college, career opportunities in STEM, and utilizing data and technology to solve real-world problems (like weather reporting and airport security).
- This can enhance a student's commitment to persist in the major and strengthen their desire to become a STEM professional.

Implications of the Research

- This study adds to the emerging body of knowledge on the effectiveness of cohort-based interventions on URM students majoring in STEM disciplines.
- This study also adds to the knowledge base on the impact of professional development activities on undergraduate students majoring in STEM disciplines.
- There are opportunities for theory development in how a cohort learning model can be enhanced by incorporating specific academic and career development activities.

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Thank you!

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Enhancing the Learning Experience: Implementable and Adjustable Learning Models for Educators

Sheila Tabanli, Ph.D. (she/her)

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Rutgers University-New Brunswick

***Acknowledgement:** Rutgers-NB Diversity, Inclusion, and Community Engagement (DICE) - Tyler Clementi Center Research2Practice fellowship program.

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Know the Presenter

Dr. Sheila Tabanli (she/her) is a STEM educator with 25+ years of experience in curriculum, instruction, and assessment in K-16 settings. She is currently an Assistant Professor of Teaching in the Department of Mathematics at Rutgers University-New Brunswick. Recipient of the 2024 Rutgers-New Brunswick Chancellor's Faculty Excellence in STEM Diversity award, Dr. Tabanli focuses on bridging the research-to-practice gap in math education. Her innovative approaches, including the creation of interdisciplinary Methods of Mathematical Problem Solving, a course recognized for its purposeful, student-centered approaches, as evidenced by strong student evaluations and improved student achievement in STEM courses. She brings extensive teaching and mentoring experience across multiple countries, with a particular focus on empowering women in STEM and academia on a global scale.

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Abstract

Is introductory mathematics a gateway or a gatekeeper to STEM?

This presentation, positioned at the intersection of evidence-based mathematics education, cognitive science and social emotional learning (SEL), explores how self-regulated learning framework can guide students to self-advocate to improve their sense of belonging and success in their STEM courses. Using insights from a non-traditional undergraduate hybrid course Methods of Mathematical Problem Solving (Math125) at a flagship university as designed by the presenter, the session highlights the practical applications of evidence-based strategies to empower learners to develop a robust STEM identity through the self-regulated learning (SRL) framework.

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Session Goals

(Goal#1) Identify how the self-regulated learning (SRL) framework can be used to promote student self-advocacy, belonging, and academic success in STEM courses.

(Goal#2) Examine the integration of evidence-based practices from mathematics education, cognitive science, and social emotional learning (SEL) to support holistic STEM learning.

(Goal#3) Analyze practical applications of SRL strategies in a non-traditional undergraduate math course (Math 125) to understand how they contribute to the development of students' STEM identity.

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Guess & Check:
What is the Most Hated Subject from the 1950s?

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The Most Hated Subject from the 1950s to Now...

September 18, 2024

Minding the Perception Gap in College Math Classrooms and Beyond

Math educator Sheila Tabanli offers three instructional strategies that instructors teaching the "most hated subject" can integrate into courses to create a community of learners focused on compassion and connection.

By Sheila Tabanli

Socially acceptable myths about math education include "people with certain gender identities have innate ability to pursue math careers" and "some people have a math brain that favors them to understand math easier."

seb_ra/iStock/Getty Images Plus

A 1956 *New York Times* article details a report from the Educational Testing Service of Princeton, revealing that in elementary and secondary school, mathematics earned the title of "the most hated subject."

Fast-forward to the 2020s, and in the higher education setting it is widely acknowledged that—feelings aside—mathematics underpins all other STEM disciplines. The evidence is clear that calculus often serves a gatekeeping function across STEM disciplines. The disparities in math education disproportionally affect students from historically marginalized demographics. When asked why they are leaving STEM degrees, students often report being frustrated with courses overburdened with content and with pacing structures that inhibit comprehension and reflection, according to math scholar Elaine Seymour's testimony to the Committee on Science of the U.S. House of Representatives.

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Guess & Check:
What is the nationwide average DFW for Calculus I?

5%

10%

25?

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DFW Rates in Calculus I

White & Mitchelmore, 1996

Research continually shows that calculus is consistently a difficult subject for students, mainly because of the abstract concepts required with many of the topics.

Gordon, 2002. Special Reports at EdSource.

At 21 of the CSU's 23 campuses, at least 20% of students on average in Calculus 1 received D or F grades or withdrew over the past three years, according to an EdSource analysis of data from the schools. Administrators consider "DFW" rates of 20% or higher a matter of great concern. At 10 of those campuses, including Los Angeles, the DFW rates have been 30% or higher in Calculus 1.

Bressoud et al. (2024), The Calculus Sequence (MAA)

Because of their centrality, calculus courses are under enormous pressure. Enrollments are large, failure rates are high (the average DFW rate in Calculus I is 27%), and many partner disciplines complain that too many students who have completed their study of calculus struggle to use that knowledge. Few colleges or universities have the resources to cut class size or undertake significant restructuring of the course. In those fortunate places where a dean or provost has promised targeted funding to improve calculus instruction, it is seldom clear how those funds would be best spent.

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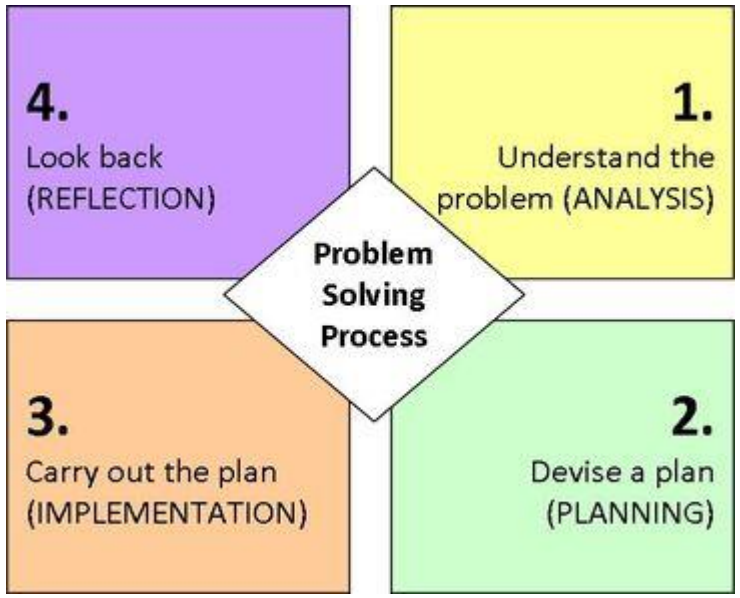
Polya's Framework for Mathematical Problem Solving



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Self-Regulated Learning

- Self-regulation refers to self-generated thoughts, feelings, and behaviors that are oriented to attaining goals (Zimmerman, 2000).
- Self-regulation is *not* a mental ability or an academic performance skill; rather it is the self- directive process by which learners transform their mental abilities into academic skills.
- Learning is viewed as an activity that students do for themselves in a proactive way rather than as a covert event that happens to them in reaction to teaching.

