What do we mean by science communication?

Who are we talking to?

What are we hoping to achieve?

What happens when this goes well?

What happens when this goes poorly?
How do we learn science communication?

How **might** we learn instead?
There’s momentum for formal training

RECOMMENDATIONS

RECOMMENDATION 1: EXPAND TRAINING ACCESS

Provide access to formal communication training opportunities for all STEM graduate students.

While most graduate education programs target the cognitive and technical skills required in STEM disciplines, emotional and communication skills are gaining wider recognition for their contributions to leadership and career success. Although associated traits like charisma and innate abilities vary from person to person, communication skills can be improved with a combination of training, feedback, and practice (Silva and Bultitude 2009; Berkhof et al. 2011). Training is particularly important since people tend to chronically overestimate their communication effectiveness (Keysar and Henly 2002; Kruger et al. 2005; Keysar 2007), and not only does communication ability not improve with time and experience alone (Moore et al. 2013), it may even degrade (Ha et al. 2010).

Our snapshot of communication trainings and courses suggests that graduate students encounter wildly variable access to communication resources depending on their department, discipline, university, and geographic location. While not all students require or will take advantage of the expertise and coaching available to them, all students should have the ability to enroll in graduate-level coursework and/or professional development programming.
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We have a lot to gain

Within our field
Grants, papers, adoption of your findings
Teaching
Recruiting the best students
Crossing the last 10 feet at conferences

Outside our field
Expanded career options
Recruiting collaborators
Forming interdisciplinary teams
Fewer than 8 out of 100 grad students will take a faculty job

<table>
<thead>
<tr>
<th>Field</th>
<th>Graduates</th>
<th>Job openings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Sciences*</td>
<td>183k</td>
<td>12k</td>
</tr>
<tr>
<td>Engineering</td>
<td>169k</td>
<td>51k</td>
</tr>
<tr>
<td>Physical Sciences</td>
<td>43k</td>
<td>9k</td>
</tr>
<tr>
<td>Mathematical Sciences</td>
<td>33k</td>
<td>7k</td>
</tr>
<tr>
<td>Computer Science</td>
<td>107k</td>
<td>108k</td>
</tr>
</tbody>
</table>

So Many Degrees, So Little Demand

The number of graduates with technical majors (shown: bachelor, master and Ph.D. degrees awarded in 2015-16) tends to outpace job openings (shown: 2014-24 projections, annualized). Computer science is the exception.

How are we preparing for non-academic jobs?

*Does not include health care occupations.
Bureau of Labor Statistics, National Center for Education Statistics
What do you want to see?
What do you not want to see?
Structuring Presentation
Presentations are boring

Why?
Presentations are overwhelming Why?
Expertise creates an expert blindspot

Expert Blind Spot: When Content Knowledge Eclipses Pedagogical Content Knowledge

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¹University of Colorado, nathanm@stripe.colorado.edu
²Carnegie Mellon University ³University of Wisconsin-Madison

The importance of content knowledge on proficiency in teaching practices is well documented (Borko et al., 1992; Shulman, 1986). But is this statement completely unimpeachable? Are there drawbacks for teaching that are specifically due to subject matter expertise? In this paper we draw on evidence from mathematics and language arts education to show ways that advanced knowledge in a content area can lead to notions about learning that are in conflict with students' actual developmental processes. This underscores the need for empirically based theories of instruction, and for teachers to integrate assessment practices in their classroom curricula that have the potential to challenge their assumptions about mathematical development in their students.

THE NATURE OF EXPERTISE

Before the launching of the cognitive science research program in the 1950’s, experts were considered to be a different breed from others. They were regarded as more intelligent, with greater memory capacity, and superior intellectual resources (Ericsson & Smith, 1991). However, careful research into the reasoning processes of experts as they performed both familiar tasks, and related but unfamiliar tasks, has shown that experts function with the same internal constraints as non-experts. Elevated performance levels were shown to be due to the acquisition of vast amounts of well-organized, domain-specific knowledge; intense, long-term practice within a narrow field; and exploitation of regularities of familiar tasks (Ericsson & Smith, 1991). Even so, demystifying expertise does not undermine its allure for education, and many prominent researchers argue that expert performance should guide our educational efforts (Hatano & Inagaki, 2000; Sternberg, 1996).

Expertise is not without its problems, however. Think aloud reports from experts and novices show that experts are less likely to have access to memory traces of their cognitive processes when engaged in tasks within their domain of expertise (Ericsson & Simon, 1984). This appears to be due to the automatization of certain cognitive processes in experts. Among novices, these processes are deliberate and stepwise, and so they leave a memory trace which is more likely to be inspectable and verbalizable.

