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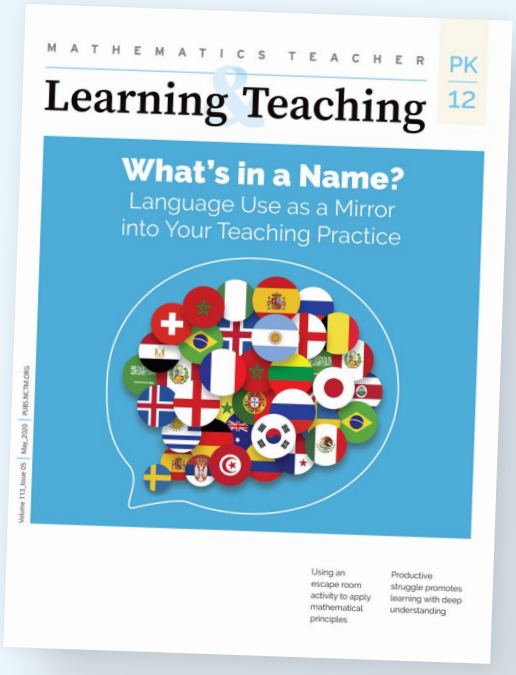

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Student Engagement with the "Into Math Graph" Tool

We introduce the Into Math Graph tool, which students use to graph how "into" mathematics they are over time. Using this tool can help teachers foster conversations with students and design experiences that focus on engagement from the student's perspective.

Amanda K. Riske, Catherine E. Cullicott, Amanda Mohammad Mirzaei, Amanda Jansen, and James Middleton

Many of us, as mathematics teachers, have struggled to engage our students productively in challenging tasks (Turner, Christensen, and Meyer 2009). *Engagement* is how and to what degree students invest their behavior, intellectual energy, emotions, and interactions, whereas *productive engagement* is engagement that supports learning and longer-lasting investment with mathematics (Jansen 2019). A recent review of research on mathematics engagement shows that learning and engagement are inseparable (Middleton, Jansen, and Goldin 2017). Teachers play a vital role in encouraging deeper and more productive student engagement (Shernoff, Ruzek, and Sinha 2017). Research shows that students' cognitive investment in challenging tasks depends on their beliefs,

emotions, and adaptation to classroom social norms (Middleton, Jansen, and Goldin 2017). These variables influence students' behavior and present insight on their perspective toward mathematical tasks and mathematics in general. By understanding student perspectives on engagement, we, as teachers, can better tailor tasks and feedback to encourage productive engagement.

In this article, we introduce the Into Math Graph tool, which helps us learn about our students' mathematics-related experiences and mathematical engagement by inviting students to define and graph their engagement over time. This tool documents and allows us to understand how and why our students' engagement increases, decreases, fluctuates, or remains the same. This tool was created for the Secondary Mathematics in-the-Moment Longitudinal Engagement Study (SMiLES) to help researchers understand how students experience and describe their mathematical engagement (Edusei, Jansen, and Mohammad Mirzaei 2019). Here, we discuss how we can use this tool as teachers, share examples of student responses, and discuss implications for practice.

Ritchhart and Church (2020) challenge teachers to be "students of our students" (p. 11) to support student engagement. We advocate this philosophy to facilitate effective, adaptive teaching. The Into Math Graph tool can help foster conversations with students so we can understand engagement from *their perspectives*. Students can experience engagement in their cognition, social interactions around mathematics, emotions, interpersonal relationships with their peers and teacher, or perceived usefulness of mathematics. Because of these different ways of engaging, multiple forms of engagement often play out in our classrooms simultaneously. One student may experience positive engagement while independently figuring out a problem (cognition), whereas another student could be engaged when debating mathematical concepts with peers (social interactions). A challenge of teaching arises when both of these students are in class with 28 other learners who experience mathematics and demonstrate engagement in

We use *into math* as a student-friendly term for mathematical engagement.

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varying ways. The Into Math Graph tool helps us learn about our students' experiences, so we can design and frame engaging learning experiences with all our students in mind. Please note we use *into math* as a student-friendly term for mathematical engagement.