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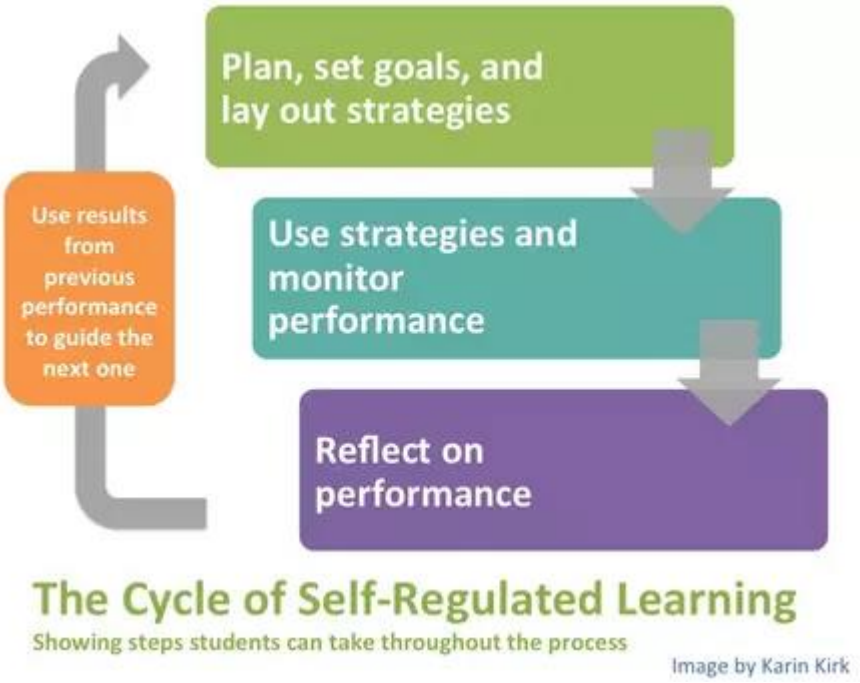
The Cycle of Self-Regulated Learning



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Gaps in Mathematics Teaching & Learning

- Math Readiness Gap
- Math Achievement Gap
- Pandemic Learning Gap
- *Research-to-Practice Gap in Math Teaching & Learning*
- Novice-to-Expert Perception Gap

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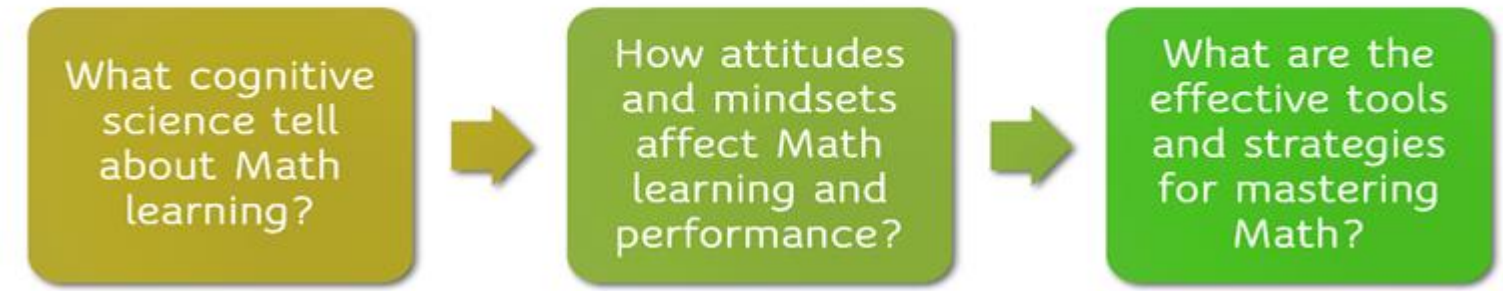
The Framework: My Course Design

Figure 1.
Essential Questions for Methods for Mathematical Problem Solving (M^2PS)



- **RR2PG instructional framework & 3C Pedagogical Model**
  - Grounded on research in cognitive science, such as chunking, retrieval practice, metacognition.
  - Grounded on research in SEL (Social Emotional Learning) such as self-compassion, perseverance, normalizing mistakes, and celebrating progress.
- Fink's Significant Learning Theory (Learn how to learn and other dimensions)

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*Manuscript in writing

RR2PG (Reducing Research2Practice Gap In Teaching) Instructional Framework *

Prior to Class	During Class	After Class
• Priming Effect. • Retrieval Practice.	• Retrieval Practice. • Dual coding. • Chunking. • Elaborative Interrogation.	• Retrieval Practice. • Pomodoro. • Spaced Repetition. • Interleaving.

Social Emotional Learning (SEL)

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*Manuscript in writing

Let’s Analyze:

Without solving the following problem,

Please list the skills, procedures, concepts, etc., that a student must master to solve this problem accurately.

How many different concepts did you list? 1, 5, 20??