It has also been shown that subjects with a large amount of domain knowledge may actually be at a disadvantage when compared to novices on certain tasks (e.g., Wiley, 1998). Expertise can act as a mental set (Einstellung). Within mathematics education settings, this can lead domain experts to focus on known efficient and effective representations and procedures for solving...
Reframing the challenge of presentation

Presentations are boring because they’re overwhelming

Presentations are overwhelming because we have an expert blindspot

Our goal today: Reduce complexity through structure
Reduce complexity through structure

12 objects
Reduce complexity through structure

3 groups
Reduce complexity through structure
Reduce complexity through structure
Reduce complexity through structure

Pittsburgh
(4 1 2)
Chunking reduces complexity by treating several objects as one group.
Presentations can be chunked
Presentations can be chunked
Presentations can be chunked

Sections

Slides
Presentations can be chunked

Main message

Sections

Slides
Structuring Presentation

Reframing the challenge

Presentations are boring because they’re overwhelming because we have an expert blindspot

Chunking reduces complexity and can be applied at many levels
Structuring Presentation

Reframing the challenge

Chunking slides

Chunking sections

Chunking presentations
Structuring Presentation
Reframing the challenge
Chunking slides
Chunking sections
Chunking presentations
Survey results

What should this course cover?

<table>
<thead>
<tr>
<th>Topic</th>
<th>% Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grant Proposals</td>
<td>13%</td>
</tr>
<tr>
<td>Writing for non-scientists</td>
<td>16%</td>
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<tr>
<td>Scientific writing</td>
<td>30%</td>
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<tr>
<td>All of the above</td>
<td>41%</td>
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Students are interested in many topics in writing

What should this course cover?

- Grant Proposals: 13%
- Writing for non-scientists: 16%
- Scientific writing: 30%
- All of the above: 41%
Sentence titles state the point, not just the topic

**Point**

Students are interested in many topics in writing

**Topic**

Survey results

What should this course cover?

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Sentence titles are critical because information has many interpretations.

Your point

Students are interested in many topics in writing

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Equally viable point

Most students don’t care about grant proposals

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Your slide’s message goes in the title

Supporting evidence goes here

Assertion-evidence approach
Alley 2006
Sometimes that message is complex

$$\min_A \|XA\|_* + \gamma \text{Tr}\{A^TWA\}$$

subject to \( A_i \in \{0, 1\} \)

$$\sum_j A_{i,j} = 1$$

$$\sum_i A_{i,j} \geq 1$$
Equations can be chunked

$$\min_A \|XA\|_*$$
Equations can be chunked

$$\min_A \|XA\|_*$$

Find $A$ such that $XA$ has a certain property
Equations can be chunked

\[
\min_A \|X A\|_*
\]

Find A such that \(X A\) has a certain property

subject to

\[
A_i \in \{0, 1\}, \quad \sum_j A_{i,j} = 1, \quad \sum_i A_{i,j} \geq 1
\]

A has to have the following structure
Equations can be chunked

\[
\min_A \| XA \|_* + \gamma \text{Tr}\{ A^T W A \}
\]

Find A such that XA has a certain property

Ideally A also satisfies this requirement as much as possible

subject to

\[
A_i \in \{0, 1\}
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\[
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\]

A has to have the following structure
Diagrams can be chunked

Figure 1 LDA tweak Model in Plate Notation
Diagrams can be chunked

Documents have **Topics**
Diagrams can be chunked

Documents have Topics

Words are based on document topics
Diagrams can be chunked

Documents have **Topics**

**Words** are based on document topics

**Tags** are based on topics and words
Diagrams can be chunked
Structuring Presentation

Reframing the challenge

Chunking slides

Chunking sections

Chunking presentations
Structuring Presentation

Reframing the challenge

Chunking slides

Chunking sections

Chunking presentations
An outline slide shows structure

Your presentation

Section 1
Section 2
Section 3
But the memory fades
Return to the outline to reorient

Your presentation

Section 1

Section 2

Section 3

Places points in context
Summarize and review
Reentry point
Allows section chunking
Sections and transitions form the body of the presentation.

Body

- Preview
  - Section 1
  - Transition
  - Section 2
  - Transition
  - Section 3
Structuring Presentation

Reframing the challenge

 Chunking slides

 Chunking sections

 Chunking presentations
Structuring Presentation
Reframing the challenge
Chunking slides
Chunking sections
Chunking presentations
The problem with most presentations is the lack of a clear explicit goal.
That chart explained the Quantum Hall Effect.
Now, if you’ll bear with me for a moment, this next graph shows rainfall over the Amazon Basin...
Your slide’s message goes in the title

Supporting evidence goes here

Assertion-evidence approach
Alley 2006
Your entire talk should also have a message.

Your slide’s message goes in the title.

Supporting evidence goes here.

Assertion-evidence approach
Alley 2006

Your main point.
Developing a message and a talk is a reciprocal process.

Your slide’s message goes in the title.

Your slide’s message goes in the title.

Your slide’s message goes in the title.

Supporting evidence goes here.

Assertion-evidence approach
Alley 2006

This is harder than it looks.
How do you choose the right goal?

