SLICE

Sign Language Incorporation in Chemistry Education:
How Embodied Cognition Can Increase Comprehension



Rochester Institute of Technology

Dr. Tina Goudreau Collison

Rochester Institute of Technology



RIT by the Numbers

~14,000 undergraduates + ~2,800 graduate

~700 matriculating Deaf/HH students (BS degree)

Organic Chemistry = 200 students /year

~2-8 Deaf/HH students



National Technical Institute for the Deaf (NTID) by the Numbers

1176 enrolled students

Recognizing the Barriers

I Teach

They Interpret

Life is Good



Recognizing the Barriers

Traditional teaching methods unintentionally favor auditory learners

We use big words



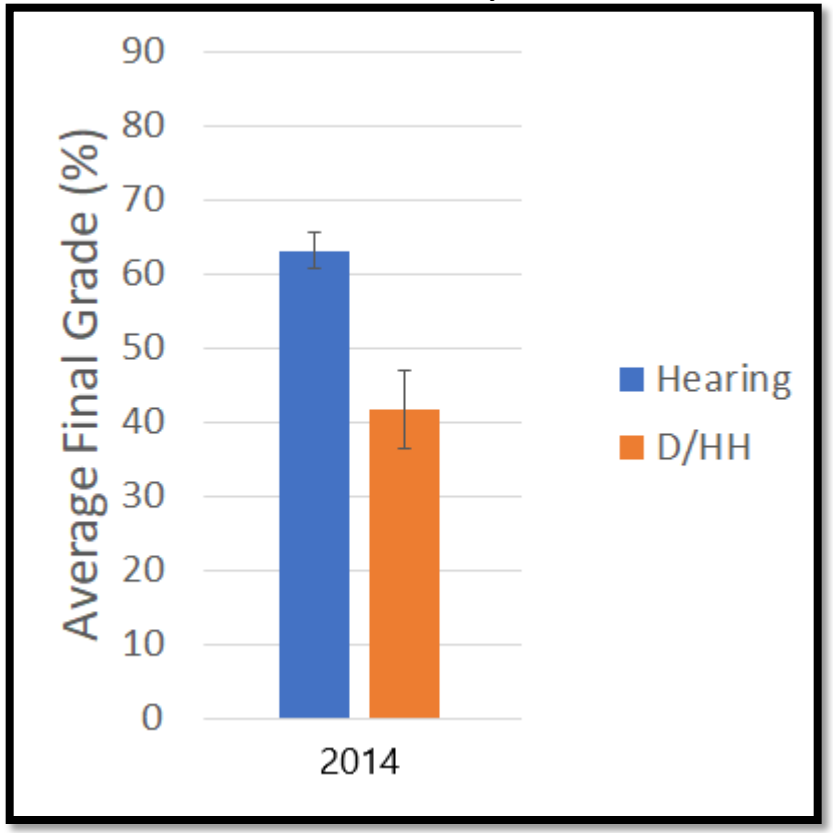
Recognizing the Barriers

Data from 2003-2014[1] shows D/HoH students underperformed compared to their hearing peers.

- Why start at 2014?
- Why alkene/alkyne exam focus?
- What was our goal?

Goal: Implement interventions that would improve D/HH student performance to meet class average

Exam 4 – Alkenes /Alkynes content



1. Clark, K. et al, *J. Chem. Educ.* **2021** 99, 1, 122–128.

How Did SLICE Develop?

Our Organic Chemistry SLICE Team/Family



Dr. Tina Goudreau
Professor
College of Science



Jennifer Swartzenberg
Senior Lecturer
NTID Science and Mathematics



Dr. Amie Sankoh and Deanna Phillips

First two Deaf TAs for organic chemistry workshops



Emmanuel Perrodin-Njoku



Franly Ulerio-Nunez

First TAs to start developing organic chemistry signs

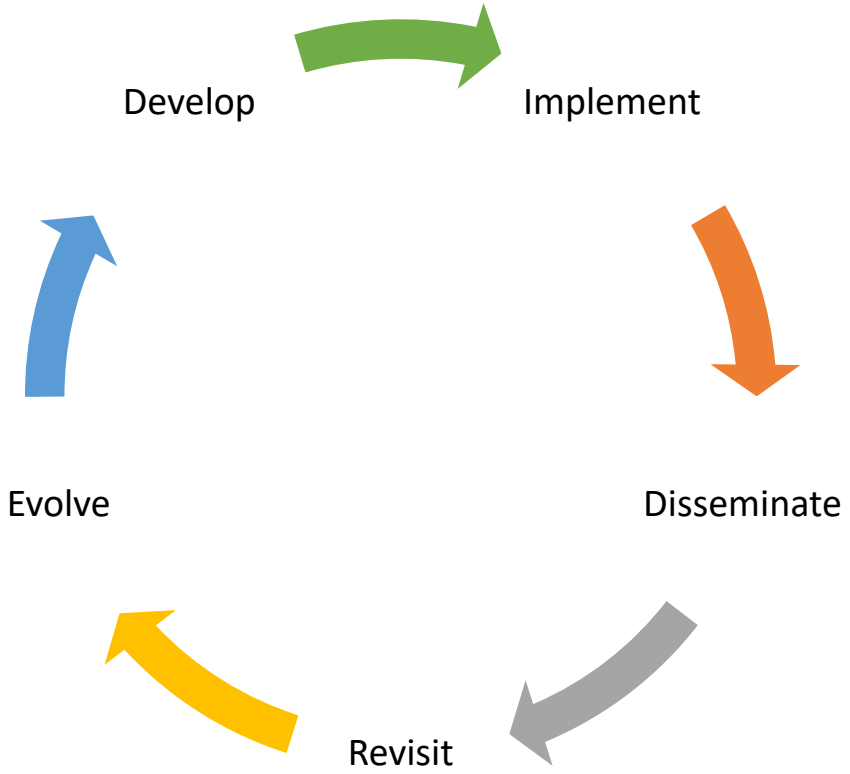
How Did SLICE Develop?