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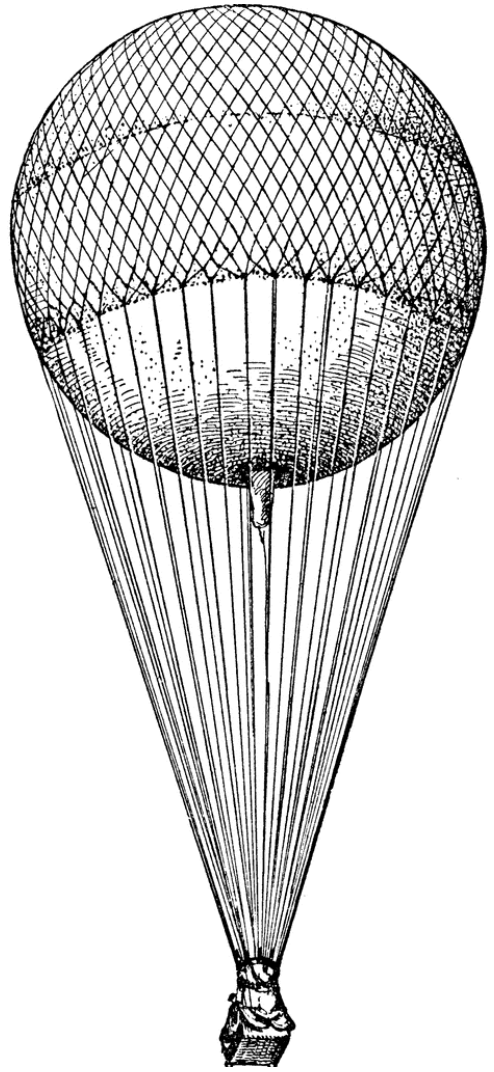
Math 135: Calculus I
Chapter 3: Derivatives
3.11 related rates problem

- A spherical balloon is being filled with gas in such a way that when the radius is 2 ft., the radius is increasing at the rate of .15 ft/min. How fast is the volume changing at this moment?



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Learning and Teaching

Learning is complicated.....

Teaching is complicated.....

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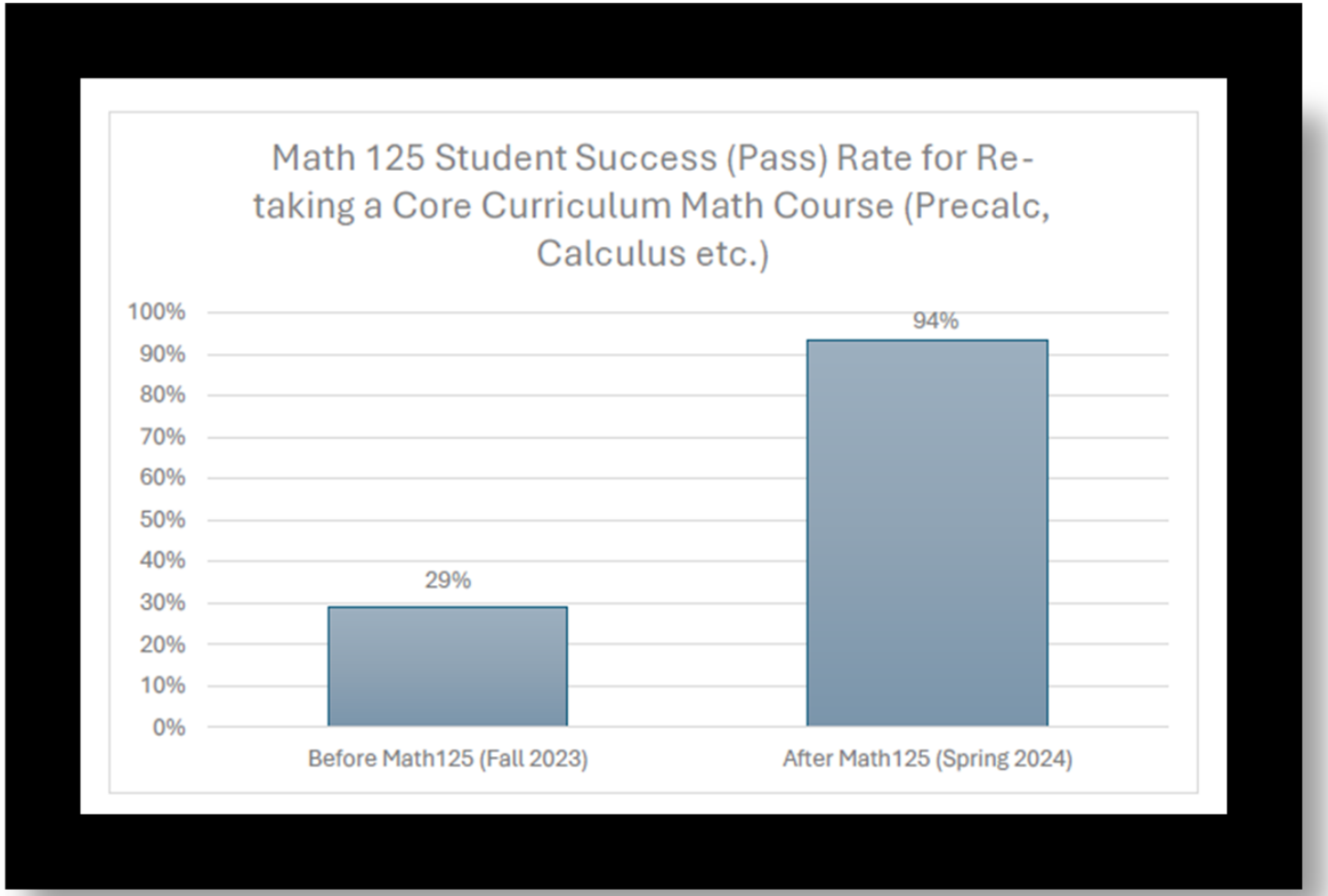
Quantitative Data Outcome



