ENGAGING HIGH SCHOOL STUDENTS IN MATHEMATICS

Facilitator Guide for a 6 Session Professional Development Series

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Engaging High School Students in Mathematics

Students often disengage from mathematics when they experience it as removed from authentic contexts and disproportionately focused on calculating with procedures. This 6-session professional development series provides tools for teachers to encourage a range of mathematical competencies in students using authentic problem-solving to develop motivation. The series is designed to help teachers adapt their instructional practice in ways that will increase the initiative, perseverance, and eagerness of their students to engage in mathematical reasoning and problem solving. Throughout, there is an emphasis on encouraging students to engage in productive struggle and generate their own problem-solving strategies.

The series involves interactive teacher experiences and resources organized around these topics:

- Teaching Authentic Problem Solving: Developing Greater Mathematical Reasoning with Students
- Mathalicious Curriculum
- Rich Material Tasks: Developing Multiple Mathematical Competencies with Group Work
- Problems in Context: Planning for Authentic Tasks
- Project-Based Learning
- Supporting Academic Tenacity in Mathematics: Teacher Questioning and Feedback

This Facilitator Guide is designed to be used with the PowerPoint slides and other resources housed on the website http://engage.every1graduates.org.

Teaching Authentic Problem Solving: Developing Greater Mathematical Reasoning with Students

Objectives

The goal of this session is to show teachers how they can increase the initiative, perseverance, and eagerness of their students in tackling application problems and help their students develop and apply more sophisticated mathematical reasoning in formulating and solving problems.

Guiding Questions

- How can we equip our students to become authentic problem solvers who confidently and patiently reason their way to a solution?
- How can we adapt the application problems we use in classroom instruction to generate mathematical discourse and engage students in productive struggle as they determine what information and methods they need to solve the problem?
- How can we help students learn to ask pertinent questions, develop and justify an effective strategy, and identify the key information they need in solving challenging problems?

At a Glance

- "Do Now" activity for teachers listing the challenges students have when asked to complete application problems in their classrooms.
- Discussion of the characteristics that students often display when asked to apply mathematical reasoning and processes to the world around them.
- Presentation and discussion of multiple examples of how we can adapt the application problems we use in classroom instruction to:
    - Generate mathematical discussion
    - Have students themselves determine what is needed and how to complete problems
    - Have students employ (and become comfortable with) different problem-solving strategies

Materials

Handout M1 (Teaching Authentic Problem Solving, 6 pages)

Procedure

Set-up: Open the PowerPoint presentation on a computer connected to a projector and speakers. Project the session's title (Slide 1). The room should be set up so that teachers can sit at tables in small discussion groups such that each group member can see the screen or smart board where the slides/videos will be projected and hear the accompanying audio.

Do Now: List the Challenges to the Effective Use of Application Problems (4 minutes)

Facilitator welcomes teachers as they arrive and asks them to complete the "do now" activity on the first page of the handout.

Introducing the Session's Focus: Five Challenges – Which of These Do You Experience and How Might We Overcome Them? (4 minutes)

- Facilitator summarizes how authentic problem solving taps into the BRACE components of motivation that were discussed in earlier whole-school professional development sessions (Slide 2).
- Facilitator shares five challenging characteristics that students often display when asked to apply mathematics to real life (Slide 3).
- Teachers briefly share their own experiences with these challenges.
- Facilitator introduces the session's focus: Overcoming these challenges by adapting the application problems we use in classroom instruction so as to generate mathematical discussion, have *students themselves* determine what is needed (and how) to solve the problems, and encourage students to employ and become comfortable with diverse problem-solving strategies.

Using Images or Extremely Short Videos to Draw Students into Authentic Problem Solving (7 minutes)

- Facilitator demonstrates how to draw students into focused, authentic problem solving by presenting an image (Slide 4) or a video lasting just a few seconds (Slide 5) that naturally raises a compelling question. (Teachers identify the questions raised: "Which glass of soda would I choose?" "Will the ball go in the basket?")
- Facilitator uses the soda problem to model the four key questions we need to train our students to ask themselves whenever they encounter a real-life problem that involves mathematics (Slides 6 and 7).

Helping Students Become Savvy and Patient Problem Solvers by Removing "the Straight Clear Path" We Have Been Providing. (Slide 8, 4 minutes)

- Facilitator suggests that we often unintentionally limit students' growth in mathematical reasoning by giving students all the information they need to solve the problem at the beginning, formulating the problem for them, and even signaling the substeps that they might need to follow to find a solution. This common practice also transforms potentially interesting problems into boring exercises.
- Facilitator plays the video excerpt of Dan Meyer's TED talk describing how we can adapt growth-stunting application problems into ones that are more effective in helping students become savvy and patient problem-solvers.
- Next, the facilitator introduces a sample geometry problem from the PARCC (Slide 9) and demonstrates how to adapt the problem for classroom use to make it more effective in promoting student growth (Slide 10). The facilitator also shares examples of guiding questions that the teachers can use with students to support students' reasoning as they tackle the adapted problem (Handout p. 4).

