Active STEM Learning through Discourse in Inquiry with Online Learning Resources

Dr. Shande King, Nick Kim, Dr. Lynn Liao Hodge,
kingn2@spu.edu, nkim2@vols.utk.edu, lhodge4@utk.edu
Seattle Pacific University, The University of Tennessee, Knoxville

THE UNIVERSITY OF TENNESSEE KNOXVILLE
CENTER FOR ENHANCING EDUCATION IN MATHEMATICS & SCIENCES

SEATTLE PACIFIC UNIVERSITY

OVERVIEW

Although virtual teaching removes easy access to tangible manipulatives and other face-to-face interactions with laboratories and hands-on activities, active learning can still be achieved by emphasizing student discourse via inquiry-based learning. By focusing on student questioning and promotion of student discourse, along with carefully planning for virtual manipulatives and other STEM active learning online resources, K-12 STEM teachers can maximize student participation and advance critical thinking.

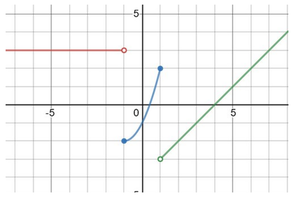
In this presentation, we provide examples of technological tools and resources that engage students in problem-solving and critical thinking activities through active participation in small-group discourse. Further, we provide recommendations for support of assessment of student learning with these technologies. We also explain a framework to establish questioning norms that engage the students through discussion in inquiry-based STEM learning. Finally, we will provide some reflections from pre-service teachers who have actively utilized these resources and teaching pedagogies in their classrooms for active STEM learning.

ONLINE LEARNING RESOURCES

Nearpod:

- Free, interactive lessons with multimedia embedding options and quizzes, polls, open-ended questions, etc.
- Gives students a voice in the learning
- Students take ownership of learning
- Teachers can formatively assess learning through live student responses

"Splash screen in Nearpod" by Wesley Fryer is licensed under CC BY 2.0



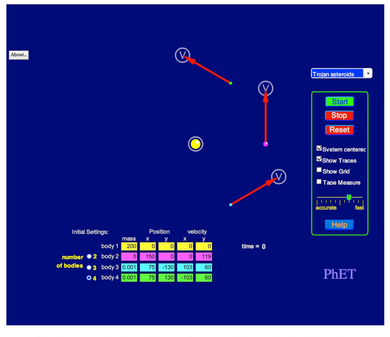
"desmos-graph" by corey462 is marked with CC PDM 1.0

Desmos:

- Free graphing and scientific calculators with multi-colored visuals
- Allows for student explorations of characteristics of graphs and functions
- Teachers use as a tool for student self-discovery during the learning vs. after the learning

PhET simulations:

- Free, interactive simulations that encourage learning by student exploration
- Can be embedded directly into teacher websites or Learning Management System (LMS) websites
- Students discover how and why the mathematics and/or science work with visuals controlled by their decisions
- Teachers use as a tool for student understanding throughout class



"Cool Toys pics of the day: My Solar System" by rosefirerising is licensed under CC BY-NC-ND 2.0

3 Act Math and Number Talks:

- Short videos and/or question prompts to initially engage students in questioning
- Lesson centers around student input and self-discovery while teacher facilitates discussion among students
- Students apply mathematics to support their reasoning and justifications while discussing with each other
- Teachers use as the main instructional series vs. a traditional lecture

"Act 2-World's Largest Gummy Bear" by crookedframe is licensed under CC BY-NC 2.0

RECOMMENDATIONS FOR IMPLEMENTATION

Many recommendations for implementing these online learning resources into a STEM class find foundation in the TPACK framework, which stands for the "technological pedagogical content knowledge" framework" (Graham, 2003). With the goal of active STEM learning from a remote or online environment, teachers utilize the TPACK framework so that students interact with the content in a way that the learning becomes meaningful to the students. Additionally, with students today being raised in the 21st century as digital natives, lessons that find foundation in the TPACK framework hold students accountable to learning throughout the entire learning process (King, 2019). The following practices support successful implementation of the online learning resources for meaningful learning in STEM classrooms.