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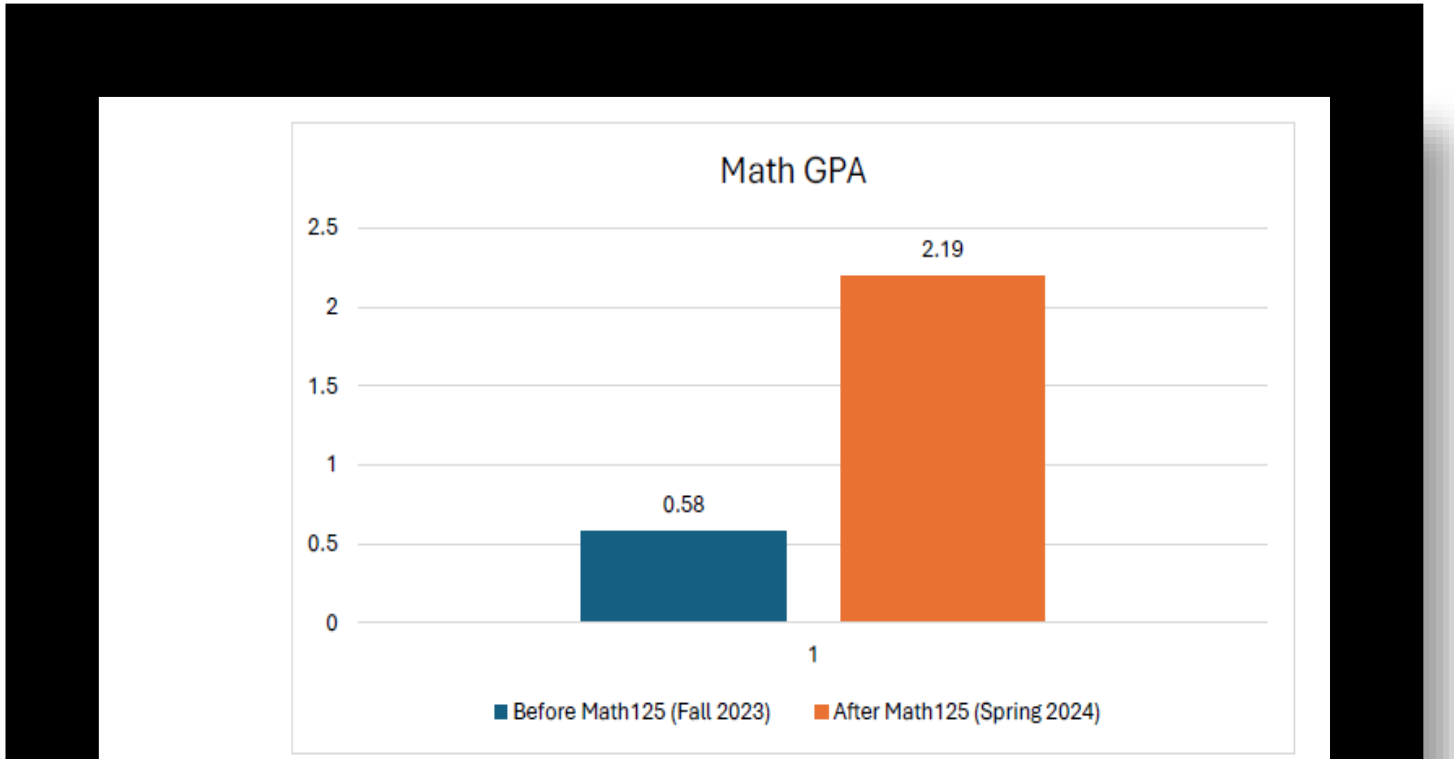
Quantitative Data Outcome



Total number of students: 31

Source: Data Analysis by Math Head Advisor Dr. Emily Sergel on June 6, 2024

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Learning and Teaching

Learning is complicated.....

Teaching is complicated.....

The way I see the content as the instructor (content expert) is different from how students (novices) perceive the same content. This is due to a cognitive bias called the **curse of expertise**. If this is not acknowledged and addressed, it creates a gap called **Perception Gap**.

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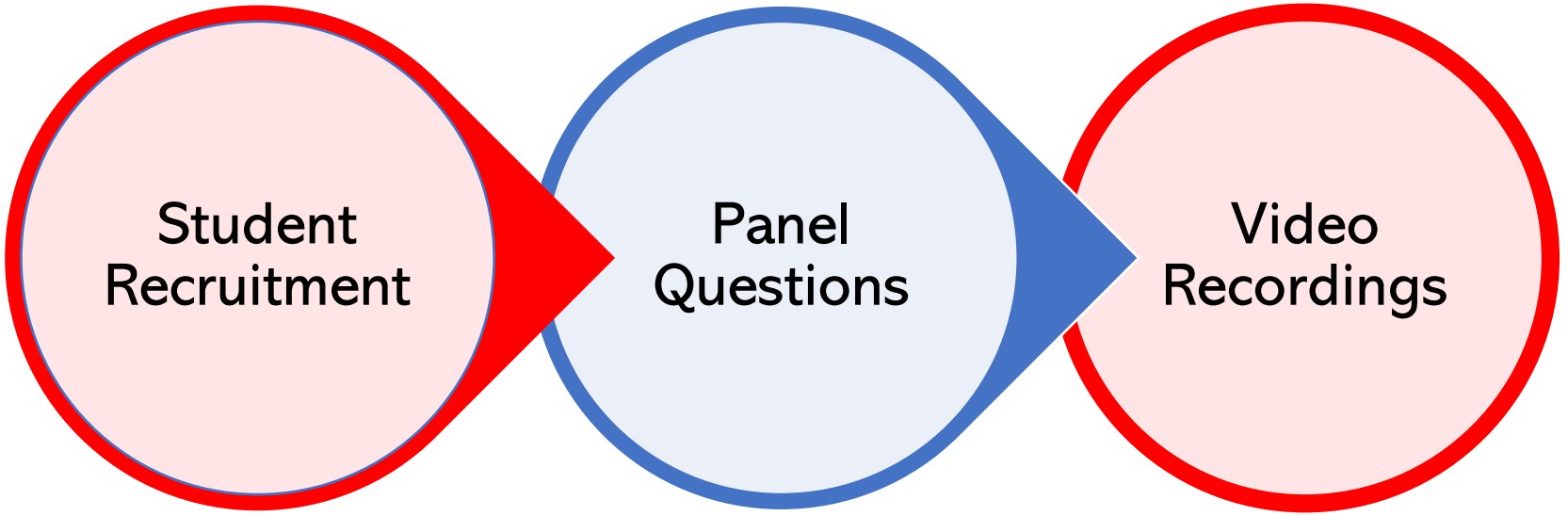
Rutgers Research2Practice Fellowship: Perception Gap Between Novices and Experts



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Rutgers Research2Practice Fellowship: Interview Questions for Virtual Student Panel

Comparing and contrasting their ***K-12 and Rutgers*** math learning experiences

Finding the memories of moments of **joy** in learning math.