Our Organic Chemistry SLICE Team/Family



What Was Our Process?



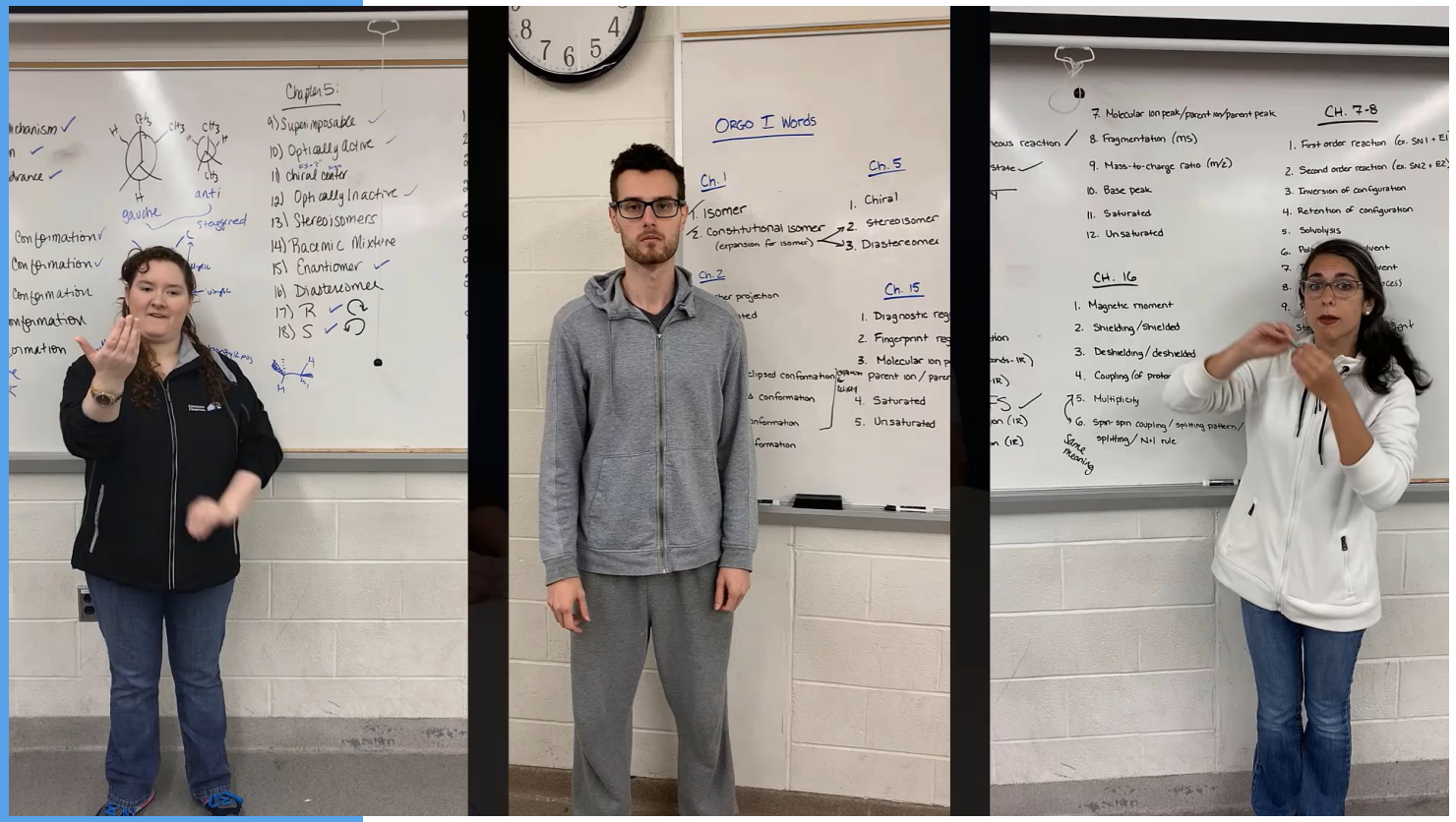


DEVELOP



- Development of term bank from lecture and lab
- Sorting terms into categories:
  1. Good sign exists
  2. Sign exists, but is not chemistry specific
  3. No sign developed
  4. Best fingerspelled