USING THE TOOL

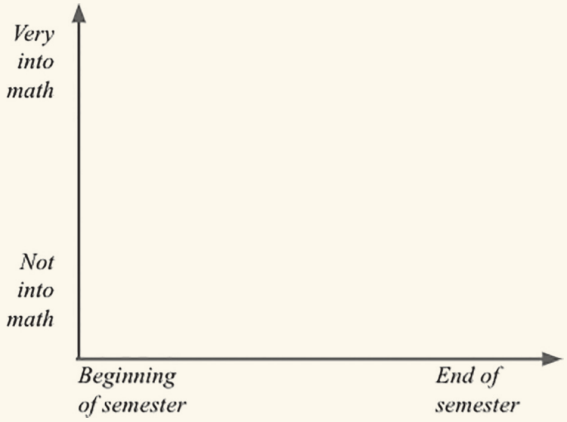
The Into Math Graph tool asks students to respond to four prompts:

1. What do you think it means to be *into math* class? Why?
2. Think of a time when you were really *into math* or *not into math*. What happened? What was that like for you?
3. Graph a relationship (a line, curve, or curve with turns, etc.) representing how "into" *math* you were over the semester (see figure 1).
4. Explain your graph. What happened at points of change, such as maximums/minimums, fluctuations, and segments of stability?

Students answer prompts 1 and 2 before drawing their graph. Prompt 4 has students reflect and elaborate on direction changes, inflection points, or important events displayed in their graph.

We developed two versions of the Into Math Graph tool: (1) a paper version and (2) a Desmos (2015) graphing calculator classroom activity. Both consist of the earlier prompts and graph. We encourage other teachers, when using the tool, to modify the time period and aspect of class students reflect on. Students reflect on their engagement during the course of a semester, but variables on both the horizontal and vertical axes can be changed. For example, teachers could ask students to reflect on their *understanding* over the course of a specific unit or *the level of difficulty* they experienced while doing a project.

Fig. 1



The Into Math Graph tool allows students to reflect on their engagement level (vertical axis) in mathematics class over time (horizontal axis).

The Desmos version allows teachers to edit the prompts and graph and includes suggestions in the *Teacher Moves* tab. Choose one of the four options (see figures 1 and 2) that aligns with what teachers want to learn about their students and delete the additional options. Option 1, shown in figure 1, allows for an open scale of engagement (vertical axis) and time (horizontal axis).

Option 2 provides scales for time and engagement, prompting students to be precise about time and consistent for engagement, although each engagement level will be relative to each student. The time scale can be adjusted to any unit of time, including projection into the future for goal setting. Option 3 allows students to reflect on engagement in relationship to the timing of assessments during a unit or semester. This information can allow teachers to understand how students anticipate assessments and how assessments influence students' engagement. Option 4 includes a table for students to connect vital points on the graph to specific events of their choice. The table assists with identifying patterns within and between students and their changes in engagement. For example, the table could illuminate how students experienced new activities and allow us to modify the activities or how we frame the unit to engage students more personally. Alternatively, the vertical axis can be changed to *understanding*, *motivation*, or *challenge* (or any other construct) to gain more insight into students' self-assessment of the construct. If a teacher decides to change the construct, also changing the prompts is important.

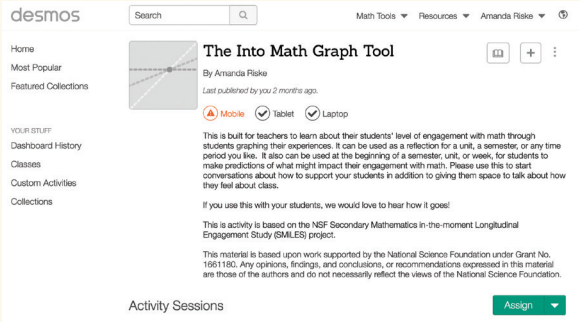
Enacting the tool with Desmos provides the ability to view all students' graphs simultaneously through the teacher dashboard (for a tour of the Desmos activity, see video 1). The dashboard provides a snapshot of the class's engagement over the same period of time, perhaps providing information on how the students experience the culture of the class. Teachers can save their students' reflections to revisit during the school year or implement the tool again to monitor students' perspective changes.