"Is it Too Late?" -- Teachers Tackle an Authentic Problem (9 minutes)

- Teachers twice watch a 52-second video depicting a real-life paint mixing problem (Slide 11).
- Facilitator displays the four key questions again (Slide 12), and presents a graphic organizer featuring these four key questions -- a useful tool for helping students become more proficient in the problem solving process (Slide 13 and Handout M1, pages 5 & 6).

- Teachers use the graphic organizer (on page 5 of the handout) to formulate and solve the problem, as the facilitator displays the graphic organizer on the screen (Slide 13). Teachers then share their formulation and solution of the problem.

Using Word Problems in the Classroom to Help Students Develop their Reasoning: Additional Examples (10 minutes)

- Teachers read a word problem (Slide 15) and then discuss one student's attempt to articulate what the problem is asking and apply his own method in solving it (Slide 16). Then, the facilitator leads a discussion of how to respond to students' mistakes and misconceptions (Slide 17). The facilitator then draws teachers' attention to a planning guide they can use in preparing for a class session that will include authentic problem solving (Handout p. 7).

Session Summary (6 minutes)

- Facilitator shares "Key Takeaways" regarding how to teach authentic problem-solving (Slide 18).
- Finally, the facilitator shares two websites that are good sources of authentic problems (Slide 19).

Workshop: Mathalicious Curriculum

Note: In this session we provided teachers with one-year access to the lessons available on Mathalicious.com. As delivered, the session included a sample lesson that was publicly available on the Mathalicious site at the time, but Mathalicious periodically changes which lessons are available without a subscription. If you would like to walk through a sample Mathalicious lesson with teachers without a subscription, select an appropriate lesson from those that are publicly available:

https://www.mathalicious.com/lessons/search?lesson[public]=1

and adapt the guide as needed.

In order for teachers to more fully experience the lesson as students during the session, you may want to avoid selecting a lesson that requires students to gather outside materials. Most, but not all, Mathalicious lessons include a lesson guide; selecting a lesson that includes a lesson guide may spur more discussion of lesson planning using Mathalicious.

If you have full access to Mathalicious and would like the original facilitator guide based on the *You're So Fined* lesson, please email Martha Mac Iver (mmaciver@jhu.edu) or Tristan Hann (tristan.hann@jhu.edu).

Objectives

The goals of this session are to:

- Connect teachers to the Mathalicious curriculum
- Experience a Mathalicious lesson

Guiding Questions

- How can we increase students' exposure to cognitively demanding real-world mathematical content with Mathalicious lessons?
- What does a Mathalicious lesson entail (planning, teaching, reflecting)?

At a Glance

- Activity: sample lesson
- Go through lesson guide and guiding questions provided by Mathalicious
- Browse Mathalicious lessons
- *Optional:* Provide Mathalicious.com login information for teachers

Materials

Student handout for selected sample lesson, downloaded from Mathalicious

Lesson guide for selected sample lesson, downloaded from Mathalicious

Video/audio capabilities for media portion of selected sample lesson

Procedure

Set-up: Navigate to the selected sample lesson page at Mathalicious.com. Click on the "Teach" tab. Ensure that sound is working and set at the appropriate volume.

Introducing the Session's Focus: Mathalicious (5 minutes)

Facilitator asks teachers if any of them are familiar with the website Mathalicious.com, and if so, if any have utilized the curriculum before. If any teachers respond affirmatively, facilitator asks if they would like to share what their experiences have been with Mathalicious. If no one volunteers or if no teachers are familiar with the website, facilitator explains that Mathalicious.com provides educators with engaging, real-world lessons that are intended to challenge students to think critically. **(4 minutes)**

Facilitator distributes the printed student handout and lesson guide to teachers. Facilitator informs teachers that they are going to experience a Mathalicious lesson first hand, followed by an opportunity to look through the Mathalicious.com lesson database. **(1 minute)**

Activity: Sample Mathalicious Lesson (35 minutes)

Facilitator informs teachers that he/she is going to be jumping back and forth from the role of the "teacher" to the PD session facilitator, and that, likewise, teachers are completing the activity as "students" while also considering the tasks from the perspective of a teacher. **(1 minute)**

Facilitator plays the brief video clip on the lesson's "*Teach*" tab, and informs teachers that with their students they could spend a couple minutes discussing questions prompted by the video clip. Facilitator prompts teachers to work through the questions in Act 1 of the lesson with a partner. **(7 minutes)**

