



GUIDEBOOK

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

By Sheila Tabanli, Ph.D.
Research2Practice Program Fellow

Suggested Citation

Tabanli, Sheila. (2024). *Guidebook for Reducing the Novice-to-Expert Perception Gap in Mathematics to Increase STEM Diversity*. Rutgers University—New Brunswick: Division of Diversity, Inclusion and Community Engagement. <https://nbdiversity.rutgers.edu/r2p-virtual-library>.

© Sheila Tabanli

Introduction



During the first activity, participants recalled a time when they were a novice and spoke about how the expert in that situation may have affected their experience and approaches to learning.

In groups of 3-4, please share a recent experience in which you learned something new...

- 1) How did you feel?*
- 2) How was your instructor's approach/attitude to your learning?*
- 3) How did the instructor's approach impact your learning?*
- 4) What are your key takeaways from this experience?*

This guidebook is intended for the higher education STEM teaching faculty who have an expertise in the domain content knowledge and who are interested in improving their pedagogical content knowledge in effective teaching practices to create more emphatic learning environments for their students. The ultimate goal is to be inclusive in instructional methods in the face of diverse student demographics and the recent public opinion of decreased perceived value of higher education in order to make higher education an equitable field.



Gaps in Math Teaching & Learning

The most significant gaps in math teaching and learning in higher education based on the literature, public polls, and anecdotal notes of the author in the 25+ years of teaching experiences in K-16 settings are listed below:

Gaps in Math Teaching & Learning

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

The way an expert (a Math professor) views math content is different than the way a novice (a Math student) perceives the same content. In other words, my students in an introductory Calculus course do not see the same Calculus problems the same way I see them.

Although one cannot deny the importance of addressing other gaps, in the context of our guidebook, our primary focus is to define the novice-to-expert perception gap in higher education math classrooms and to demonstrate the implications of this unnoticed gap in math classrooms. We define experts as math domain content experts who are professors trained in the math domain content knowledge in higher educational settings such as a professional with a graduate degree in Mathematics and related fields, qualified to teach college level math courses. Novices are the students (learners) registered to take a specific math course in their academic career in a higher education setting. In this guidebook the words students and learners are used interchangeably.

By creating this guidebook, as a part of the Rutgers Tyler Clementi Center for Diversity Education and Bias Prevention Research2Practice Fellowship Program¹ informed by student perceptions and literature review coupled with authentic classroom teaching experiences of the author for more than two decades in K-16 math classrooms, we aim to:

- 1 reduce the perception gap by improving the discourse and empathy between students and professors.
- 2 improve learners' sense of belonging in math classrooms and beyond.
- 3 increase professors' sense of excitement in math classrooms and beyond.
- 4 provide actionable recommendations and practical resources to STEM educators.

¹ Research2Practice Fellowship Symposium talk can be found at https://www.youtube.com/playlist?list=PL4Lg9EUyyj79YMv2FhvAIH9JOvtaVt_gd

Student Perceptions About Math Learning

Process for Obtaining Student Perceptions

In order to understand student experiences in Mathematics classrooms, a Qualtrics survey was prepared and shared with students who are currently taking Introductory Math courses such as Precalculus, Calculus and who also recently completed these courses.



The Qualtrics survey was also sent to student scholars at the SAS EOF program as a part of recruiting efforts by the SAS EOF program director, Dr. Michelle Shostack. Five students who submitted the survey were invited for a virtual panel recording at the Rutgers iTV studio. The students were compensated for their time and sharing their expertise in their math learning experiences with gift cards.

The process of recruiting students is shown in Figure 1, the virtual student panelists' names, pronouns, and pictures are in Figure 2.



Figure 1: Procedure for Recruiting Student Panelists



Figure 2: Virtual Student Panelists

Key Points from The Student Panel

The common themes based on student interviews are identified as the 3C's (compassionate, connected math learning community):

(3 C's)

Compassionate
Math Teaching
& Learning in a
Connected
Community

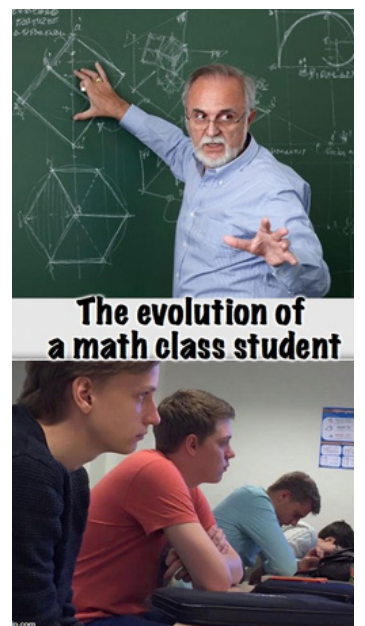
Build a compassionate learning community with peers and the instructor

Offer relatable experiences to learners

Address the curse of expertise in instruction

Create judgement-free learning spaces

Notice anything about this photo?



Evolution [Digital image]. (2018). Retrieved from imgflip.com/i/2alau0

Below, we present some excerpts from the students on the virtual student panel responding to some of the questions during the in-person interviews at Rutgers iTV Studio.

Q: What would help you speak up and ask questions more often in math class, particularly when you are confused by the content your professor is presenting?

I think I'll be more likely to speak up in class if it didn't feel like I was in a bubble ... it feels like being spoken to the entire hour and a half, but I feel like if classes were more interactive, if we were to interact with the professor and interact with the students around us then I see I'm not necessarily alone in my circle. *–Participant T*

For me it really matters a lot when I feel like the question I'm asking isn't being judged or it's a judgment free zone. So often times when professors really take a pause after they ask the question and that can even be for like 10 seconds and 10 very slow seconds and look almost across the room, making eye contact with students because sometimes I have a question, but I'm just working through how to process even articulating it and having that time where I know the teacher is expecting me to have the question gives me a lot of confidence to raise my hand and ask. *–Participant X*

I feel like I'm more apt to talk in class when I feel like other people around me are also feeling the same confusion and in class if everyone kind of became a little bit of community, a kind of atmosphere it would make me more comfortable to speak up. *–Participant Z*

Honestly, what helps me to speak up personally is other students that may also have the same problems and I feel like when I'm more involved in the mathematics community or community of the classroom I am in it's more engaging and I'm more able to speak up for myself. *–Participant W*

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

My professor should know that, but I do like to take my time. I feel like Rutgers the curriculum moves fairly fast and it's almost hard to absorb the information completely and sometimes I get lost or get held behind because I don't understand concept and then it just keeps compounding and then it puts you in a very difficult place to keep learning. –Participant Z

I wish my professor was a little bit more understanding of the fact that not everyone learns best in a lecture environment. I know that was definitely a struggle coming into Rutgers because most of my classes from 20-30 students and... so I think making it more collaborative environment would definitely lessen some of the struggle to adopting into a large lecture environment. –Participant T

I wish my professor knew about me and my math learning is that I would like to be taken through all the steps of the process to getting to the final answer for example if a professor, if I ask a professor a question about algebra portion of math and they say "oh well, that's just a given! You are just supposed to understand that" then I'm less prone to being able to wrap my head around the problem as a whole as opposed to the professor walking me through the problem step by step. –Participant W

I wish my professor would know about me and my math learning is that their passion for the subject really translates over to how much I'm engaged with it. So when we're relating topics like velocity with something, they've actually done maybe throughout their career but that they can apply to the real world that really sees how the skills I'm learning are going to benefit me in the real world. Their passion makes me feel more passionate about the subject and that's ultimately what I think gets the best results. –Participant X

Sometimes I just need a push in the right direction sometimes I'm hard to understand 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 I'll be the only one that doesn't understand that. By the professor helping me privately, it'll help me understand the concept so when I'm in the classroom, I may feel more encouraged to speak up when I don't understand something. –Participant Y

THE "WHY":
WHAT ARE THE IDENTITIES OF MATH STUDENTS (EXPERTS)?