- **Personalize the learning:** Using digital devices and online learning resources allowed one teacher to "[customize] the text, questions, and quiz according to her students' needs" (Delacruz, 2014). These resources give students the chance to work at their own pace and ask questions at the parts of the lesson that they find most confusing or difficult.
- **Individualized feedback**: Using interactive lessons with multimedia components allows students to "learn at their own pace and in their own time, in addition to taking into account their individual differences" (Al-Ibrahim, 2018). Further, these online resources allow students to ask individualized questions so that teachers can respond to each student in a student-focused pedagogy.
- **Emphasize student analysis as formative assessment:** Interactive lessons promote more student work instead of teacher lecture. When class men for live sessions (whether in person in hybrid classes or via video conferencing), time was focused on discussion where students shared their explanations and analyses of learning while also being assessed in their learning.
- **Identify content to be reassessed:** Using student discussions and feedback open doors for "pinpointing content and application areas for students, whether for a few students or for a large percentage of the class" (Mattai & Ennis, 2014).
- **Encourage interaction with the content and other students:** These online resources push students to discover the content through interaction vs. absorption of the material in a lecture format, which increases their motivation to participate and contribute to the discussions. Conclusively, students "interact with one another more meaningfully to make the content more meaningful" (King, 2019).
- **Social learning:** The design of online learning provides a non-threatening environment for students to interact with the content on their own. Knowing how to design online active STEM lessons that focus on student inquiry with online learning resources, the teacher created a classroom culture that students considered "a more student-centered learning style," since they were "constantly engaged in active learning and collaborative class activities" (Al-Ibrahim, 2018). Particularly, the lecture-related discussions focused the students' learning and discussions on what they learned in the interactive lessons, which kept students engaged and targeted the learning objectives for the lessons.

PRESERVICE TEACHER REFLECTIONS

"Visual learners can benefit from seeing the graphs."

"This method promotes learning because first the students participate in critical thinking about the material. Then, by sharing their own methods that they came up with for solving the problem with each other, they can use their own ideas, the ideas from their classmates, or a combination of different methods to solve a specific problem. Students have the opportunity to learn, from themselves, their teachers, and their peers during a number talk."

"...allows for the students to produce their own inquiry based questions, but it also allows for the teacher to step in and ask inquiry based questions when needed."

"Students will reflect on numbers and feel more comfortable with solving problems in more than one way. Students are able to look at the different things that help them find the answer to a problem. They come up with the things that will help them do this."

"This teaching method promotes inquiry learning because it allows students to ask questions that they have and share different ideas with each other. Having the students ask questions and share ideas with each other, promotes even more questions and ideas within the class, allowing the students to grow their knowledge on the topic."

"Students can speak with one another and bring up the questions they have to their peers. It gives them a chance to discuss things with other students."

QUESTIONS & CLASSROOM NORMS

Question prompts to encourage student-student dialogue:

To introduce a lesson:

- What do you notice about…
- What do you still wonder about…

In the middle of a lesson:

- Who has a question for…
- Turn to your partner. Explain why you agree or disagree.
- Talk with your group. How do your thoughts relate to those of the other group(s)?

At the end of a lesson:

- Summarize one thing that still confuses you.
- State the objective of today's lesson in your own words.
- Discuss with a friend how you could apply what you learned in today's class to:
  - A past lesson
  - A potential future lesson
  - A real-life context

Question prompts to emphasize active participation and reasoning:

- Which of these is not correct? Why?
- Which does not belong? Why?
- Can you explain your thought?
- What is an/another example? Why?
- What connections can you make to:
  - The reading
  - What you already know
  - The picture
  - The lesson objective
  - Someone else's thought
- Explain the error. How would you fix this?
- Why does this not always work?

Question prompts to clarify students' ideas:

- What evidence shows this to be true? False?
- Who can explain what (someone else) is saying, in your own words?
- What part of the drawing/diagram/image/problem is relevant to the problem/task?
- How do you explain…

Class Norms and Routines:

- Engage students with a question or topic to consider, then allow student discovery through discussion and collaboration.
- Implement at-home technology that promotes student involvement in learning vs. passive reception through lecture.
- Provide opportunities for students to individually respond, and/or give feedback.

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