THE TOOL IN USE

Now that we have introduced the Into Math Graph tool and have given a sense of its implementation, we will share some of the examples from the SMiLES project. We used the Into Math Graph tool during student interviews to understand how high school students perceived their engagement during a semester in their current mathematics class. These examples illustrate what teachers may learn about their own students' experiences. We suggest teachers use the written reflection component of the tool instead of interviewing each student.

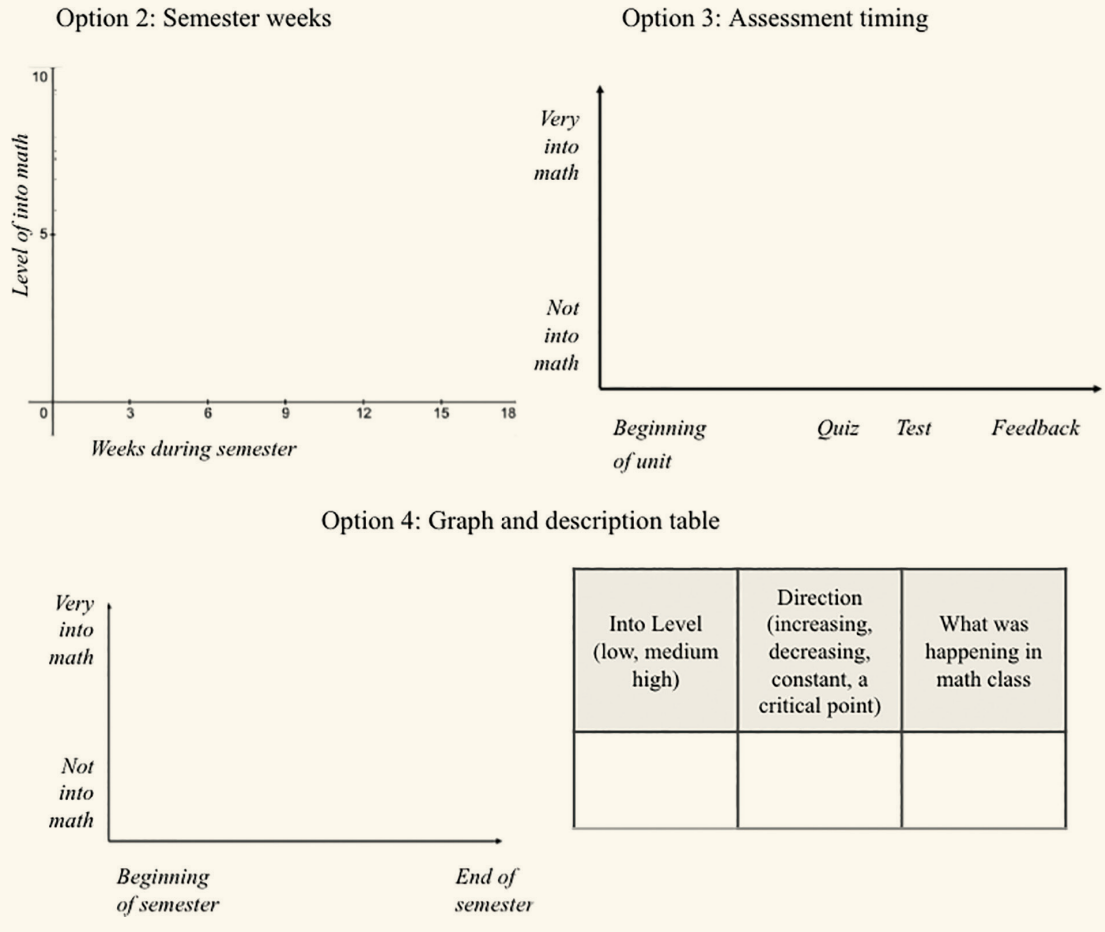
We interviewed 44 students enrolled in compulsory mathematics courses in their first or second year of high school using the Into Math Graph tool described earlier. Students defined what mathematics engagement (*into math*) meant to them, gave an example, and sketched

Video 1 A Tour of the Tool as a Desmos Activity



Watch the full video online.