DEVELOP



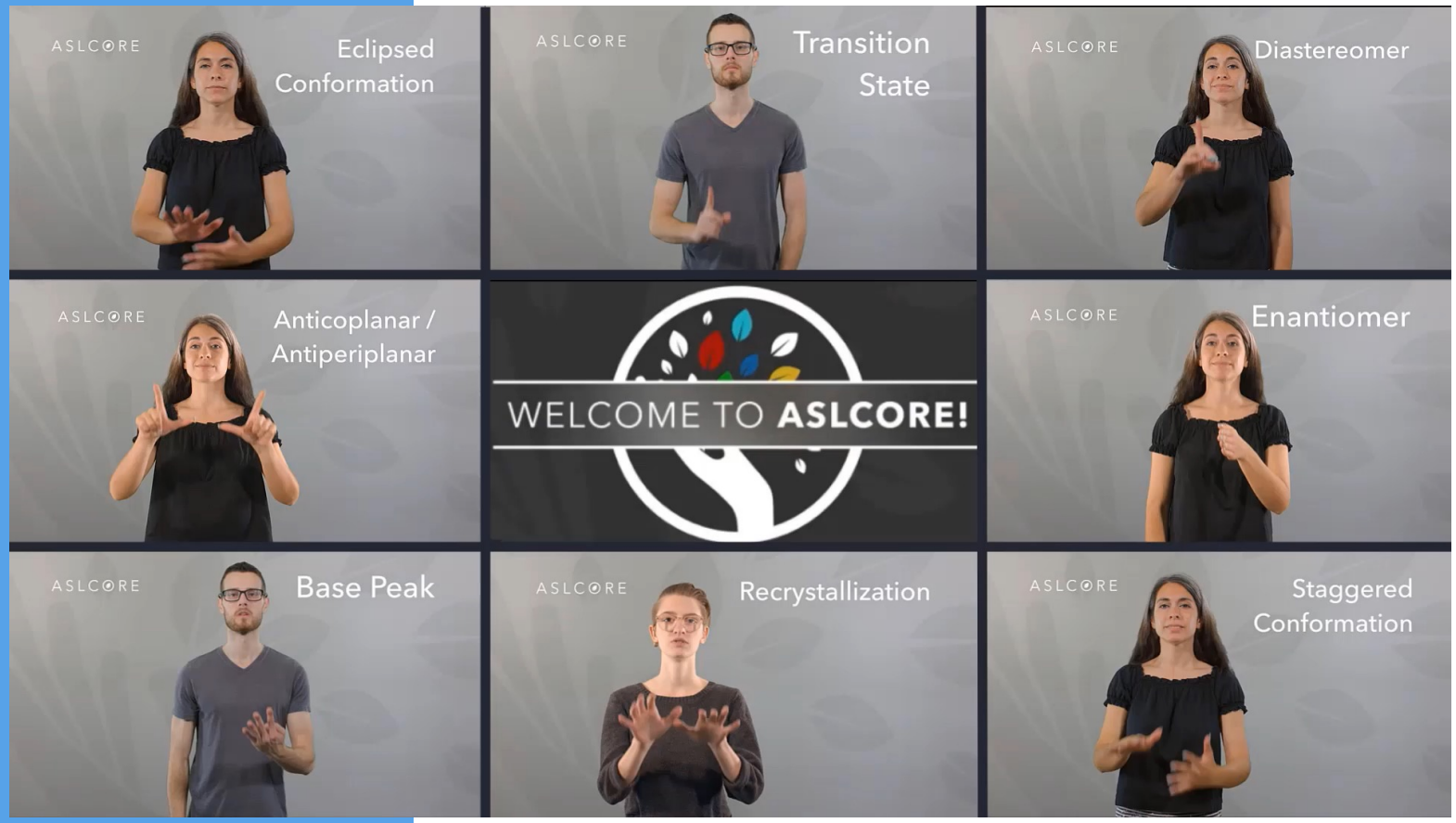
- Catalogued the terms
- Rough video recordings of sign
- Refined signs

Implement



- Signs are utilized during lectures
- Signs are communicated to Interpreters
- Signs are weaved into the course materials
- Some signs are taught to entire class
  -Universal Design

Disseminate



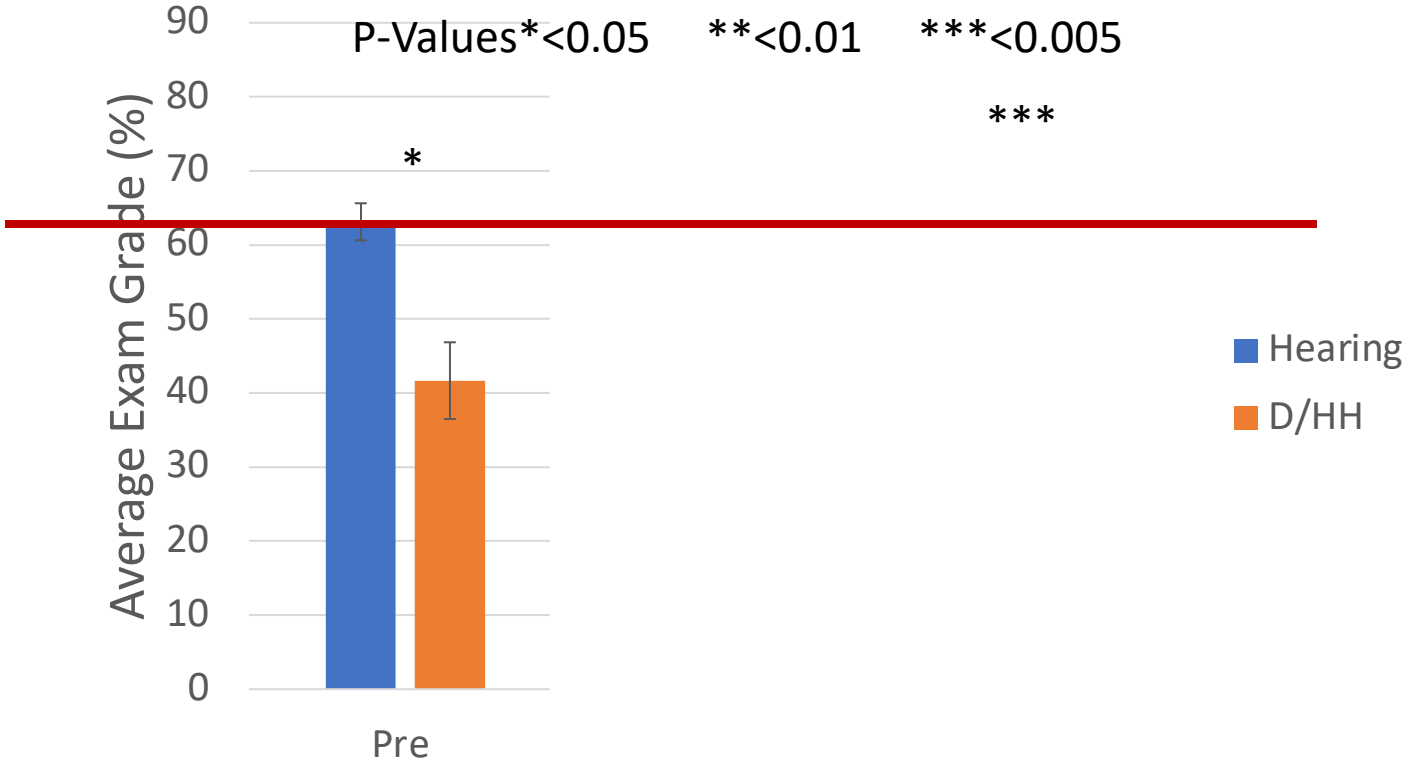
- Formally recorded the signs
- Created expansions
- Placed into ASLcore