In the lesson's *"Teach"* tab, facilitator clicks on Q1 to show teachers the results for the first question. Facilitator informs teachers that this is a moment where one would elicit student thinking, by asking (for example) whether the results are what students would expect. **(2 minutes)**

Facilitator (as teacher) clicks to Q2 on the *"Teach"* tab and uses the guiding questions on the lesson guide to facilitate a conversation among the teachers (who are role playing students) about question 2. (**10 minutes)**

Facilitator has teachers read through questions 3 and 4 with a partner, prompting them to discuss the value of each question. Facilitator prompts teachers to think about "*what are the key insights to be gained from each question*?" **(7 minutes)**

Facilitator prompts teachers to read the remaining question(s) and discuss with a partner their thoughts on the final question(s) and the lesson as a whole. **(8 minutes)**

Planning for a Mathalicious lesson (20 minutes)

Facilitator prompts teachers to look through the lesson guide, paying close attention to the Guiding Questions and Deeper Understanding sections that many guide include below student questions. **(5 minutes)**

Facilitator invites teachers to discuss the ways in which they see this type of lesson being useful to students, and unpack any obstacles/problems they foresee. **(7 minutes)**

Optional: Facilitator informs teachers that they have a one year subscription to Mathalicious.com. Facilitator gives teachers the remaining time to browse the Mathalicious lesson database and identify a lesson they are willing to try in an upcoming unit. **(8 minutes)**

Rich Mathematical Tasks: Developing Multiple Mathematical Competencies with Group Work

Objectives

The goals of this session are to:

- Discuss the various mathematical competencies that are required to "do mathematics" successfully
- Have teachers reflect on how much opportunity they are currently providing to students to develop in each competency
- Expose teachers to mathematical tasks that foster multiple forms of mathematical growth
- Present and model student group roles that allow for teachers to implement mathematical group work effectively

Guiding Questions

- Is our teaching practice disproportionately valuing calculations with procedures over other mathematical competencies?
- How can we increase opportunity for students to reason, work with tables and graphs, justify methods, rephrase problems, and represent ideas/concepts/patterns?
- How can we adapt rich mathematical tasks into group work that supports and involves all group members equitably?

At a Glance

- Discussion of six mathematical competencies.
- Pie chart activity for teachers to reflect on their ideal balance of the six competencies and the opportunities they provide to their students in their classrooms for each.
- Group activity – mathematical task. Each teacher is assigned one group role for the task.
- Presentation and discussion of different group roles and teacher roles during group work.
- Activity – task analysis. Teachers go through four tasks and identify the mathematical competencies each task supports.
- Discussion of how teachers can adapt or design problems used in classroom instruction to develop multiple mathematical competencies.

Materials

Handout M3 (Working with Rich Mathematical Tasks, 11 pages)

Group roles cards, printed and cut (one set per four teachers)

Printout of yearly calendars for the next two years (one per four teachers)

Procedure

Set-up: Arrange desks or tables so that teachers can sit in groups of four. Place four PD handouts at each seating group. Have group role cards pre-cut into sets of four, kept separately with yearly calendars until "Friday the 13th" activity.

Before We Begin: Quote "being good at mathematics" (2 minutes) (page 1)

Facilitator welcomes teachers as they arrive

- Have teachers sit in groups of four.
- Ask teachers to read and reflect on the quote on the first page of the handout.

Introducing the Session's Focus: Discussion of Six Mathematical Competencies (5 minutes) (page 2)

Facilitator goes through each of the six mathematical competencies (outlined by Jo Boaler, Professor of Mathematics Education, Stanford University) to be further explored in the session. Introduce the competencies by going through each one so that each is understood.

- *Asking questions* – This is not asking clarifying questions to a teacher, but being able to ask oneself the types of questions that are inherent to mathematical reasoning, such as "what would happen if I were to ___?" or "if I am able to figure out ____ [piece of the problem], would it help me find ____?"
- *Drawing/creating pictures and graphs* – This competency is used as a means of communicating mathematical ideas so as to make sense of the mathematics (such as when organizing information into a graph).
- *Rephrasing problems* – Being able to understand or reconceptualize a problem in a way that makes the mathematical task at hand more evident. An example is understanding that a problem asking which pizza option is a better deal is really asking which pizza provides the best cost-size ratio.
- *Justifying methods* – Being able to justify a method or approach is instrumental in mathematical reasoning and helps students transfer their learning to novel problems and situations.
- *Representing ideas/concepts/patterns* – This is being able to represent a concept, pattern, or idea in multiple ways: abstractly (such as algebraically), in words, with pictures or graphs, etc.
- *Calculating with procedures* – Fluency with skills, computations, and procedures.