"CONFUSED COLLEGE MATH STUDENT" - 12/19/2023

Conclusion



After carefully examining the virtual student panel responses three key takeaways are extracted that can be easily integrated into math faculty behaviors and teaching practices in higher ed classroom settings:

01

Create judgement-free learning spaces by valuing mistake making and learning from one's mistakes.

02

Design and implement engaging learning activities to encourage discourse and community-building.

03

Develop empathy and understanding towards the students' novice status by being mindful of the perception gap.

We can all intentionally and deliberately implement compassionate faculty attitudes and student-centered teaching practices in order to avoid memes like the ones below to improve STEM diversity for all.

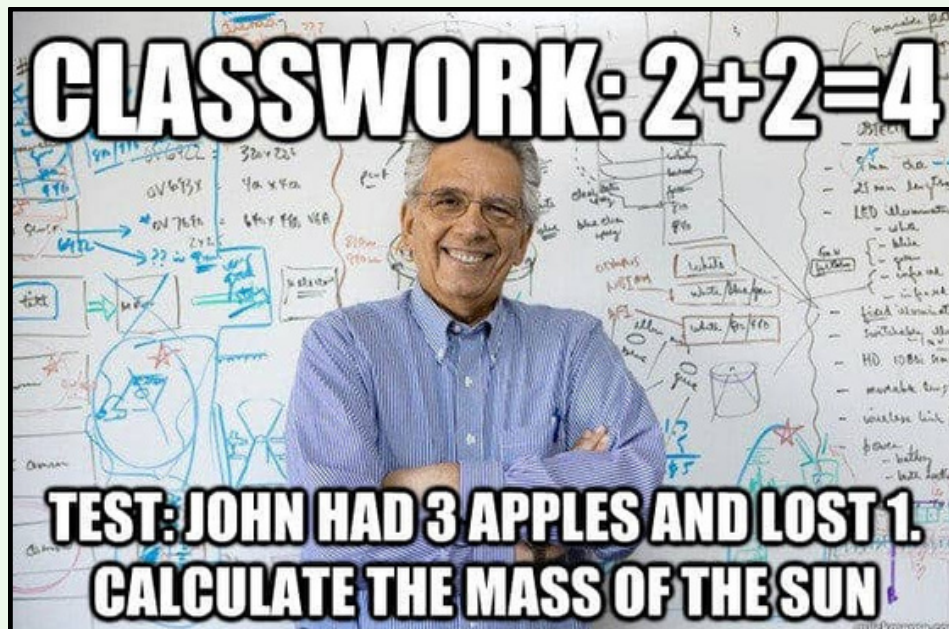
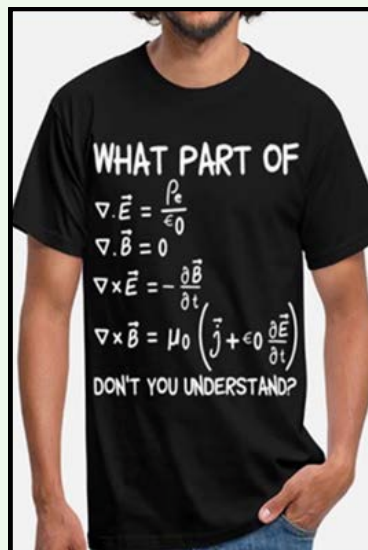


Figure 3: Memes about gender stereotyping, identities of mathematicians, and social “norms” around math understanding.

Acknowledgements

I wish to acknowledge the invaluable contributions received from several individuals:

Student Panelists

- Bethesda Faison
- Anushka Majumdar
- Duaa Raza
- Colby Reed
- Kaila Spence

Tyler Clementi Center for Diversity Education and Bias Prevention

- Dr. Crystal Bedley (Sr. Director)
- Ernesto Lorenzo
- Edgardo Acevedo
- Jason Brandon

Rutgers–New Brunswick

- Dr. Michelle J.
Shostack (SAS EOF
Program Director)

About the Author



Sheila Tabanli, Ph.D. (she/her) is an Assistant Teaching Professor of Mathematics at Rutgers University–New Brunswick. Prior to joining Rutgers, she worked as a math teacher and administrator in K-12 public schools for over a decade. Her professional interests include developing student-centered, evidence-driven instructional strategies to offer equitable math learning experiences. Dr. Tabanli has extensive experience designing and implementing curricula

and presenting workshops & PDs. She developed a course where she teaches her instructional framework grounded on cognitive science and Social Emotional Learning research. As Chancellor's teaching fellow, she developed individualized student pathways to reduce students' math achievement gaps. Sheila leads the RR2PG faculty support group focused on reducing the research-to-practice gap in teaching. She is the recipient of the 2024 Rutgers–New Brunswick Chancellor's Excellence in STEM Diversity award.

Practical Recommendations

- Workshop/PD activity for math instructors to identify the novice-to-expert perception gap.
-

- Interview questions to examine student perceptions about math learning experiences.
-

- Final Exam Study Guide to enable students' self-assessment and study planning.
-

- Exam reflection assignment to to inform student exam preparation and mindful studying.
-

- Unpacking the demanding nature of math problem solving for professors and students.
-

- Feedback-driven practices as a low-stakes assessment - SIPPERS Framework (Tabanli, 2021).

Practical Recommendations

→ Get to know students' strengths and passions - First Day Survey (Mowreader, 2023).

→ Worked-out, step-by-step assessment solutions as instructional resources to understand novice-like orientations.

→ Spreading the joy of learning while modeling a life-long curiosity and growth.

→ Speak up Points for error corrections and improved student engagement.

→ Polya's Mathematical Problem-Solving Framework (Polya, 1945) worksheet template for scaffolding.

→ Evidence-based learning resources to enhance metacognitive skills and self-regulation of learning.

Workshop/PD activity for math instructors to identify the novice-to-expert perception gap

How-to guide

Design and deliver a workshop for math teaching faculty to understand what it means to be a novice. Although every expert was once a novice in any field, due to the curse of expertise phenomenon the experts may not understand and may not relate to novices' experiences and challenges to learn. The following workshop was designed and delivered as part of the 2024 R2P symposium to have the participants develop empathy for novices.

Workshop Activity#1: Encouraging Experts to Develop Empathy for Novices

(Math Domain Content Expert as a Novice in Another Domain)

In groups of 2-3, please share a recent experience in which you learned something new...