Revisit and Evolve



- Signs utilized during Deaf-only workshops
- Signs contextualized using ASL with TA
- Signs evolve among cohorts

What have we achieved so far?



Effect Size		
	Pre vs Mid	Pre vs post
Exam 4	1.25	1.72
Final Grade	1.18	1.54

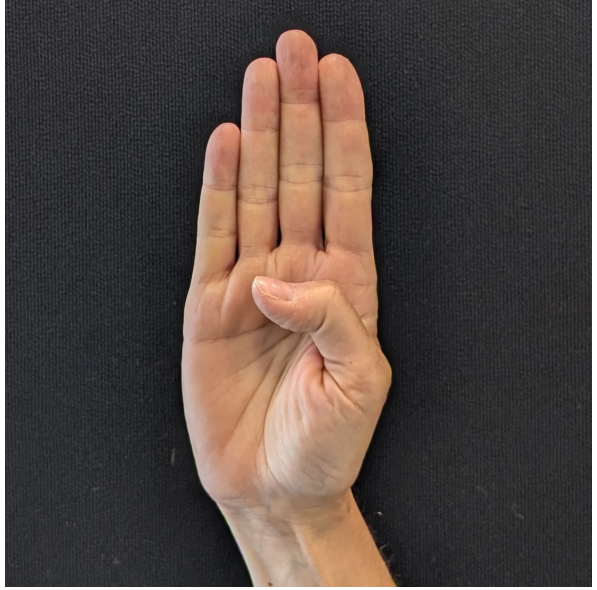
d > 0.8 effect size is significant

Cohort (Ay year, D/HH students)	
Pre	(2014, n=4)
Mid	(2015, n=3)
Post	(2016-2019, n=18)

Kaitlyn Clark*, Asma Sheikh*, Jennifer Swartzenberg, Ashley Gleason*, Cody Cummings*, Jonathan Dominguez*, Michelle Mailhot*, and Christina Goudreau Collison "Sign Language Incorporation in Chemistry Education (SLICE): Building a Lexicon to Support the Understanding of Organic Chemistry", *J. Chem. Educ.* 2021 99, 1, 122–128.



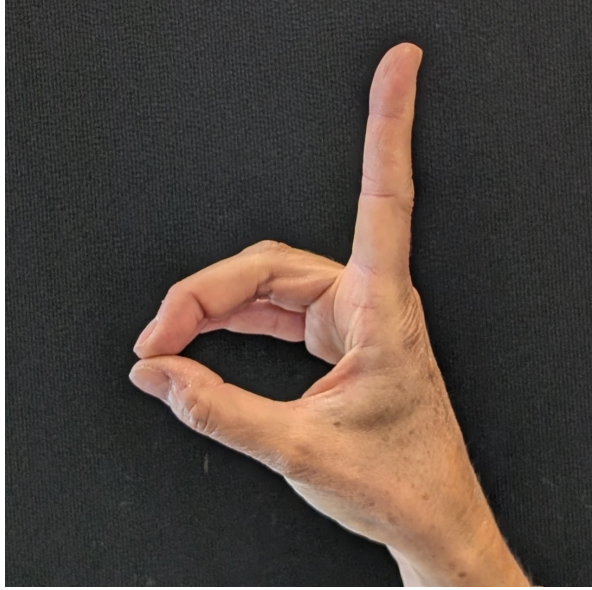
A



.



