Your Mission Should You Choose To Accept It:
How a Futuristic Narrative Framework Helped to Increase Math Discourse and Engagement in an Online Undergraduate Course
It all started with a story...

Two professors and a learning design team decided to tackle the issue of increasing mathematical discourse and student engagement in online math courses.

5 Mins  J

It all started with a story. Two professors and a learning design team decided to tackle the issue of increasing mathematical discourse and student engagement in online math courses. Their solution was twofold. First, they created a futuristic video narrative that challenged the students to apply mathematical concepts as a means to save the world. Secondly, they designed a course that offered synchronous conversation opportunities and just-in-time resources to aid in the translation of the language of math.
Guiding Theoretical Principles

- Emphasizing the Importance of Mathematical Discourse
- Using Novelty to Increase Situational Interest
- Developing Interactive Synchronous Sessions to Practice Discourse
- Creating Audio Tools to Translate the Language of Mathematics

The Importance of Mathematical Discourse
In 2014, the National Council of Teachers of Mathematics called for the infusion of teaching practices that “facilitate discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments” (NCTM 2014, 23). Increased mathematical discourse has benefits for both students and instructors (Katt et al, 2018). For students, discourse provides an opportunity to reflect on their own understanding while learning from the perspective of their peers. For instructors, discourse provides a mechanism to assess and extend their students’ mathematical understanding. The unique challenge of this design opportunity was in creating a framework that promoted this type of discourse in an online setting.

Using Novelty to Increase Situational Interest
Motivating students to talk about math can be a challenge in a traditional classroom; this challenge is amplified in an online environment. Inherently, the perception of interest is tied to the individual student, but findings suggest that the selection of content and increased engagement can be linked to the development of situational and individual interests (Hidi & Renninger, 2006). Students who are intrinsically interested in an activity are more likely than students who are not intrinsically
interested to exert effort (Downey and Ainsworth-Darnell, 2002; Miserandino, 1996), and learn at a conceptual level (Ryan, Connell, and Plant, 1990). Intentional course design that includes challenge, choice, novelty, fantasy, and surprise can increase students’ situational interest (Malone and Lepper, 1987). For this course, the infusion of a novel approach (video narrative) was selected as the main strategy to influence discourse.

**Synchronous Sessions for Discourse**

The development of the learning environment also has an impact on the level of discourse. A learning environment in which concepts and material are presented from a growth mindset can increase the self-efficacy of students and thereby increase their willingness to participate in the discourse (Dweck, 2006). When mathematical content in a course is framed as an open growth subject, students respond with an increased sense of motivation and perception of interest (Boaler, 2016). For this course, a biweekly synchronous session schedule (two times per week) was built into the course design to allow for discourse between the students and the instructor. The storyline of the video narrative was written to create a problem that could be viewed from multiple perspectives. This open-ended approach links with the principles of growth mindset: difficult situations can be viewed as opportunities to experiment to find solutions. Breakout rooms were used to provide opportunities for student-student sessions and collaboration tools were used to allow for instructors to offer a conversational approach to the ‘worked’ examples.

As students discussed the challenges, linked to a shared narrative example, they were able to engage with their peers and instructors in a way that went beyond a standard asynchronous approach common in online formats. The novelty of the narrative increased the engagement level of the students in alignment with Boaler’s findings in 2016:

> “Mathematics is a subject that allows for precise thinking, but when that precise thinking is combined with creativity, flexibility, and multiplicity of ideas, the mathematics comes alive for people. Teachers can create such mathematical excitement in classrooms, with any task, by asking students for the different ways they see and can solve tasks and by encouraging discussion of different ways of seeing problems.” (p.59)

**Creating Audio Tools to Translate the Language of Mathematics**

And, lastly, a major hurdle to increasing discourse in mathematics is linked to the language of math. Faculty observations led to the conclusion that some students are hindered in participating in classroom conversations simply because they do not know
how to speak the language of math. They hesitate from asking questions or making a statement because they are not sure how to translate a visual image (equations, symbols, etc.) into a verbal statement. Developing the language of a subject (mathematics in this case) requires students to engage in practicing and using its discourse (Duschl and Osborne, 2002, p. 40). A just-in-time solution to this issue was built into the design of this course. An audio library was developed that offered students a chance to listen to the pronunciation of common mathematical terms and notations. The faculty members read the equations to present the format and nuance of the language of math.
**Collaborative Framework | Pedagogical Shift**

- **Change inertia**: Math Faculty are comfortable with "chalk talks" just lecturing using a blackboard. There is an inherent desire to a digital replica of a standard lecture based class.

- **Seeing Options**: We needed to see that a pedagogical shift wasn't a fundamental shift. There was a different way to communicate our material that didn't change the content.

- **Consensus**: There is a give and take between learning designers and faculty. Learning designers helped structure the course to adapt to an online environment, where the faculty made sure the material was preserved.

5 min  B
Collaborative Framework: Shared Language

Shared language is a streamlined approach for communication with faculty and other stakeholders about how to use digital tools/strategies to support teaching and learning.
Collaborative Framework: Mock-Up Tools

Prototyping helps communication
Collaborative Framework | Design Challenge

How to help prepare non-mathematics majors students to

- effectively advance in mathematics
- and transfer their understandings to future areas of study?
Motivating problem sets that came from the story.

In the narrative, the characters needed to send coded messages, so we showed them how they code do this with the content they were learning.

---

**Application of Linear Algebra to Cryptography**

Encryption is used widely by people, private organizations, and the government to safeguard their data from misuse. Today, we will use linear algebra to encode and decode data.

First, we assign numerical values to the alphabet.

|   | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10| 11| 12| 13| 14| 15| 16| 17| 18| 19| 20| 21| 22|

**Example 1.** Using this, we can write a sentence with numerical values. For example:

\[
\begin{bmatrix}
    8 & 9 & 0 & 3 & 12 & 1 & 19 & 19
\end{bmatrix}
\]

Now, if this was all we did, this message would be very easy to decode. So let’s make it more secure.

Take the string of numbers and put the data into a \(2 \times n\) message matrix.

\[
\begin{bmatrix}
    8 & 0 & 12 & 19 \\
    9 & 3 & 1 & 19
\end{bmatrix}
\]
To help understand and transfer the conceptual content knowledge by the following strategies:

- The use of multimedia into topic explanations
- Rephrasing the terminology about the discipline
- Communicating your understanding with others in their own languages.
Examples of Math Discourse Tools

The Glossary

Linear Algebra: Glossary

- System of Equations
- Span
- Subspace (R^n)
- Standard Basis
- Subspace (Vector Space)
- Submatrix
- Similarity
- Shifting Theorem

Select a term:

Standard Basis

The Standard Basis of R^n is \{e_1, e_2, \ldots, e_n\}, where \(e_i\) is a n-length unit vector with 1 in the i-th element, and 0 elsewhere.

The standard basis of R^2 is

\[ \{e_1, e_2\} = \left\{ \begin{bmatrix} 1 \\ 0 \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \end{bmatrix} \right\} \]
Quiet Reflection
Poll Everywhere Q1
Poll Everywhere Q2
Poll Everywhere Q3
Contact Information:

Judy Lewandowski, PhD  jlewando@nd.edu
Kuang Hsu, PhD          khsu1@nd.edu