1. How did you feel?
2. How was your instructor's approach/attitude to your learning?
3. How did the instructor's approach impact your learning?
4. What are your key takeaways from this experience?



Interview questions to examine student perceptions about math learning experiences

How-to guide

The following questions were asked to the students during the recordings at Rutgers iTV to understand their perspectives in their math learning at Rutgers. Examining and studying these student perspectives is specifically crucial to understand the first-year student experiences and to improve student retention. First-year students transition from high school expectations to university expectations while trying to adjust to a new phase in their lives. These questions could be used anonymously in classroom setting to adapt and transform math teaching practices based on student feedback.

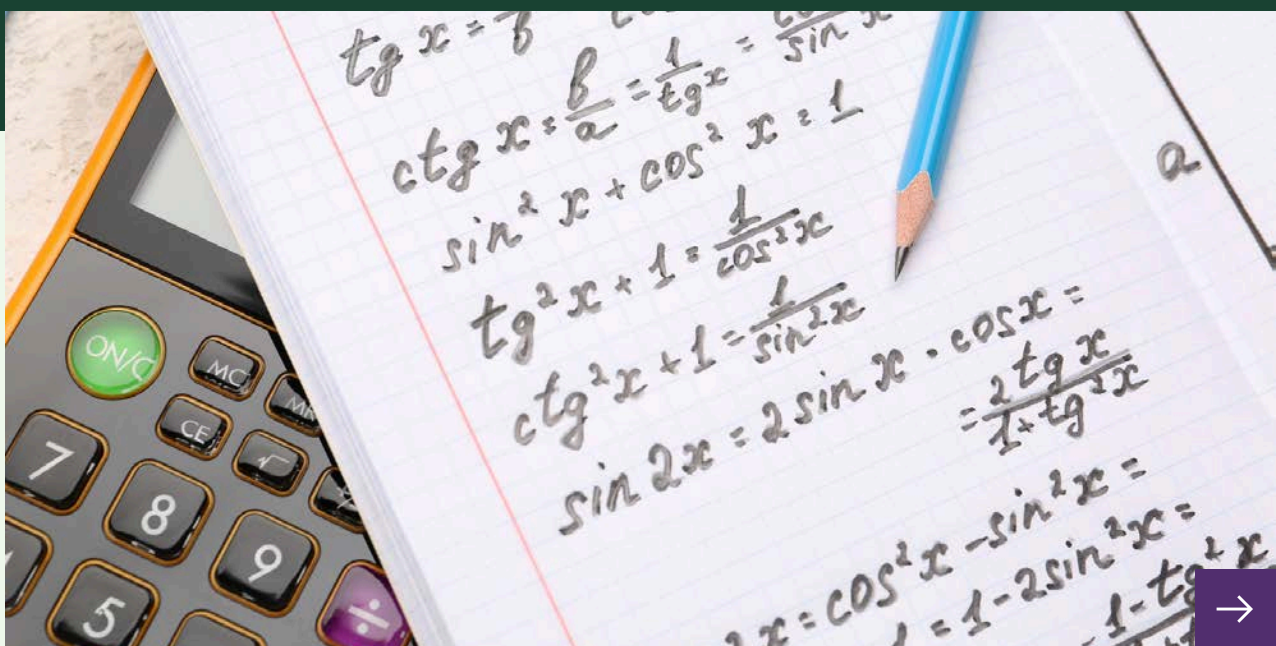
Student Panel Questions: Examining the Perceptions of Novices towards Math Learning

1. What is your name, pronouns, major/minor (if any)?
2. What was it like learning math in K-12? At Rutgers?
3. Would you share a moment when you found joy in learning about math? What would make learning math a joyful experience for you?
4. What would help you speak up and ask questions more often in math class, particularly when you are confused by the content your professor is presenting?
5. What do you wish your professor would know about you and your math learning?
6. What would attract you to pursue a career in STEM? If you are interested in pursuing a STEM-related career, do you consider Math a gateway to STEM or a gatekeeper? Why or why not? How can we further support you?



Final Exam Study Guide to enable student self-assessment and study planning

How-to guide In order to support students' learning journey to the finals week, the following study guide is given at the beginning of the semester and the procedures of each section will be added right after it is taught in lectures. This enables students to have a 1-pager procedural booklet that they can refer to while studying for their finals. Traditionally, in math, final exams are cumulative high-stakes assessments that may produce anxiety for some students. In the lack of this 1-pager, students may feel overwhelmed by the vast content they need to study.



Math135 Final Exam Study Guide Prepared by Dr. Sheila Tabanli

Instructions: Rate your level of understanding on the curriculum topics to create a study guide for yourself to identify what you need to improve on.

Big Ideas	Topic Covered	Confident	Somewhat confident	Not confident	Retireve/write down the procedure
Prereq	Algebra & Precalc Review				
LIMITS	2,1, 2,2: Introduction to limits				
	2,3, 3,5: Eval. limits (0/0 form), 3,5: special trig limits				
	2,4: infinite limits, vertical asymptotes				
	2,5: limits at infinity, horizontal asymptotes				
	2,6: continuity (skip IVT)				
DERIVATIVES	3,1, 3,2: def. of the derivative, eq. of the tangent line				
	3,3, 3,4, 3,5, 3,9: derivative rules				
	3,7: chain rule				
	3,8: implicit differentiation and 3,9: log. differentiation				
	3,11: related rates and applications				
APPLICATIONS OF DERIVATIVES	4,1: maxima and minima, extreme value theorem				
	4,3: intervals of increase & concavity				
	4,4: graphing functions				
	4,5: applied optimization				
	4,7: l'Hospital's rule				
	4,6: linear approx., marginal analysis (business apps)				
	4,9: antiderivatives, initial value problems				
INTEGRAL	5,1, 5,2: intro to integral				
	5,3: fundamental theorem of calculus				
	5,5: substitution rule for integrals				

Exam reflection assignment to analyze exams from students' perspectives to instill expert-like orientations

How-to guide

Traditionally, Math final exams are high stakes assessments. This may cause math anxiety for some students who might be already struggling with test anxiety. By reviewing every major exam in a distributed fashion, students are given opportunities to identify their areas of improvement to have targeted studying. This assignment can be administered after each exam to enable students reflect on their exams, analyze their mistakes, and learn from reflecting on their mistakes.

Math 135 Learning Activity Prepared by Dr. Tabanli – Exam Reflections

In order to improve your learning by encouraging you to review the past midterms with the aim of identifying and not repeating the same mistake and well-prepared for your cumulative final exam, I have designed this assignment for you! After each midterm, you will be assigned an “exam reflections” activity. This graded assignment involves you critically analyze



your midterms, compare and contrast between your submitted incorrect answers and the correct answers by referring to the posted solutions on the Math 135 coordinator's teaching website and MyLab for the two questions that you did not earn full credit of. Your mistake may originate from Algebra and Precalculus mistakes, core misunderstanding of the taught/reviewed concepts, not paying attention to the instructions in the question etc. If you have less than two questions that you did not earn full credit for, you receive an option of writing about your strategy and approach to two problems.