Fig. 2

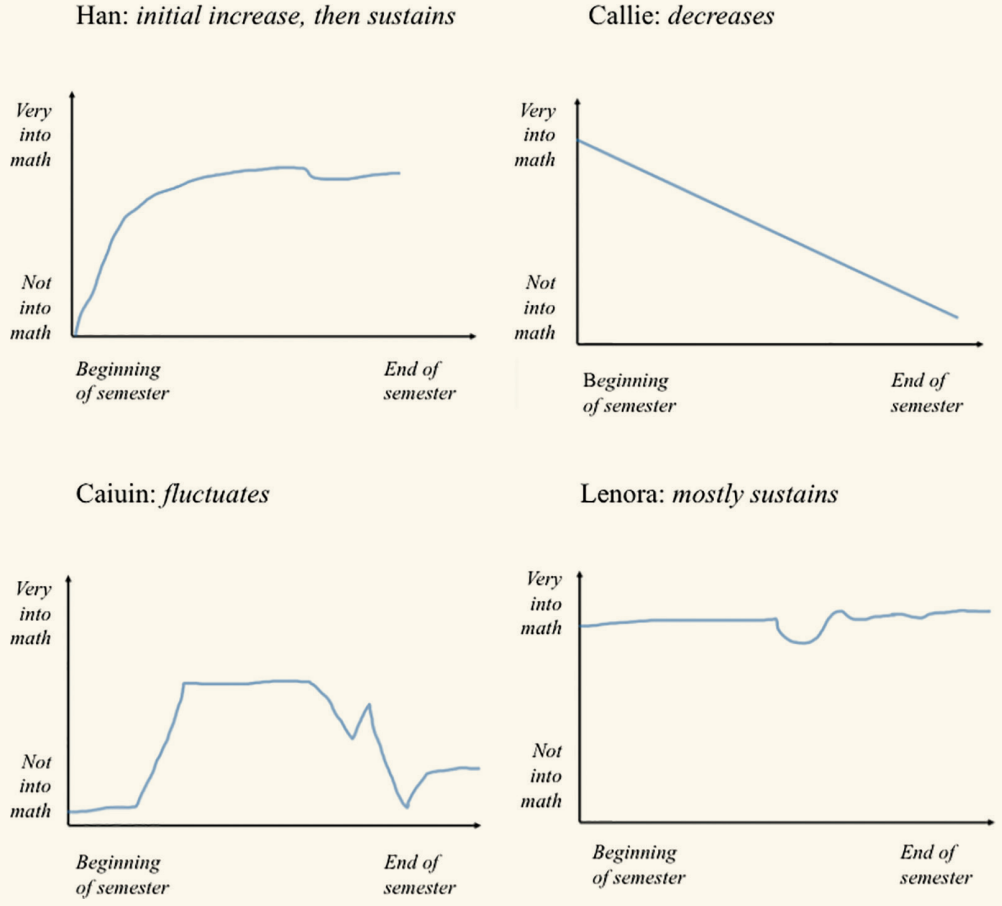


Teachers can choose from four graphing options and edit them to suit their needs in both the paper and Desmos versions.

their graphs. The interviewer then asked students to reflect on their graphs, as suggested in prompt 4. This prompt elicited reasons for students' graphing choices. Students described their engagement in a number of ways that we characterize as cognitive processes, social interactions, emotions, interpersonal relationships with their peers and teacher, and perceived usefulness of mathematics. Students described these dimensions of engagement as overlapping and intersecting. For example, students could have enjoyed the activity but perceived the mathematics to not be particularly useful. Students' responses varied regarding what influenced the direction of their engagement level (e.g., increasing, decreasing, fluctuating, or stabilizing). Figure 3 displays examples of student graphs from the SMiLES interviews conducted at the end of a semester.