When confused, ***speak up*** and ask questions (or not) and how often.

Any other memories about their math learning experiences.

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Rutgers Research2Practice Fellowship: 3C Pedagogical Model

(3 C's)

Compassionate Math Teaching & Learning in a **C**onnected **C**ommunity *through* ***C****ognitive Apprenticeship*

- Judgement-free learning spaces matter
- Connections to real-life examples and curriculum matter
- Connections with peers and instructor matter
- Addressing the curse of expertise matter (*step-by-step instructions for procedures w/ wait time*)

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Rutgers Research2Practice Fellowship:

What do you wish your professor would know about you and your learning math?

- “That other students and I need to be walked through concepts and problems, step by step for understanding”
- “Learning math would be more joyful for me if class wasn't mainly about a professor talking to a group of students. I wish math classes were more interactive and collaborative. “
- “Sometimes I just need that push in the right direction because sometimes when I'm in a classroom setting it's really hard for me to understand it and I'm afraid speaking up in class may embarrass me because I have other peers around me and they could understand it and I'd be afraid that I'll be the only one that doesn't understand it.”

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Rutgers Research2Practice Fellowship:

What do you wish your professor would know about you and your learning math?

- “Their passion for the subject really translates over to how much I'm engaged with it…that really sees how the skills I'm learning are going to benefit me in the real world, and their passion makes me feel more passionate about the subject.”

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Tabanli, S., Guidebook for Reducing the Novice-to-Expert Guidebook for Reducing the Novice-to-Expert Perception Gap in Mathematics to Increase STEM Diversity, **U.S. Library of Congress, Copyright Registration Number: TXu002462200, 2025**.

https://go.rutgers.edu/TabanliGuidebook

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GUIDEBOOK

for Reducing the Novice-to-Expert Perception Gap in Mathematics to Increase STEM Diversity

By Sheila Tabanli, Ph.D.
Research2Practice Program Fellow

Funding & Partnership Acknowledgment

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Partnership: Rutgers SAS Educational Opportunity Fund (EOF) Program.

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Improving STEM Education by Making Digital Content Accessible to All Students, Including Those with Disabilities

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UNIVERSITY *of* WASHINGTON

Consider ability on a continuum

understand English, social norms
see
hear
walk
read print
write with pen or pencil
communicate verbally
tune out distraction
learn
manage physical/mental health

Note

- Races/ethnicities, gender identities, disabilities, other characteristics may not be obvious
- Consider intersectionality
- Many students with disabilities do not disclose them
- Campuses primarily offer accommodations to individuals *after* inaccessibility is discovered

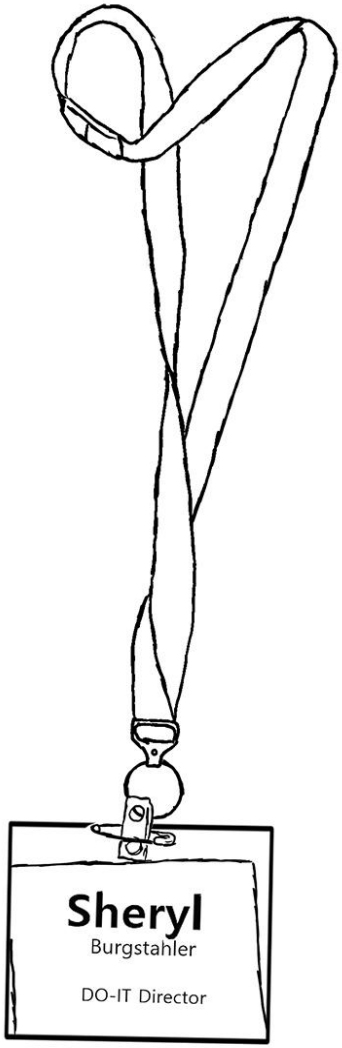
Common & expensive accommodations for courses

- Making inaccessible documents accessible, mainly reformatting PDF files
- Captioning videos