Assignment Guidelines and Grading:

You will be given a week to complete the assignment. This is an untimed activity. No late work will be accepted. Multiple attempts are allowed, only the last submission will be graded. This assignment counts as a recitation activity, it will not count as additional points to the already graded midterm. You will be graded out of 100 points. You have an opportunity of earning at most 50 points per question reflection by following the below guidelines that you may use as a checklist before submitting!

(20 Points) A clear and complete screenshot/picture of the response in MyLab is captured and attached to the submitted work by including the question number, part etc.

(10 Points) The mistake in the submitted answer is identified and corrected in a clear, detailed, and correct manner (in your own words).

(10 Points) Correct terminology and the proper notation are used in writing.

(10 Points) Use at least 3-5 complete sentences per question in your submissions.

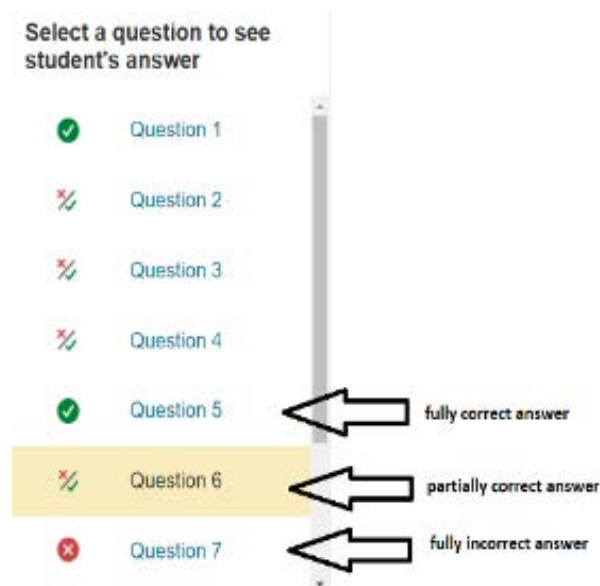


How to Review MyLab Assignments?

- Go to MyLab either through Canvas or use the direct link shared earlier.
- On the left panel, you will see a link for “Gradebook”, click on it – do NOT use the Assignments link!
- You should see the assignments available for review.
- Your click to review an assignment will open the assignment, click on your incorrect questions to see what your response was vs. what the correct response should be. (below, sample Question from Fall 2021 Exam)

How to Submit?

Only CANVAS submissions are accepted. No email / no late submissions are accepted. Please review your assignment is submitted accurately in Canvas before the due date. Only the submissions typed in Canvas will be accepted.



Unpacking the demanding nature of math problem solving for professors and students

How-to guide

The way math experts and novices view the math content is different. By scaffolding a single problem and listing the skills, concepts, and the theorems that are required to know from the earlier chapters, both experts and novices can learn to appreciate the demanding nature of mathematics to understand different perspectives. This scaffolding activity could be used with any math problem to demonstrate this demanding nature of mathematics.

Behind the scenes..

1. Differentiation rules
 1. Product rule
 2. Chain rule for e^x
 3. Power rule
2. Factor
3. Solve equations
4. Caution: determine where f' DNE
5. Exponential functions and domains
6. Check the interval and domain (identify extraneous solution)
7. Evaluate functions at different points
8. Know the value of $e \approx 2.718$
9. Compare fractions
10. EVT

The concepts a learner needs to know to solve ONE Calculus Problem!!

Exp) Determine Abs. min/max (if they exist)
 $f(x) = x^3 \cdot e^{-x}$ on $[-1, 5]$

We product rule

1) Find cr. p. $f'(x) = 0$ or DNE on $(-1, 5)$

$$f'(x) = 3x^2 \cdot e^{-x} + x^3 \cdot e^{-x} \cdot (-1) = 0 \quad \text{or DNE}$$

$$\frac{x^2 \cdot e^{-x} \cdot (3-x)}{0 \cdot 0 \cdot 0} = 0 \quad \left\} \begin{array}{l} x^2(3-x) = 0 \\ e^x \rightarrow 0 \text{ (DNE)} \end{array} \right.$$

$x^2 = 0, \quad e^{-x} = 0, \quad 3-x = 0$

$x = 0, \quad \text{none}, \quad x = 3 \quad \checkmark \quad \text{Inside } (-1, 5) \checkmark$

2) end p. $x = -1, 5$

Compare $3^3 \cdot e^{-3}$ vs. $5^3 \cdot e^{-5}$

$\frac{27 \cdot e^{-3}}{e^3} \rightarrow \frac{125}{e^5}$

$e \approx 2.718$
 $e^2 \approx 7.389$

x	$f(x) = x^3 \cdot e^{-x}$
-1	$-e^{-1}$ Abs. min
0	$0 \cdot e^{-0} = 0$
3	$3^3 \cdot e^{-3}$ Abs. max
5	$5^3 \cdot e^{-5}$

Feedback-driven practices as a low-stakes assessment - SIPPERS Framework (Tabanli, 2021)

How-to guide

It is an important skill to be “teachable” and open to feedback. By empowering students to give anonymous feedback to their instructors, instructors can utilize this ongoing feedback to adjust their teaching practices. The SIPPERS framework can also be used to ask student feedback on their own engagement as a self-reflection activity and their peer’s engagement and collaboration during groupwork activities.

Self Instructor Peer Performance Evaluation Ranking System (SIPPERS)



SELF-ASSESSMENT



INSTRUCTOR
ASSESSMENT



PEER ASSESSMENT

Midterm Exam Corrections

- MyLab quizzes (6 times /semester)
- Grading rubric (out of a scale of 0-25-50-75-100)
- Untimed, Due in a week

- **Assignment Content:** For each question you did not get a full credit in your midterm, write an exam correction by following the guidelines below:
 - The mistake in the student's submitted solution is identified and corrected in a clear, detailed, and correct manner (in student's own words).
 - Correct terminology and the proper notation are used in writing.
 - Work is clearly labeled by including the question number, part etc.
 - Use at least 3-5 complete sentences per question in your submissions.

Exam Corrections Rubric			
	Missing (0 Pts)	Inadequate (25 Pts)	Adequate (50 Pts)
Revised Solution / Written Explanation	The student did not submit the assignment.	An attempt is made to identify and correct the mistake in the solution but is described in a confusing and/or partially incorrect manner.	The mistake in the solution is identified and corrected in a clear, detailed and correct manner (in student's own words). Correct terminology and the proper notation is used in writing. Work is clearly labeled.

Self Assessment



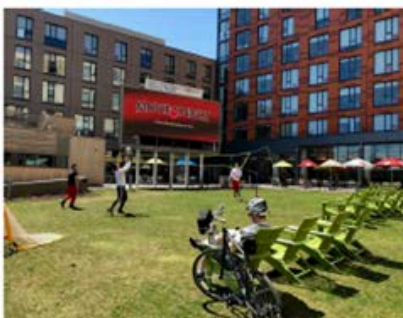
Option of writing about the **strategy** and approach to two problems (for eligible students).