Students' graphs illustrate that students entered their classrooms with varying levels of mathematics engagement. The variation could be due to experiences such as prior successes, struggles, or traumas induced through mathematics class or around their self-perception as mathematics learners. Students could start class with a low level of mathematics engagement, as Han and Caiuin did, whereas others may enter enjoying mathematics, as Lenora and Callie did. However, considering how to increase and sustain student engagement is important, as is considering how we, their teachers, are an important variable in the equation. To interpret students' graphs, understanding how each student defined mathematics engagement is crucial. We examine four student cases, observe their graphs (figure 3), and compare their descriptions. Then

Fig. 3



These graphs created with the Desmos graphing calculator (2015) represent the four categories of typical student experiences in our data.

we consider how to support student engagement using this information.

INCREASING ENGAGEMENT EXAMPLE (HAN)

Han defined mathematics engagement as paying attention to the teacher and "every little detail that [teacher] gives, so you don't miss anything [because] if you miss something, it can mess up the entire problem." He also described the teacher as important to increasing his mathematics engagement, sharing that his previous teacher "would just make us go on the computer and he wouldn't really teach us anything," whereas his current teacher "really gets [me] into the mood" for learning mathematics, particularly using computer-based activities.

When Han reflected on his graph, he said, "In the beginning of the semester, I wasn't really into math, I never really liked math." He described his increase in engagement: "Over time I did a lot more tutoring with [teacher] and went to his math class, and he gave me a little more help. As the semester went on, I started getting more focused and more into my math work." After the increase, his mathematics engagement stabilized because "there's more to math than what we know right now," and he remarked that he learns more with the "interactive notebook" and group activities.

DECREASING ENGAGEMENT EXAMPLE (CALLIE)

For Callie, mathematics engagement meant "you like math and you're interested in what happens every day in class in math and things like that." However, Callie did not identify as being engaged. She shared, "Because personally, I don't like math so I'm not into it. So, people who are into math they like the problems and like things that is [sic] being taught in math."

Callie's engagement level steadily decreased during the semester. Even though she relayed she did not like mathematics, her graph started high because "in the beginning, it was easier." She accounted for the decline of her graph saying,

> It started getting harder. . . . So my grade stayed like a C and then when we took a test, I wasn't here for that test and she put in that test. . . . So [my grade] went down to an F. So I stopped trying in math, to be honest.

Callie described her engagement as intertwined with her ability to understand the material, her grade, and how her teacher recorded her grade. She also mentioned how her teacher and classmates influenced her engagement. The pace of the lesson—"It's just sometimes she goes too fast for me and then I would get lost"—and her peers being "really loud" which "disturbs the learning environment" made Callie feel that she would not "get to learn what [teacher]'s teaching." She indicates that she might not have access to the mathematical content because of the speed of the lesson and the learning environment distractions, and she attributes her decreased engagement to these factors.

FLUCTUATING ENGAGEMENT EXAMPLE (CAIUIN)

Mathematics engagement for Caiuin meant "there has to be interaction between the teacher and the student. It can't just be like, 'Here's your paper and a pencil, and go ahead and work.'" Caiuin also believed the teacher should drive students "to come back to the classroom every day happy and wanting to learn. If the teacher's not doing anything, then why is the student going to want to come back?" When asked whether he is engaged in mathematics, he said, "I like [classmates] and I like the teacher, and I like how the class is, but I don't like the subject."

Caiuin's graph fluctuated throughout the semester on the basis of a combination of factors. Caiuin said at the beginning of the school year, "I wasn't into it at all. . . . I never wanted to come to class." His engagement increased as he "was actually paying attention and stuff" and sustained at a higher level because "it was pretty chill." He mentioned that he was positively engaged when his teacher encouraged students to debate their answers. His teacher "would get us to be passionate in a sense about what we were doing." Caiuin's teacher was a big extrinsic factor in increasing and sustaining his engagement. His decreased engagement centered on not understanding the material, adjusting to a computer-based mathematics activity, anticipating a large assessment, and his view of mathematics.

SUSTAINING HIGH ENGAGEMENT EXAMPLE (LENORA)

Lenora is engaged in mathematics and prefers it to other subjects. She shared, "I've always been better at math. . . . [classmates] always makes it fun and entertaining and [teacher] is pretty good teacher, too."