C

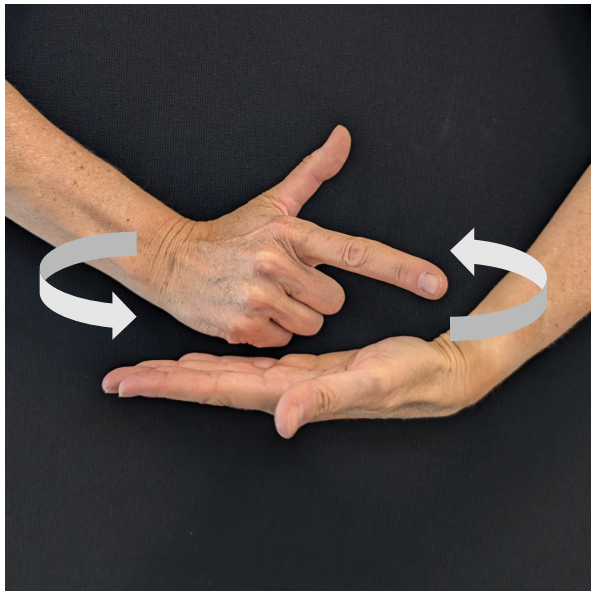


D

Steric Hindrance



Resonance

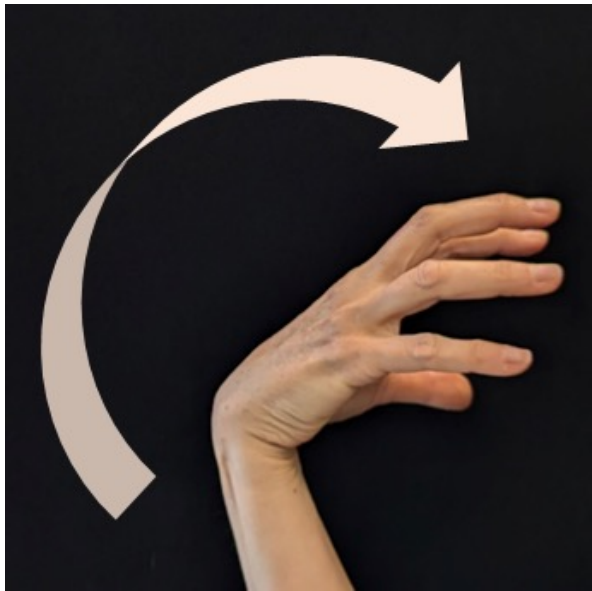


Induction

9 ëÞ□□□ñ 5 □ñÐ□ ñ¸ ⟷ 9 ëÞ□□□ñ ± ¸□ œëÐ□ ¸ñ¸

□♭5 D□ □♭± D□

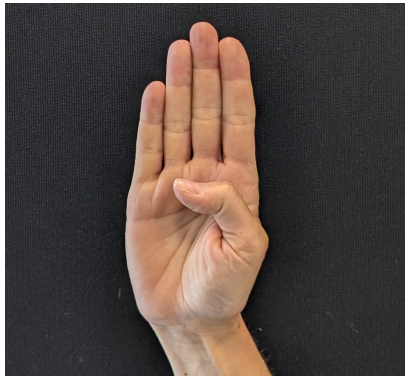




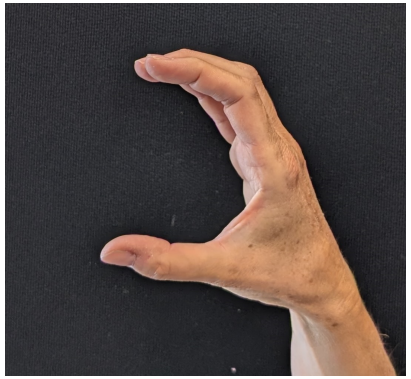
Implementation + UD



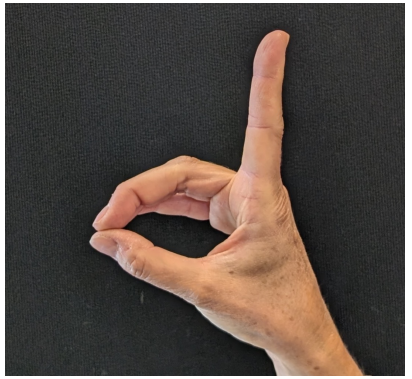
A



B



C



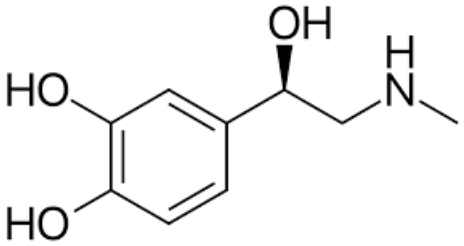
D

Polling

If you had to get a tattoo of a molecule on your body, which would you choose?

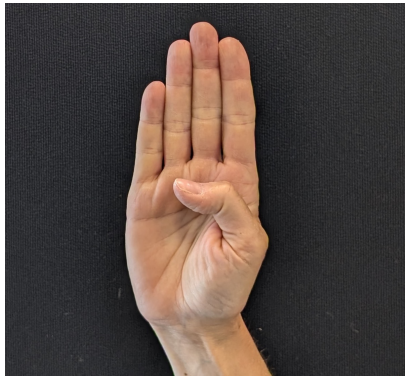


A

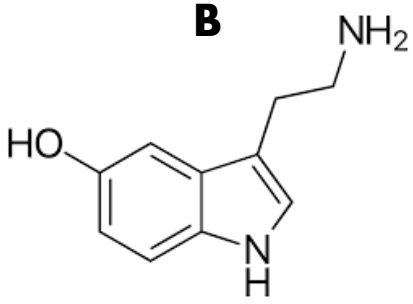


Adrenaline

(fight or flight)