Thumbnail by Unknown Author is licensed under CC BY 4.0

Mid-semester official instructor evaluation

Virtual townhall meeting

- Midterm related HW due dates
- Midterm exam format
- Camera and active learning
- Lecture outlines before lectures
- Re-cap in the recitations
- Midterm review folder in Canvas
- YARD get-together



Instructor Assessment

Pros of Online Teaching

- Virtual Meet & Greet
- 1-1 meetings after exams
- Weekend office hours
- More frequent office hours



4 Questions:

- 1) Which breakout room were you in? What were the names of your group members?
- 2) Which topic/question type your group struggled the most?
- 3) Did you find the group work productive? Did all group members contribute to some degree?
- 4) How do you rate *your contribution* (10 being max to 0 being none) to the groupwork. Explain in one sentence.

This Photo by Unknown Author is licensed under [CC BY](#)

Peer Assessment

- Ungraded
- Informal
- Weekly Canvas surveys
- Untimed
- Due at the end of the day

Get to know students' strengths and passions - First Day Survey.

How-to guide

As a first day activity, instructors can use the below survey to get to know their students, specifically a much-needed activity in large lectures. By acknowledging students' identities through their nicknames and pronouns instructors set the tone positively on the first day of classes. Reminding students about the rationale behind taking the course, pursuing their careers, and long-term goals gives a clear message that as instructors we care about students' success in our class and beyond. The activity closes with how the instructor can tailor their practices to further help students which gives a message that the learning environment is a safe and collaborative space for all.



Fou, Dom. Students in a class at Aalto University in Espoo, Finland. Unsplash, November 30, 2020. <https://unsplash.com/photos/WYoByjRH0qE>

Adapted from Math135-Tabanli First-Day Desmos Survey

Q1: Is there a preferred name/nickname that you would like to share with me?

Q2: What are your preferred pronouns?

Q3: What is your "why" of taking this course? (1-2 sentences)

Q4: What is your "why" of attending Rutgers? (1-2 sentences)

Q5: What is your WHY after college? What are you passionate about that you commit your life to it? What is your big picture in life? (3-4 sentences)

Q6: How is your relationship with math?

Q7: How committed are you to succeed in this course? What will be your evidence of this commitment? (1-2 sentences)

Q8: Name one major roadblock for achieving better outcomes in Math and how I can help you to overcome it. (1-2 sentences)



Worked-out assessment solutions as instructional resources to guide student exam preparation

How-to guide

Generally, the exam solutions are typed in LaTeX by math professors and provided to the students in a technical math jargon that may not be easily understood by all learners. Instead, providing personally prepared, hand-written, scaffolded solutions in a more learner-friendly language provides a better access point to all students, specifically in introductory college math courses. The solutions could be provided step-by-step by sharing the common student mistakes and prerequisite information that can relate to student experiences better. In other words, instructors can prepare solutions as if they are the novices and in a format that is similar to how students are expected to answer during testing.



It is a good practice to provide solutions of the assessments to students so they learn how to do it correctly. However, using intensive technical language in solving the problems, as if a math colleague would read and understand, is not beneficial to novice students. Students (especially in introductory math courses and who are not math majors) may have a hard time to understand how to follow the solutions due to technical jargon. Instead providing students hand written solutions, free of technical jargon but supported with plain English, as if a student produces the solution could be more helpful. An additional advantage is when an expert mimics a novice when producing solutions this will help them to think like a novice and understand the students' perceptions of learning and doing math.

Fall 2023 Quiz#1 Solutions

Problem 1. (5 points) Let $f(x) = \frac{2}{x}$.

(a) Find $f(x+h)$

(b) Find $f(x+h) - f(x)$

(c) Find and simplify $\frac{f(x+h) - f(x)}{h}$

$$\begin{aligned}\frac{f(x+h) - f(x)}{h} &= \frac{\frac{2}{x+h} - \frac{2}{x}}{h} \\ &= \frac{\frac{2x - 2(x+h)}{x(x+h)}}{h} \\ &= \frac{\frac{2x - 2x - 2h}{x(x+h)}}{h} \\ &= \frac{\frac{-2h}{x(x+h)}}{h} \\ &= \frac{-2}{x(x+h)} \cdot \frac{1}{1} \\ &= \boxed{\frac{-2}{x(x+h)}}\end{aligned}$$

Set up the diff. quotient
make denominators same

Don't forget to dist. (-)

cancel out the terms, rewrite h as $\frac{h}{1}$

"keep-change-flip"

Problem 2. (5 points) Assume $\ln x = A$ and $\ln y = B$. Evaluate the following expression in terms of A and B . Your final answer can not contain "log".

$$\ln \left(\frac{e^2 x^{5/2}}{\sqrt{y}} \right)$$

$$\begin{aligned}\ln \left(\frac{e^2 x^{5/2}}{\sqrt{y}} \right) &= \ln(e^2) + \ln(x^{5/2}) - \ln(y^{1/2}) \\ &= 2 \ln e + \frac{5}{2} \ln x - \frac{1}{2} \ln y \\ &= \boxed{2 + \frac{5}{2} A - \frac{1}{2} B}\end{aligned}$$

Use the $\ln$ prop.
to rewrite the exp.
(sum, diff prop.)

(exponent prop. for $\ln$)

subs A, B

recall: $\ln e = 1$

Q6) Find ALL Horizontal Asymptotes for
 $f(x) = \frac{12x+5}{\sqrt{16x^2+X+1}}$

$$\lim_{x \rightarrow +\infty} \frac{12x+5}{\sqrt{16x^2+X+1}} \rightarrow \text{find the highest exponent term "x^2" then div. ALL by } \sqrt{x^2} = |x|$$

$$\lim_{x \rightarrow \infty} \frac{\frac{12x+5}{x}}{\sqrt{\frac{16x^2+X+1}{x^2}}}$$

if $x > 0$ $\wedge$
 if $x < 0$ $-x$

$$= \lim_{x \rightarrow \infty} \frac{12 + \frac{5}{x}}{\sqrt{16 + \frac{1}{x} + \frac{1}{x^2}}} = \lim_{x \rightarrow \infty} \frac{12}{\sqrt{16}} = \frac{12}{4} = 3$$

$y = 3$

$$\lim_{x \rightarrow -\infty} \frac{12x+5}{\sqrt{16x^2+X+1}} = \lim_{x \rightarrow -\infty} \frac{\frac{12x+5}{x}}{-\sqrt{\frac{16x^2+X+1}{x^2}}}$$

$$= \lim_{x \rightarrow -\infty} \frac{12+0}{-\sqrt{16+0+0}} = \frac{12}{-4} = -3$$