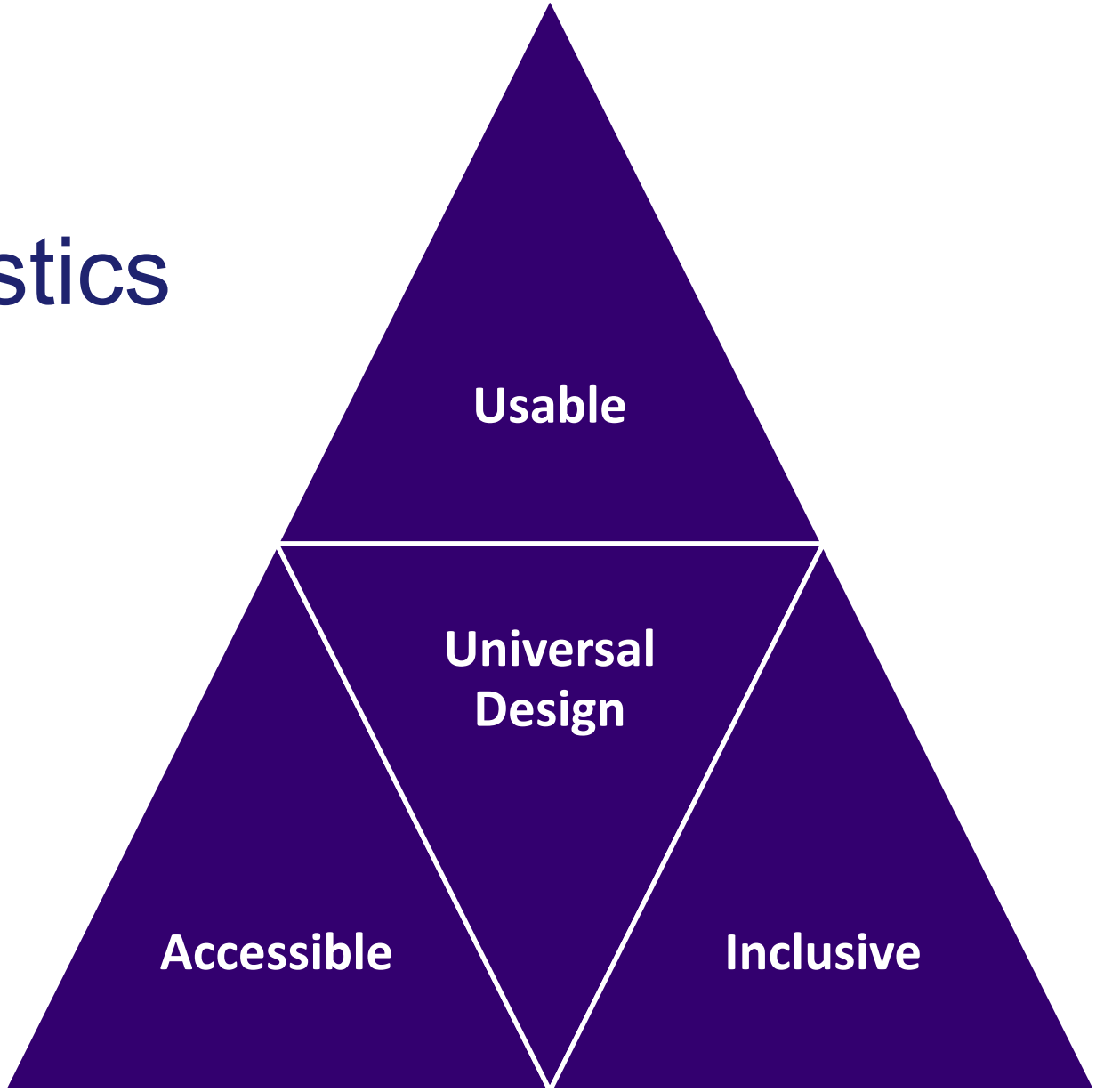
Definition: Universal design (UD) =

"the design of products & environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design."

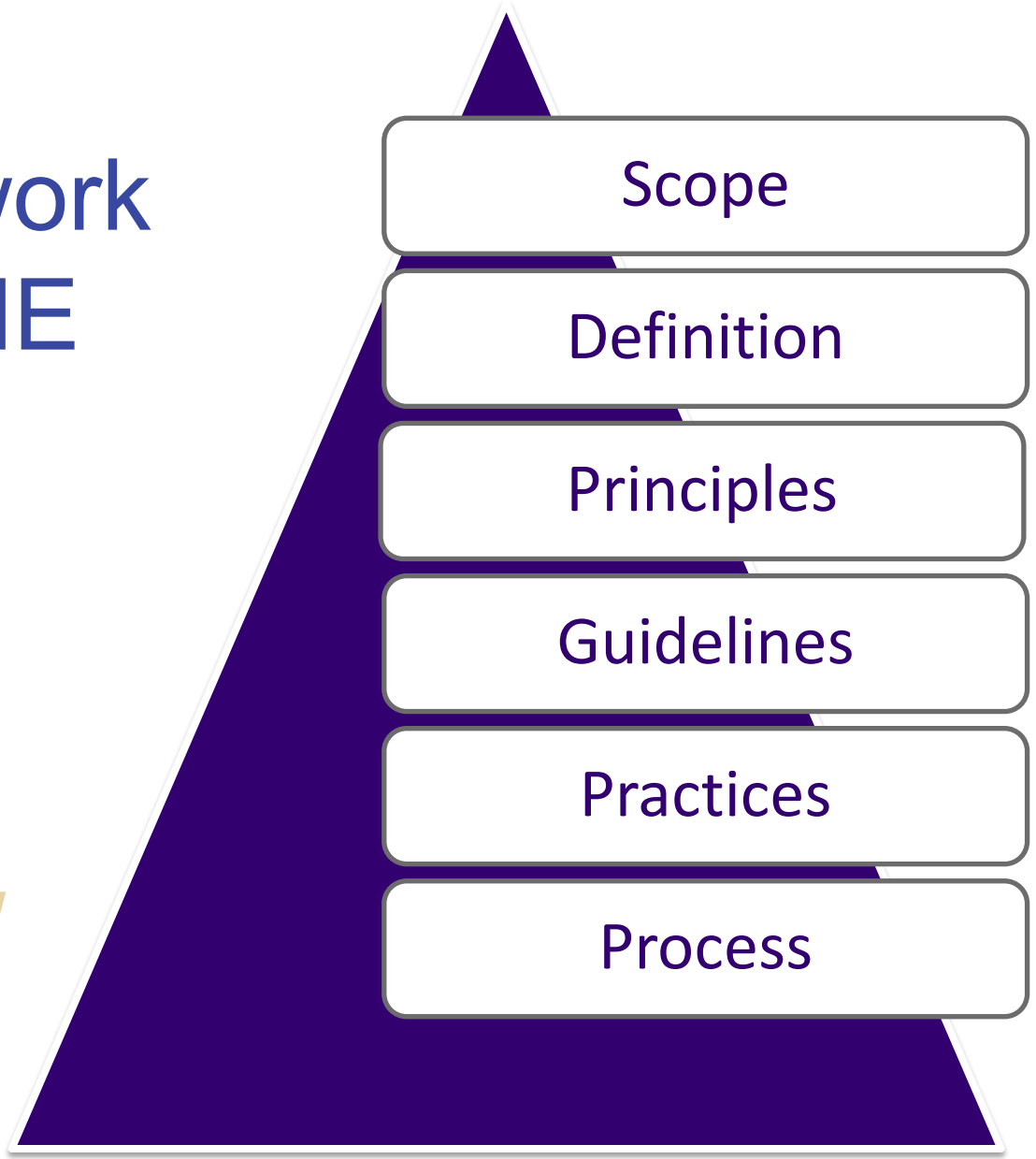
The Center for Universal Design
www.design.ncsu.edu/cud