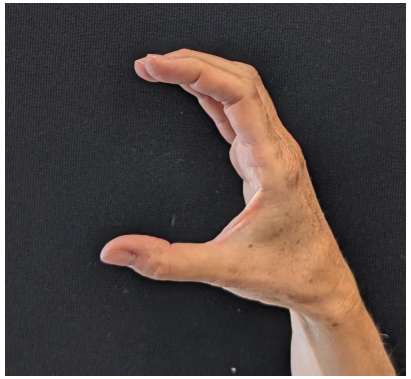


B

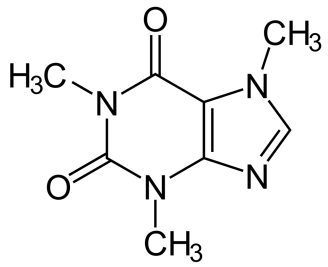


Seratonin

(the mood stabilizer)

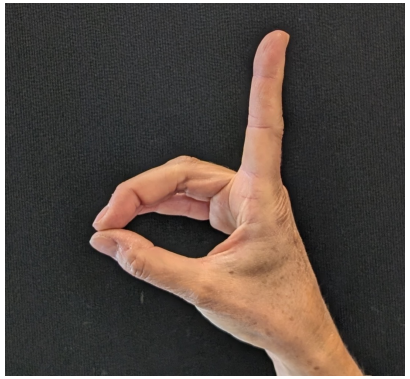


C

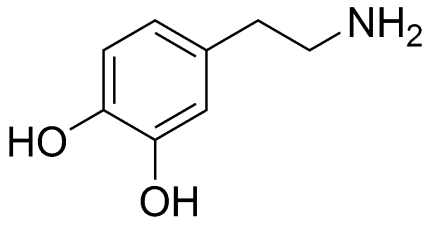


Caffeine

(no explanation needed)



D



Dopamine

(the rewarding molecule)

Short Answer Response



Make the sign for atom and discuss the components represented by your hands.

The hand shape for the electron cloud will be used in other signs.

Short Answer Response

Induction

Electron Donating ⟷ **Electron Withdrawing**

(EDG) **(EWG)**

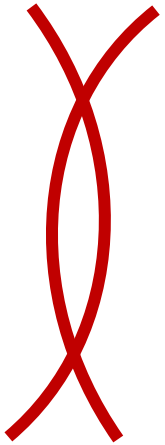




Short Answer Response



Steric Hindrance



What's happened since 2020?



AY 2020

- Lost our functioning in-person D/HH workshops.
- Lost an entire D/HH student cohort as future TAs.

AY 2021

- Wore masks, this was a problem!
- Access services was fragile.
- No available D/HH workshop TAs.

AY 2022 and 2023

- Low D/HH students registered in organic chemistry further complicating AY 2023.

AY 2024

- First year with robust D/HH student numbers for 2025 Tas!

Now What?

Our ~~Organic~~ Chemistry SLICE Team/Family



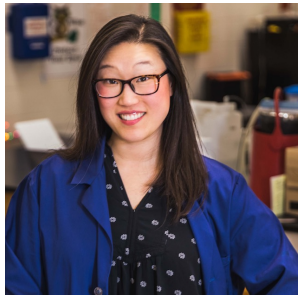
Dr. Tina Goudreau
Professor
College of Science



Jennifer Swartzenberg
Senior Lecturer
NTID Science and Mathematics



Dr. Pepsi Holmquist
Assistant Professor
NTID Science and Mathematics



Dr Lea Michel
Professor
College of Science



Sophia Fernandez
Environmental Science



Dakota Halterman
BioTech & Molecular Bio



Leah Morgenthal
Biology



Elijah Strom
Neuroscience



Chang-May Tang
Biomedical Sciences

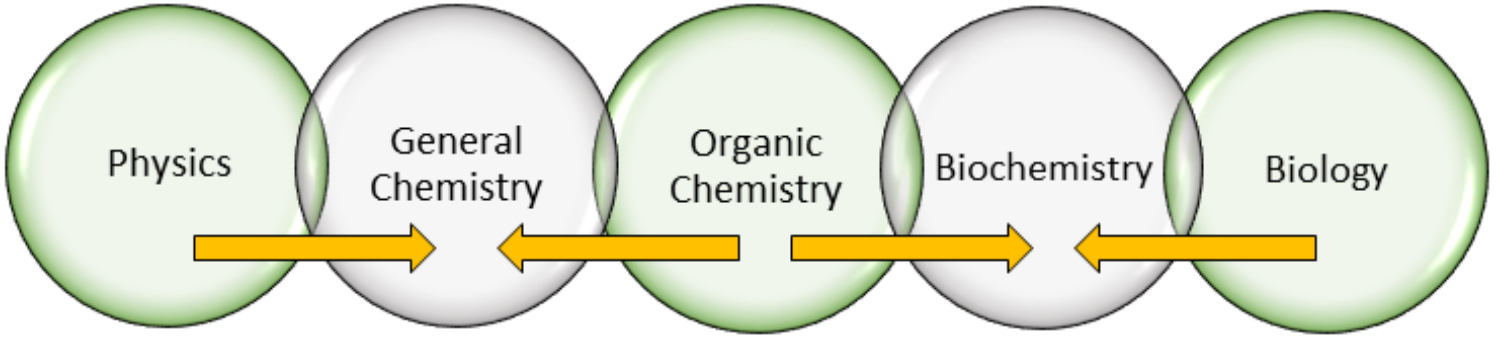


Hailey Jordan
Biochemistry/Interpreting

Current Work – Guiding Research Questions

Commitment **NSF**: Create Biochemistry and General Chemistry Lexicon for ASLcore and develop training videos and expansions.









Signing Amino Acids

When expressing Amino Acids in ASL, you should start by fingerspelling the entire word. Moving forward, you may abbreviate. For example, start with "A-L-A-N-I-N-E," then shorten to "A-L-A" or simply "A."