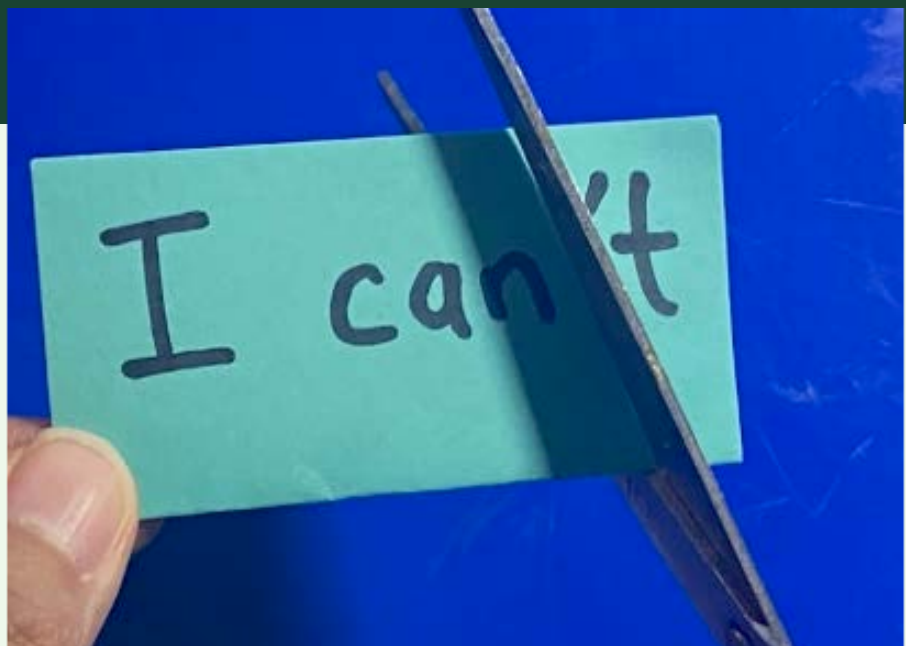
$y = -3$

The H.A. of $f(x)$ are: $y = 3, y = -3$

Spreading the joy of learning while modeling life-long curiosity and growth

How-to guide

All experts were once a novice in their current areas of expertise. Experts remembering the days when they were once a novice and sharing these experiences of overcoming challenges and instilling a growth mindset will not only normalize making mistakes but also enable the experts to develop empathy for the novices. Learning is a lifelong commitment and it brings a sense of joy and accomplishment to the learner. Professionally developing in the domain of effective teaching, besides the domain content mastery, enable the professors to model what it means to be a life-long learner.



Higher education institutions provide several opportunities for teaching faculty to improve their teaching effectiveness and to develop a broader scholarly identity beyond their domain content expertise. Sharing personal stories, such as my grant rejection, with students models perseverance and fosters a growth mindset. This creates humility and mutual understanding in a classroom setting that is traditionally hierarchical. Normalizing failure and mistake-making in math promotes perseverance, a critical skill for any math student. By openly discussing challenges and setbacks that are experienced by the math content expert, we can help students build resilience and a deeper appreciation for the learning process.

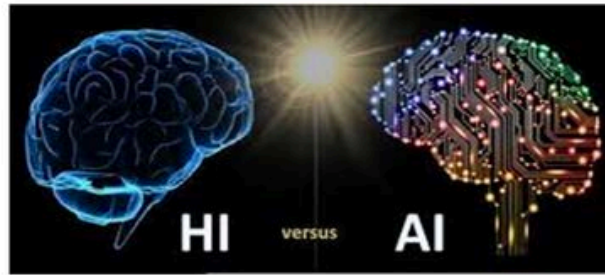
Growth in teaching practices can also be achieved by exploring a new tool or an approach to teaching such as incorporating Artificial Intelligence (AI) as a class activity by setting clear expectations on how to effectively utilize it (Gasman, 2024). Creating and administering a “non-traditional” AI-inspired assignment where students are encouraged to use the new technology for their academic growth will open the doors for honest discourse between instructors and students.

This AI-inspired Check for Understanding (CFU) activity that I designed for my course (Math 125) enabled me to get out of my comfort zone and to share this personal challenge with my students. After all, I am considered a math content expert, however, this does not make me an expert in an unfamiliar area, such as incorporating AI use in a class activity.



CFU (Check for Understanding)- AI vs HI

4 AI prompts that will accelerate your learning:



1. Apply the 80/20 Principle for Efficient Learning

Prompt: "Based on the 80/20 Principle, what 20% of concepts in [insert subject or field] would give me 80% of the overall understanding? Please concisely explain the concepts."

💡 Why this prompt: The 80/20 Principle ([a.k.a](#) Pareto's Principle) suggests that 80% of your learning outcomes or understanding can come from studying just 20% of the available material. By targeting the most critical information, you can achieve a substantial level of understanding with less effort.

Tip: You may include a statement like this within a prompt "...To delve deeper into this optimization, kindly provide concise explanations for each identified concept, elucidating their interconnectedness, practical applications, and pivotal role in shaping the foundation of knowledge within the specified domain."

2. Use the Feynman Technique to Understand Complex Topics

Prompt: "Can you explain the concept of [insert topic here] as if you were teaching it to a [fifth-grader](#)? Please use simple language and avoid jargon."

💡 Why this prompt: Richard Feynman was a Nobel Prize-winning physicist. He believed subject mastery was achieved by 1) simplifying concepts, 2) teaching them to a child, and 3) returning to fill in knowledge gaps. This prompt helps you to clarify your understanding.

3. Follow Atomic Habits' 4 Laws to Build the Habit of Learning

Prompt: "Imagine I want to develop the habit of [insert the desired habit here]. Can you provide creative ideas for each of the Four Laws of Behavior Change? Specifically, suggest a cue that will remind me to start the habit, a way to make the habit attractive and create a craving, a method to make the habit easy to perform as a response, and a reward that will make the habit satisfying."

💡 Why this prompt: James Clear's Atomic Habits teaches four laws to build a habit: 1) Make it obvious, 2) Make it attractive, 3) Make it easy, and 4) Make it satisfying. Get inspiration for how to build any learning-related habit—whether waking up earlier, taking notes in meetings, staying hydrated, etc.

4. Create a Spaced Repetition Study Plan to Retain Information Long-Term

Prompt: "Create a spaced repetition study plan to retain information long-term. I have the following topics I want to cover and the number of days left until my exam for each topic: [insert the topic#1 here]. – [x] days, [insert the topic#2 here] – [x] days, [insert the topic#3 here] – [x] days, [insert the topic#4 here] – [x] days. I can study for up to [insert the number of hours here] hours a day. Include how long I should study each topic per day and when I should review them for maximum retention."

💡 Why this prompt: Spaced repetition means reviewing material in short, systematic intervals. You'll learn at an optimal cadence (backed by science) for long-term memory.

Adopted from: [LinkedIn Article \(Meer, 2024\)](#)

Your task: is to use an online AI tool such as <https://chat.openai.com/> and pick 1 effective study method based on the 4 methods given in this assignment and ask AI for their suggestions. Read the AI response to your prompt and summarize it in your own words of 80-120 words. Then, use an AI detector website such as: <https://quillbot.com/ai-content-detector> to detect the authenticity of your writing. Please take a screenshot of this percentage of text being likely AI-generated and submit it along with your authentic text, AI generator suggestions and the prompt you chose.

Your content should include the following components in order for you to receive full credit:

1. The prompt you chose and typed in AI generator.
2. The response you received from AI.
3. Your authentic reflective summary on the AI generated response such as your main takeaways and actionable items (80-120 words).
4. The screen shot of the "% of text is likely AI-generated" after you feed your response to AI detector website.

Happy creating!