Lenora attributed her relatively high level of mathematics engagement to liking the subject but did not specify why. She said, "So I'm pretty into math. I like math. Most subjects are pretty cool." When she is engaged in a unit, she is "probably going to be paying attention and doing the work or whatever. Or in even doing the little extra practices or whatever."

The small dip in her graph was revealing. She explained, "Every once in a while there's a unit and I'm just lost," and she "understood at the beginning, but then it just got confusing." Lenora also appreciated when her teacher "just gives us an equation, not a word problem because it kind of threw me off a little bit." Although Lenora enjoyed mathematics, she preferred watching her teacher demonstrate the steps to solve a problem before trying on her own. She also appreciated when the teacher decoded confusing problems instead of letting her grapple with the problem.

From these four students' examples, we learn that the Into Math Graph tool gives students the opportunity to voice their own definitions of engagement and allows us to hear students' perspectives, understand what is working for them, and identify what might not be as helpful. These perspectives can be gained not only from interviews but also from students' written reflections.

HOW CAN THE TOOL HELP PRACTICE?

Let's think about the student examples as if they were from our class and how we can engage them further. Might we change instruction to accommodate the students' preferences or instead help students reframe their experiences? Perhaps we can do some of both.

These students' engagement levels were affected by how they understood or performed in the course, which can be layered with intrinsic and extrinsic factors. Some students were more engaged when they perceived mathematics as easier, and their engagement decreased when they felt lost or confused. We can avoid compromising the rigor of the content by reframing experiences of challenge with students to support them. Caiuin asserted that his engagement was his teacher's responsibility rather than a joint effort. If we taught Han, Callie, Caiuin, and Lenora, we could encourage them to view learning as a continuous and internally rewarding process of growth (Boaler 2016) and revising (Jansen 2020) among a learning community instead of performing perfection or mastery on first attempts. These perspectives can orient students toward intrinsic motivation on challenging tasks and decrease overwhelming feelings.

Listening to students' experiences can also inspire us to shift our teaching practice. Students reported the value of receiving academic support, such as tutoring from the teacher (Han) and extra practice (Lenora), as helpful to their engagement. Opportunities for social engagement and student-centered discourse practices through defending a mathematical position with peers were also associated with positive engagement (Caiuin), so we can invite students to use mathematical debates (Luzniak 2019) or share rough drafts (Jansen 2020) when solving problems. We can also pair students to try new strategies together. Then we can use the Into Math Graph tool to gather student feedback on new teaching practices. We acknowledge that not all students' graphs will point to instructional practices that help them engage with mathematics, such as Callie's. Regardless, this tool can help open up lines of communication with our students about mathematics engagement.

The Into Math Graph tool can illustrate how the same activity can engage students differently. These variations could be attributed to students' histories in previous classes, school experiences, teachers, or resources. For example, Han spoke negatively about how his previous teacher used computer-based activities and then expressed his appreciation for how his current teacher uses computer-based activities to mediate and promote learning. Using this tool at the beginning of the school year can help us access students' prior experiences and design activities with their histories in mind. Han's perspective can serve as a reminder to be mindful of how we use technology and to integrate it into lessons to promote learning.

This tool is unique because it affords insights about students over time. Teachers have used alternative tools to get to know their students, such as prompts for students to reflect on their beliefs about mathematics (Leatham and Hill 2010) or short surveys about students' experiences with specific classroom activities so teachers can use data from students to improve their practice (Nieman et al. 2020). The Into Math Graph tool considers students' reflections on their experiences over a period of time, which contrasts with other tools that focus on a single time point.

Checking in with students about engagement by using the Into Math Graph tool offers insights about how to support them. Asking students to reflect on their engagement welcomes authentic perspectives and may discourage pseudo-engagement or their

attempts at appearing to engage as teachers or peers may expect. As teachers, we are responsible for creating the best possible situations for students to increase their knowledge. Listening to students' experiences with mathematics is a step toward being a "student of our students." Thus, supporting them increases and sustains students' appreciation for the mathematics we are so *into*.

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