Visit www.reactivities.org/slice

Current Work – Guiding Research Questions

RQ NSF: To what degree does the adoption of STEM signs in the classroom impact a Deaf/HH students' attitudes in the classroom?

RQ NSF: To what extent must sign adoption occur by hearing instructors in order to register reported impacts by the deaf students in the classroom?

Theoretical Framework for Case Studies

Self-Determination Theory (SDT) - An approach SDT proposes that educational environments influence motivation and engagement through three psychological needs[1]:

- **Competence**
- **Relatedness**
- **Autonomy**

1. Contemporary Educational Psychology https://doi.org/10.1016/j.cedpsych.2020.101860

Preliminary Data - Interviews


Hailey Jordan

RQ: To what degree does the adoption of STEM signs in the classroom impact a Deaf/HH students' attitudes in the classroom?

Semi-structured interviews one-on-one between Hailey Jordan (research student), student participant, and interpreter (when requested). The interview was recorded, transcribed, shared with interviewee for accuracy and then analyzed.

Participant A - Third-year CHST major taking **organic chemistry** whose native language is ASL. Attended both a deaf institute and mainstream schooling and communicates primarily in ASL.

Participant B - Third-year COS major taking **organic chemistry** who was born hard of hearing in a Deaf family whose native language is ASL. Was enrolled in mainstream school.

Preliminary Data - Interviews

Themes	# Coded Instances	What we coded from the interviews
Competence (+ or -)	43	Feeling capable of understanding and participating in chemistry as it relates to clarity of the concepts and self efficacy.
Relatedness (+ or -)	16	Connection with the instructor and peers, and feeling valued, included, and respected as a classroom member.
Autonomy (+ or -)	17	Having a meaningful voice in learning and communication. Using signs to bridge the material and the language.

Preliminary Data - Inteviews

RQ: To what degree does the adoption of STEM signs in the classroom impact a Deaf/HoH students' confidence and self-efficacy in the organic classroom?

Themes	# Coded Instances	Defining Themes
Competence (+ or -)	43	Feeling capable of understanding and participating in chemistry as it relates to clarity of the concepts and self efficacy.

Participant A: *"I feel like [the signs] were helpful with understanding what the biggest takeaway and the mechanism was like syn-4 (does sign) and syn-3 (does sign) you can tell what it does by looking at it…I felt really good about the lab where we were just doing pi-base or syn-3 or syn-4. …I really understood the content and I was able to teach it to my other classmates"* (+**Competence**)

Preliminary Data - Interviews

RQ: To what degree does the adoption of STEM signs in the classroom impact a Deaf/HoH students' confidence and self-efficacy in the organic classroom?

Themes	# Coded Instances	Defining Themes
Relatedness (+ or -)	16	Connection with the instructor and peers, and feeling valued, included, and respected as a classroom member. .
Autonomy(+ or -)	17	Having a meaningful voice in learning and communication. Using signs to bridge the material and the language

Participant B: *"me and my friend group we use [the signs] a lot to explain like tough concepts like some of our other friends don't understand, we use it every day without even thinking…in STEM there's not many signs so having [the signs] makes a big difference"*, (+ **Relatedness,** + **Autonomy**)

Preliminary Data - Interviews

RQ5: To what degree does the adoption of STEM signs in the classroom impact a Deaf/HoH students' confidence and self-efficacy in the organic classroom?

Themes	# Coded Instances	Defining Themes
Relatedness (+ or -)	16	Connection with the instructor and peers, and feeling valued, included, and respected as a classroom member.

Participant A: *"[the instructor] is making the environment a lot more accessible for Deaf and Hard of Hearing"* (+ **Relatedness**), *I do think that having another deaf student teaching me would be helpful…I feel like that would make a huge difference"* (- **Relatedness**)

Participant B: *"[the instructor] boosted the comfort a little bit, just having some signs"* (+ **Relatedness**)

Preliminary Data - Interviews

RQ: To what degree does the adoption of STEM signs in the classroom impact a Deaf/HoH students' confidence and self-efficacy in the organic classroom?

Themes	# Coded Instances	Defining Themes
Competence (+ or -)	43	Feeling capable of understanding and participating in chemistry as it relates to clarity of the concepts and self efficacy.

Participant A: *"hearing students, they can just take their notes and listen and go at their own pace with what's going on. I always have to be moving my eyes from the screen, the professor, the power point, like my eyes are always in so many different places it's hard to follow."* (- **Competence**)

Preliminary Data - Interviews

RQ: To what degree does the adoption of STEM signs in the classroom impact a Deaf/HoH students' confidence and self-efficacy in the organic classroom?

Themes	# Coded Instances	Defining Themes
Competence (+ or -)	43	Feeling capable of understanding and participating in chemistry as it relates to clarity of the concepts and self efficacy.

Participant A: *"The interpreter is really hard to follow, like the interpreter, they both are really good, like super high quality in the class every time I look at them I wanna take my notes and I'm missing a lot of information."* (- **Competence**)

Preliminary Data - Interviews

RQ: To what degree does the adoption of STEM signs in the classroom impact a Deaf/HoH students' confidence and self-efficacy in the organic classroom?

Themes	# Coded Instances	Defining Themes
Competence (+ or -)	43	Feeling capable of understanding and participating in chemistry as it relates to clarity of the concepts and self efficacy.