UD characteristics

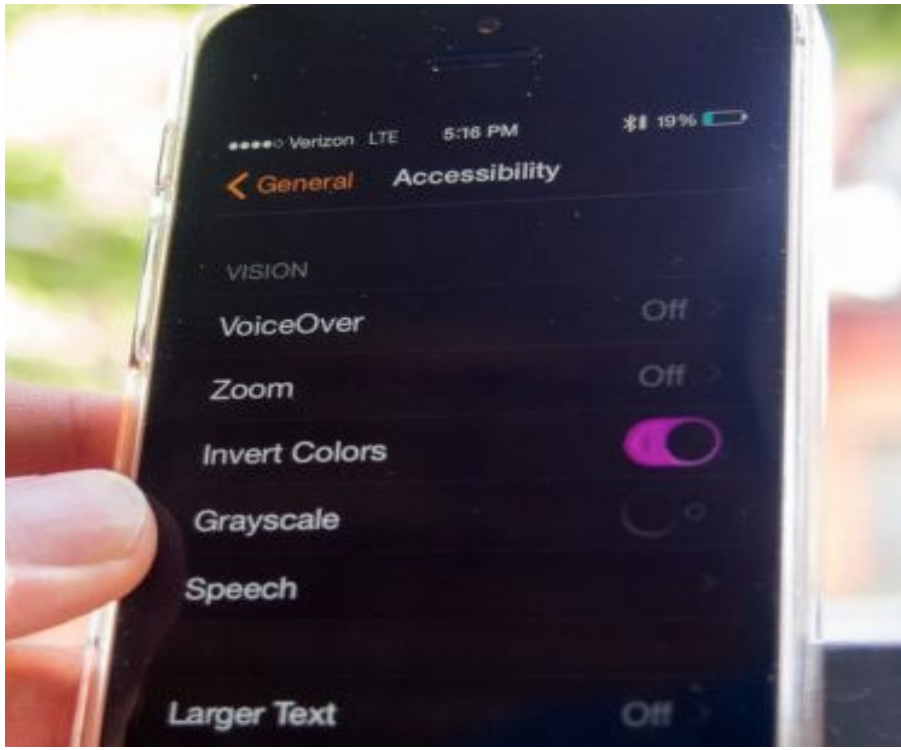


Framework for UDHE



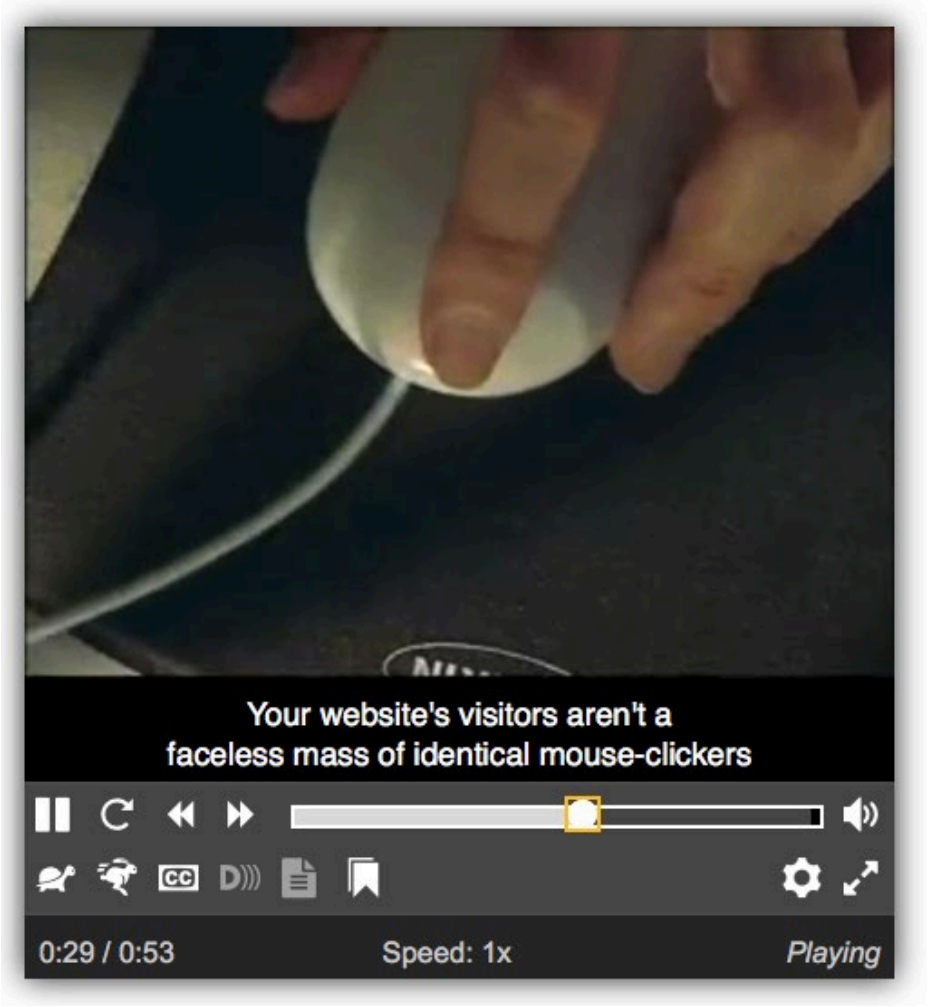
UD of technology

- builds in accessibility features



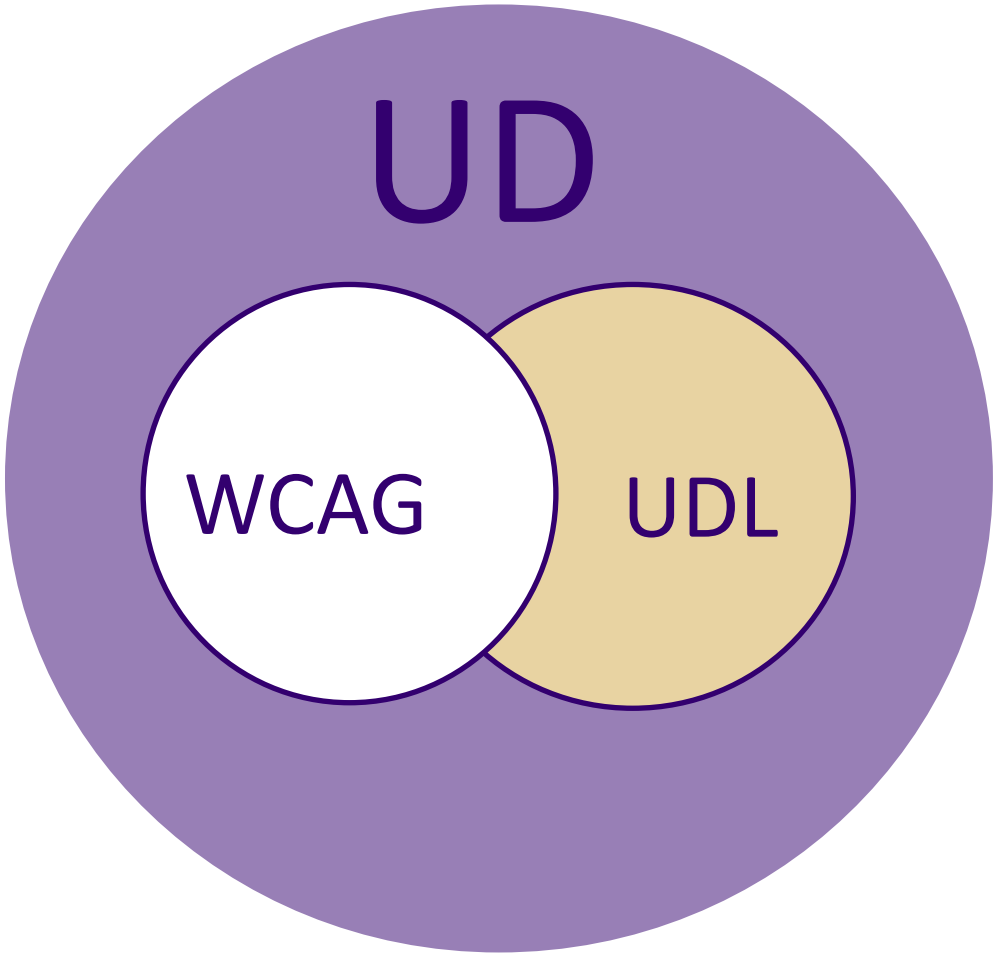
- ensures compatibility with assistive technology

Multiple beneficiaries of UD, e.g. captions on videos…People who:



- are unable to hear the audio
- are English learners
- are in a noisy or noiseless location
- have slow Internet connections
- want to know the spelling of words
- need to find content quickly

3 sets of **principles** underpin UD guidance for all aspects of education



-7 Universal Design

- 3 Universal Design for Learning
- 4 Web Content Accessibility Guidelines

In a nutshell,

1. Provide multiple ways for participants to learn, to demonstrate what they have learned, & to engage.

2. Ensure all technologies, facilities, services, resources, & strategies are accessible to individuals with a wide variety of disabilities.

For my presentation today I

- Used MS PowerPoint template
- Spoke critical content presented on the slides
- Designed accessible PPt document, e.g., used text format; structured headings, lists, tables using formatting tools within PPt
- Used uncluttered slides; plain backgrounds, high contrast with text
- Spelled out acronyms, explained jargon

Additional tips for online courses, 1 of 3

- Point students to specific resources to gain needed knowledge & skills
- Recognize & avoid cultural, ability, & other assumptions
- Examples, assignments relevant to diverse audience
- Offer multiple ways to learn, demonstrate learning, & engage
- Caption videos

Tips, 2 of 3

- Avoid long lectures & massive slide decks
- Chunk content & organize with headings
- Overview at beginning & summary at end