'Speak Up' Points for error correction and improved student engagement

How-to guide

Offering small incentives such as “Speak up” points to students who ask questions, answer their peers’ questions, correct instructor mistakes, and actively participate could be easily incorporated into any classroom. In Fall 2023 semester, I started incorporating “speak up” points to incentivize active participation in large introductory Calculus lectures which have traditionally lower attendance than the small-group recitations due to not having any in-class, graded assessments. The advantages of incorporating small points (e.g.: an extra 1 point added to a 10-points quiz) include fostering student belonging and acknowledging error making as part of a mathematical problem solving process and learning in general. I also noticed the students who earned “speak up” points tend to participate more actively in class later in the semester.



Polya's Mathematical Problem-Solving Framework (Polya, 1945)

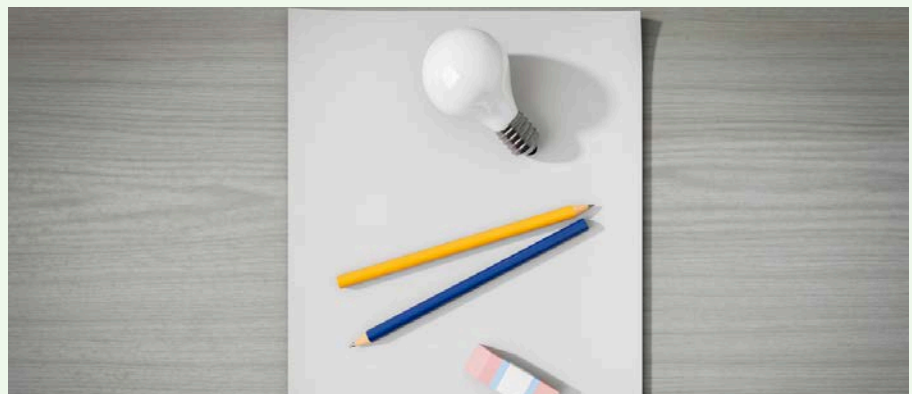
worksheet template for scaffolding

How-to guide

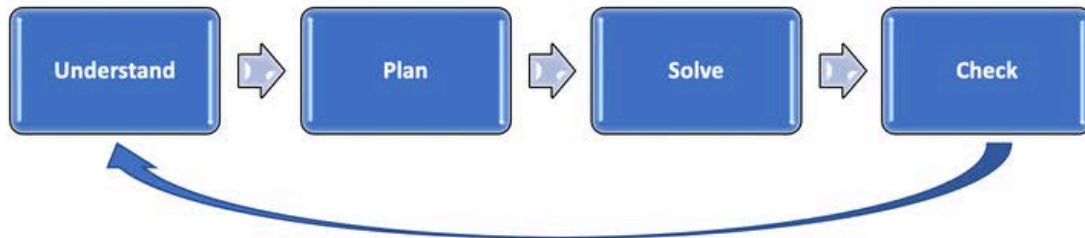
George Polya is considered the father of modern mathematical problem solving. In (Polya, 1945), he devised the 4 steps in mathematical problem solving as:

1. Understanding the problem,
2. Devising an algorithm,
3. Executing the algorithm, and
4. Checking the work.

Due to the expert status, experts may automatically and implicitly execute these 4 steps when they are solving problems. However, when these steps are not explicitly taught and shared during classroom teaching, novices may not follow these 4 simple steps in their learning practices. Therefore, the following template that I designed can be used to explicitly break down each step with a final reflection activity to invite students to be more mindful and meticulous in their math problem solving processes.



Apply Pólya's Framework for Math Problem Solving



Problem Reference: _____

A student must know/apply the _____ rules/theorem/procedure to correctly solve this problem, please write it down below:

YOUR TASK#1:

In your groups, discuss and list at least 5 concepts/skills, besides the given rule, a student must know to correctly solve this problem:

- 1) _____
- 2) _____
- 3) _____
- 4) _____
- 5) _____

TEMPLATE BY SHEILA TABANLI

1

YOUR TASK#2:

In your groups, discuss how to solve the problem by using the correct notation and terminology.

Then, independently generate a solution without asking others and referring to the discussion.

YOUR TASK#3:

Independently rate yourself in terms of how much of the discussion outcomes you were able to transfer to your independent problem solving. Circle a number on the scale below, 10 being "I was able to solve the problem myself independently." To 0 being "I could not remember the details of the discussion to produce the solution myself".

**YOUR TASK#4:**

Independently reflect and respond to these questions in 3-5 full sentences "Do you think being familiar with the concept, problem makes a difference in your approach to problem solving?".

Whole Class Discussion Questions:

- 1) How do we map Pólya's processes in his framework to the steps in our problem solving?
- 2) Identify 3 different errors a student may make if they are not following Pólya's processes correctly.
- 3) What can we learn from this activity as we prepare for the cumulative final exams?

Evidence-based learning resources to enhance metacognitive skills and self-regulation of learning

How-to guide

The below worksheet template¹ incorporates the evidence-based strategy retrieval practice from cognitive science and self-evaluation and planning from the self-regulated learning (SRL) theory. Note that the readily available textbook questions are used in the worksheet and the emphasis is on how the students' learning will be facilitated. Muddy point refers to an area a student struggles the most. Throughout the semester, worksheets could be prepared by adding "retrieval boxes" and "self-evaluation boxes" to encourage students to gain skills that are not only needed in a math class but at workplace in terms of retaining new information and planning for success!

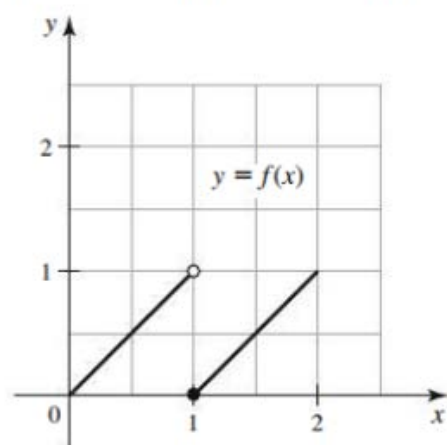


2.1-2 Introduction to Limits - Group Activity

1 Minute Brain Dump/Retrieval Practice:

15. Use the graph of f in the figure to find the following values or state that they do not exist. If a limit does not exist, explain why.

- a. $f(1)$ b. $\lim_{x \rightarrow 1^-} f(x)$ c. $\lim_{x \rightarrow 1^+} f(x)$ d. $\lim_{x \rightarrow 1} f(x)$



Practice Exercises

19–26. **Evaluating limits graphically** Sketch a graph of f and use it to make a conjecture about the values of $f(a)$, $\lim_{x \rightarrow a^-} f(x)$, $\lim_{x \rightarrow a^+} f(x)$, and $\lim_{x \rightarrow a} f(x)$ or state that they do not exist.

19. $f(x) = \begin{cases} x^2 + 1 & \text{if } x \leq -1 \\ 3 & \text{if } x > -1 \end{cases}; a = -1$

20. $f(x) = \begin{cases} 3 - x & \text{if } x < 2 \\ x - 1 & \text{if } x > 2 \end{cases}; a = 2$

Muddy Point/Next Steps:

¹ The practice exercises are from the e-text for Calculus, Single Variable: Early Transcendentals, 3rd edition, Briggs, Cochran, Gillett, and Schulz. Pearson, 2018. (ISBN: 978-0134766850).