Participant A: *"I don't know. I haven't really seen a lot of, like, ASL for [science] before coming to RIT, I didn't have any knowledge of STEM signs so … that's another reason I use captioning when I look at the interpreter, I don't understand them [STEM signs] sometimes.."* (- **Competence**)

New! TRACE Project



Leah Morgenthal
Biology

TRACE: Technical**-S**ign **R**esearch on **A**doption by **C**lassroom **E**ducators

RQ: How do educators who teach STEM to Deaf and hard-of-hearing students select, create, and adopt signs for specialized scientific terminology, and what factors influence their willingness to adopt and consistently use signs developed and disseminated by the broader Deaf STEM education community?

Are you a STEM educator for the Deaf who signs when they teach? Please consider participating in our study. The QR code will take you to a quick poll to sign up. Your help would be greatly appreciated!

Project Outcomes

- Large and growing data bank of technical STEM signs for chemistry.
- D/HoH students interviews revealing accounts of greater confidence, less confusion, or being better able to follow explanations.
- D/HoH students interviews revealing accounts of feeling recognized, included, respected, or more comfortable approaching the instructor.

Identified Challenges

- Technical signs do not largely diminish cognitive load for D/HH student.
- The pandemic disrupted the propagation of the STEM signs among the Deaf students.
- Cognitive load on Deaf students for learning technical jargon signs largely begins at the university-level.
- Learning curve by interpreters is high if interpreter assignments are inconsistent.
- Learning Curve by interpreters is high when the instructor does not know any STEM signs.
- Instructor buy-in to sign adoption is time intensive and inconsistent

Acknowledgements



Dr. Pepsi Holmquist
Assistant Professor
NTID



Dr. Lea Vacca Michel
Professor
College of Science



Hailey Jordan
RIT BS ‘26
Biochemistry/Interpreting



Leah Morgenthal
RIT BS ’27
Biology



Jennifer Swartzenberg
Senior Lecturer
NTID

IUSE-1625649
IUSE- 2314708
DUE-2149957: REU
Dr. Alicia Wooten

Preliminary Data – Baseline Survey



Hailey Jordan
Biochemistry/Interpreting

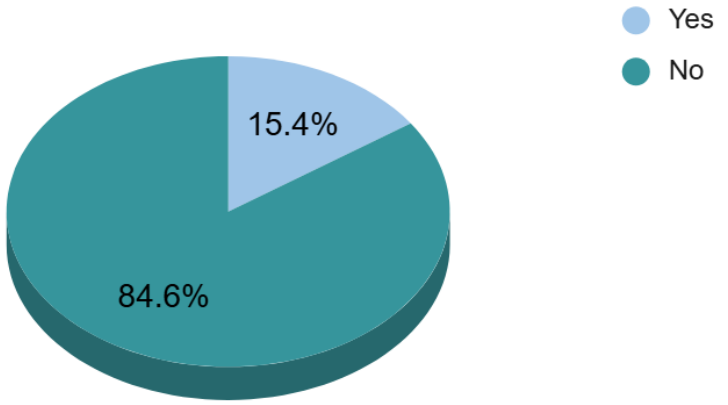
RQ: To what extent must sign adoption occur by hearing instructors in order to register reported impacts by the deaf students in the classroom?

One ASLcore awareness survey was sent to all **instructors** in physics, biology, and chemistry. N=38 responses (37% participation)

COS Instructor Response by Discipline

	Survey Response
Physics, N=51	35.3% (18)
Biology, N=28	39.3% (11)
Chemistry, N=23	39.13% (9)

COS Instructors that know signs for discipline n=38



12

# of instructors indicating that they communicate with their DHH students or interpreter prior to start of course (31%)

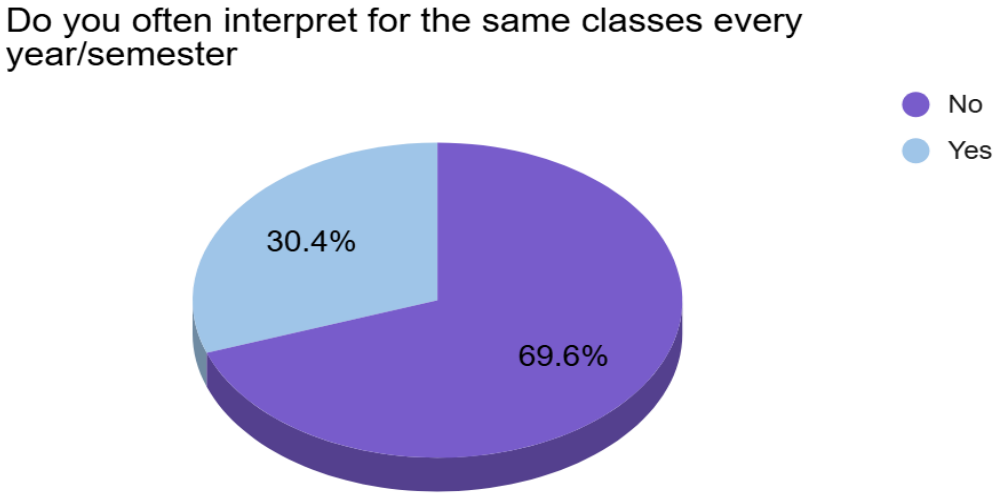
Preliminary Data – Baseline Survey



Hailey Jordan
Biochemistry/Interpreting

RQ: To what extent must sign adoption occur by hearing instructors in order to register reported impacts by the deaf students in the classroom?

One ASLcore awareness surveys was sent to all **STEM interpreters** in COS
N=23 responses (19% participation estimate)*



3

# of interpreters indicating that they communicate with the instructor prior to course.