- Outlines, other scaffolding tools
- Simplify, break down images, tables
- Avoid strict cameras-on policy
- Clear instructions & expectations

Tips, 3 of 3

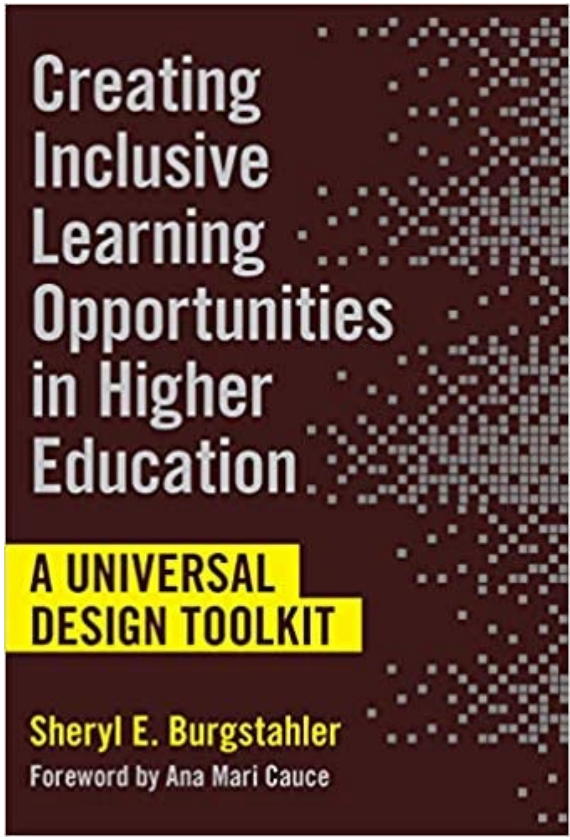
- Adequate time for practice, activities, projects, tests. Feedback on parts of large assignments & corrective opportunities
- Use small number of technology tools; all accessible (e.g., operate with keyboard alone)
- Avoid PDFs; accessible HTML in content pages ideal for primary content
- Use descriptive wording for hyperlinks, alt text for images

An attitude; a framework, goal, process—UD:

- Promotes best practices & does not lower standards
- Is proactive
- Can be implemented incrementally
- Benefits everyone
- Minimizes the need for accommodations
- Supports diversity, equity, & inclusion

Resources

- Center for UD in Education
  - UD Framework
  - Equal Access: UD of Instruction
  - 20 Tips for Teaching an Accessible Online Course
  - Links to articles
  - uw.edu/doit/cude



- Sheryl Burgstahler
  sherylburgstahler@outlook.edu

Improving Undergraduate STEM Education Initiative

Enhancing the Learning Experience: Implementable and Adjustable Learning Models for Educators

Dr. Martene Stanberry
Dr. Sheila Tabanli
Dr. Sheryl Burgstahler

@IuseProgram

AAAS IUSE Initiative

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WORKSHOP

Thank you for attending!

Slides and recording will be available in the coming days.

We value your feedback, please take a few minutes to complete the survey.

@IuseProgram

https://www.aaas-iuse.org

AAAS IUSE Initiative

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Fall 2025 AAAS-IUSE Virtual Workshop Lineup to be announced soon!

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