Strong goals describe a change in the audience.
There are common pitfalls in choosing goals

“*I want my audience to be impressed with my work.*”

**Problem:** This goal is not about the audience

**Consider:** What is it about your work that you want them to be impressed with?

**Perhaps:** The audience should be persuaded to use this method / read future papers / fund me
There are common pitfalls in choosing goals

“I don’t have a goal. I don’t want to bias the audience.”

Problem: In order to evaluate an argument, they must at least know what that argument is.

Consider: Is your conclusion “we don’t know”? Why were you asked to talk in the first place?

Perhaps: The audience should fund a follow-up study. They should treat this as a risky decision. They should think of this as a known unknown.
There are common pitfalls in choosing goals

“I want my audience to understand how this works.”

Problem: Unclear how the audience will change

Consider: Why should they understand how it works? What will they be able to do differently? How will their (academic) lives be better?

Perhaps: They should be able to implement this method. The next time they [situation] they should [action]
A tool to articulate goals that focus on a change in the audience:

<table>
<thead>
<tr>
<th>Think</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Do</th>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A tool to articulate goals
example: my Ph.D. thesis

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<tr>
<th>Think</th>
<th>From</th>
<th>To</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Gravity is negligible in cell biology</td>
<td>Gravity affects gene &amp; protein expression</td>
</tr>
<tr>
<td></td>
<td>What’s microfluidics?</td>
<td>Microfluidics is a powerful form of custom automation</td>
</tr>
<tr>
<td>Do</td>
<td>Avoid using microfluidic devices</td>
<td>Start new collaborations with mechanical engineering</td>
</tr>
<tr>
<td></td>
<td>Read papers with skepticism</td>
<td>Seek out papers in the field</td>
</tr>
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# A tool to articulate goals

**example: improve sentiment on self-driving cars**

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<tr>
<th>Think</th>
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<tbody>
<tr>
<td></td>
<td>Self-driving cars are dangerous</td>
<td>They’re already safer than humans</td>
</tr>
<tr>
<td></td>
<td>Their biggest problem is ethics</td>
<td>Their biggest problem is unpredictable circumstances</td>
</tr>
<tr>
<td></td>
<td>They will kill me to save pedestrians</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do</td>
<td>Avoid using</td>
<td>Ride in self-driving cars</td>
</tr>
<tr>
<td></td>
<td>Oppose adoption</td>
<td>Endorse regulations allowing them on the road</td>
</tr>
</tbody>
</table>

---

- **Self-driving cars are dangerous**
- **Their biggest problem is ethics**
- **They will kill me to save pedestrians**
- **Avoid using**
- **Oppose adoption**
- **They’re already safer than humans**
- **Their biggest problem is unpredictable circumstances**
- **Ride in self-driving cars**
- **Endorse regulations allowing them on the road**
A tool to articulate goals

Your turn

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</table>
“Give me six hours to chop down a tree and I will spend the first four sharpening the axe.”
Five critical points orient the audience

Need
  why?    Gap between what we want and what we have

Task
  what?    What you did to address the need

Approach
  how?    How you approached the task

Results
  what?    What you found in the process

Conclusions
  why?    What the results mean for the audience
Five critical points orient the audience

**Audience**

- **Need**
  - why?
  - Gap between what we want and what we have

**You**

- **Task**
  - what?
  - What you did to address the need

- **Approach**
  - how?
  - How you approached the task

- **Results**
  - What you found in the process

**Audience**

- **Conclusions**
  - What the results mean for the audience
<table>
<thead>
<tr>
<th>Audience</th>
<th>Need</th>
<th>A big goal in the field is X.</th>
<th>why?</th>
<th>But that requires Y.</th>
</tr>
</thead>
<tbody>
<tr>
<td>You</td>
<td>Task</td>
<td>To find Y, I performed proteomic screens</td>
<td>what?</td>
<td></td>
</tr>
<tr>
<td>You</td>
<td>Approach</td>
<td>Here’s how I did it</td>
<td>how?</td>
<td></td>
</tr>
<tr>
<td>You</td>
<td>Results</td>
<td>Here’s what happened</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audience</td>
<td>Conclusions</td>
<td>Progress towards addressing the need</td>
<td></td>
<td>How the audience might change</td>
</tr>
</tbody>
</table>
A template for presentation

Opening

Need
Task
Preview

Body

Section 1
Transition
Section 2
Transition

Closing

Conclusions
Define your goals

Goals drive decisions in communication

Focus on a **change** in the **audience**

Define your message at multiple scales: presentation, section, and slide

Include critical orienting information: need, task, approach, result, conclusion
Structuring Presentation

Reframing the challenge

Chunking slides

Chunking sections

Chunking presentations
Fall Semester

Oct 9, 12  Structuring Presentation
Oct 23, 26  Graphic Design
Nov 6, 9  Distilling Your Message
Nov 13, 16  Telling Science Stories
Nov 27, 30  Crafting Explanation
Dec 4, 7  Vocal Delivery

4:30 pm
Tue MI 411
Fri WH 8325