Further Readings

Abdullah, M.Y., Bakar, N.R., & Mahbob, M.H. (2012). Student's Participation in Classroom: What Motivates them to Speak up? *Procedia - Social and Behavioral Sciences*, 51, 516-522.

Boaler, J. (2013). Ability and Mathematics: The Mindset Revolution that Is Reshaping Education. *The Forum*, 55, 143-152.

Bloom, B. (1968) "Learning for mastery", *UCLA Evaluation Comment*, vol. 1, no. 2, pp. 1–8.

Bransford, J., Brown, A., & Cocking, R. (Eds.). (2000). *How People Learn: Brain, Mind, Experience, and School - Expanded Edition*. Washington: National Academies Press. Retrieved May 27, 2024, from <https://www.nap.edu/catalog/9853/how-people-learn-brain-mind-experience-and-school-expanded-edition>

Bressoud, D., V. Mesa, C. Rasmussen. 2015. [Insights and Recommendations from the MAA National Study of College Calculus](#). MAA Press.

Brown, P. C., Roediger, H. L. III, & McDaniel, M. A. (2014). *Make it stick: The science of successful learning*. The Belknap Press of Harvard University Press.

Burdman, P., Baker, M., & Henderson, F. (2021). *Charting a new course: Investigating barriers on the calculus pathway to STEM*. California Education Learning Lab.

Camerer, C., Loewenstein, G., & Weber, M. (1989). The curse of knowledge in economic settings: An experimental analysis. *Journal of Political Economy*, 97(5), 1232-1254.

Chen Xianglei. *STEM Attrition: College Students' Paths into and out of STEM Fields*. Statistical Analysis Report. NCES 2014–001; Washington: National Center for Education Statistics; 2013.

Corbett C, Hill C (2015) *Solving the equation: the variables for women's success in engineering and computing*. Washington, DC: American Association of University Women.

Delahunty, T., & Kimbell, R. (2021). (Re)framing a philosophical and epistemological framework for teaching and learning in STEM: Emerging pedagogies for complexity. *British Educational Research Journal*.

Further Readings

Dreyfus, H. L. and Dreyfus, SE (1986) *Mind over Machine: the power of human intuition and expertise in the age of the computer*, Oxford, Basil Blackwell.

Freeman, T. M., & Jarvie-Eggart, M. E. (2019, June), *Best Practices in Promoting Faculty-Student Interaction in Online STEM Courses* Paper presented at 2019 ASEE Annual Conference & Exposition, Tampa, Florida. 10.18260/1-2—32148.

Gasman, M. (2024, April). *How Are College Faculty Using AI?*. The Forbes. <https://www.forbes.com/sites/marybethgasman/2024/04/24/how-are-college-faculty-using-ai/?sh=264cc9a953cf>

Hagman, J.E., Johnson, E. & Fosdick, B.K. Factors contributing to students and instructors experiencing a lack of time in college calculus. *IJ STEM Ed* 4, 12 (2017). <https://doi.org/10.1186/s40594-017-0070-7>.

Henrich, A. K., Lawrence, E. D., Pons, M. A., & Taylor, D. G. (2019). *Living proof: stories of resilience along the mathematical journey*. The American Mathematical Society : The Mathematical Association of America.

Hill, C., Corbett, C., & St. Rose, A. (2010). *Why so few? Women in science, technology, engineering, and mathematics*. Washington, D.C.: American Association of University Women.

Ingram, J., Baldry, F., & Pitt, A. (2014). The interactional treatment of mathematical mistakes. *Proceedings of the British Society for Research into Learning Mathematics*, 34(1).

Jackson, Robyn R. and Claire Lambert. *How to Support Struggling Students (Mastering the Principles of Great Teaching Series)*, Alexandria, VA: ASCD Publications, 2010.

Meer, B. (2024, April). *4 AI prompts that will accelerate your learning*. LinkedIn. https://www.linkedin.com/posts/benmeer_4-ai-prompts-that-will-accelerate-your-learning-activity-7185973307110830080-4nUS/

Moore, S. & Barrett, T. & O'Neill, G. (2008). *The Journey to High Level Performance: Using knowledge on the novice-expert trajectory to enhance higher education teaching*. In Higgs, B. and McCarthy, M. (Eds.), *The Changing Roles and Identities of Teachers and Learners in Higher Education* (pp. 51-62), NAIRTL.

Further Readings

Mowreader A. (2023). Engagement Tip: Create a First-Day Survey. Inside HigherEd. <https://www.insidehighered.com/news/student-success/academic-life/2023/07/25/how-professors-can-use-first-day-class-survey>

Nuri, B., & Marsigit (2019). The Reluctance of Students to Ask in Mathematics Learning: How Does The Teacher Solve It? Journal of Physics: Conference Series, 1320.

Polya, G. (1945). How to Solve it?. Princeton, NJ: Princeton University Press.

Reinke, W.M., Herman, K.C., Copeland, C.B. (2022). Student Engagement: The Importance of the Classroom Context. In: Reschly, A.L., Christenson, S.L. (eds) Handbook of Research on Student Engagement. Springer, Cham. https://doi.org/10.1007/978-3-031-07853-8_25

Roth, J.A. (2019). Making the Struggle Productive: Conceptualizing the Role and Impact of the Mathematics Teacher in Episodes of Productive Struggle.

Sanabria T, Penner A. Weeded Out? Gendered Responses to Failing Calculus. Soc Sci (Basel). 2017 Jun;6(2):47. doi: 10.3390/socsci6020047. Epub 2017 May 10. PMID: 29616148; PMCID: PMC5878940.

Seymour, E. (2006), Testimony offered by Elaine Seymour, Ph.D., University of Colorado at Boulder, to the Research Subcommittee of the Committee on Science of the U.S. House of representatives hearing on undergraduate science, math and engineering education: what's working? Wednesday, March 15, 2006.

Tabanli, S. (2021). SIPPERS (Self Instructor Peer Performance Evaluation Ranking System), 12th Annual Rutgers Online Learning Conference.

Tabanli, S. (2022). Promoting effective teaching practices by employing cognitive science principles, Mathematical Association of America (MAA) Virtual Programming Mini Course, November 2022.

Tabanli, S. (2023a). Fostering Active Learning and Metacognitive Skills in a Cognitive-Science Based Math Course. ISSN 1812-9129, International Journal of Teaching and Learning in Higher Education, Vol 35, No 2, 209-218.

Tabanli, S. (2024). An Instructional Framework to Reduce the Research to Practice Gap in Math Instruction. Manuscript in preparation.

Further Readings

Tough, P. (2021). *The inequality machine: How college divides us*. Mariner Books.

Young, J.R., Bevan, D., & Sanders, M.M. (2023). How Productive is the Productive Struggle? Lessons Learned from a Scoping Review. *International Journal of Education in Mathematics, Science and Technology*.

Zimmerman, B. J., & Martinez-Pons, M. (1986). Development of a Structured Interview for Assessing Student Use of Self-Regulated Learning Strategies. *American Educational Research Journal*, 23, 614-628. <https://doi.org/10.3102/00028312023004614>