Pie Charts Activity (10 minutes) (page 3)

Facilitator asks each teacher to reflect on his or her conception of the ideal balance of the six mathematical competencies that people who successfully use mathematics in daily life would possess and to represent that balance as a pie chart (the large circle).

- Stress that there is no wrong answer.
- Have teachers shade the pie chart as indicated by the key.

Facilitator asks teachers to reflect on the opportunity that they are currently providing to students to practice/develop in each competency, and to create a second pie chart (the small circle) depicting this information.

Facilitator introduces the session's focus:

- There is often a disproportionate amount of focus on the "calculating with procedures" competency.
- One goal of the session is to see how rich mathematical tasks can be incorporated to help also develop other mathematical competencies in students.
- We will see how group work can be implemented in a way that supports this development.

Friday the 13th Activity (15 minutes) (page 4)

Facilitator informs teachers that they are to work through the Friday the 13th task from Nrich Mathematics (http://nrich.maths.org/610). Facilitator informs teachers that they are each going to be given a "group role" that they are to follow while working through the task.

- Pass out one group role card per teacher.
- If there is a group of three, put the Facilitator/Includer and Organizer cards together.
- If there is a group of five, have two people share the Reporter role.
- Inform teachers that only the Resource Manager can leave the table or call for help.
- Have materials (copies of calendars from future years) available, but do not pass them out. Inform groups that the Resource Manager can come seek additional materials as needed.

Give teachers a couple minutes to get started. Circulate among groups to ensure that everyone is participating.

- If a teacher is being left out or working solitarily, ask the group's Includer to make sure he/she is including everyone in the discussion.

After five minutes, call over each group's Resource Manager for a group huddle. Inform each Resource Manager, if they have not yet done so, to think about the first day of the month and why it would always have to be the same *day* of the week (a Sunday) on months that have a Friday the 13th, regardless of year. Send Resource Managers back to their groups.

After 15 minutes, end the activity, even if not all groups have completed the task.

Group and Teacher Roles (7 minutes) (pages 5-6)

Facilitator has all teachers turn to the "Group Roles" page in the handout, from Jo Boaler's *Mathematical Mindsets: Unleashing Students' Potential Through Creative Math, Inspiring Messages and Innovative Teaching*.

Go through each group role one-by-one.

- Encourage teachers to share their experiences with each role from the activity.
- Point out that the Resource Manager role allows for the teacher to hold group huddles that do not require the entire class to stop working when the teacher needs to provide additional help.
    - This role also serves the purpose of ensuring that the group *only* calls for teacher help when everyone in the group needs help.

Have teachers turn to the "Teacher Roles" page, also from Jo Boaler's *Mathematical Mindsets: Unleashing Students' Potential Through Creative Math, Inspiring Messages and Innovative Teaching*.

- Go through each teacher role.
    - Discuss the importance of setting up a class culture of collaboration, respect, and safety.

Task Analysis (15 minutes) (pages 7-10)

Have teachers independently go through the four remaining tasks (from https://www.youcubed.org/, https://nrich.maths.org/, and https://www.scoe.org/) and reflect on which mathematical competencies each task could develop.

- Point out that this activity is based upon how teachers visualizes *themselves* teaching the task.
- Teachers do not have to complete the task, but they may wish to start each one to get a sense of the mathematics required.

Every three minutes, have teachers go on to the next task.

After 12 minutes, point out that *having students work in groups* can increase student opportunity for certain competencies (especially ”justifying methods,” “representing ideas/concepts/patterns,” and “rephrasing problems”).

Designing Rich Mathematical Tasks (6 minutes) (page 11)

Facilitator goes through the “checklist” on the last page, from Jo Boaler’s *Mathematical Mindsets: Unleashing Students' Potential Through Creative Math, Inspiring Messages and Innovative Teaching*. Be clear that these are not just for designing tasks, but points to consider when incorporating existing tasks into lessons.

- “*Can you present the task before teaching the method?”*
  Allowing students to develop their own methods often leads to deeper exploration and understanding of the math. Don’t over-support; use team huddles to provide help as needed throughout the task.
- “*Can you make it visual*?”
  Are you allowing students to communicate their understanding visually, such as via a chart/table/ graph?
- “*Low floor and high ceiling*”
  Is the task accessible to all learners? Are there extensions that allow the problem to be taken to a more complex level for stronger students?

Workshop - Problems in Context: Planning for Authentic Tasks

Objectives

The goals of this session are to:

- Discuss the differences between a task that is removed from, and a task that is grounded in, an authentic context
- Have teachers work through a real-world task
- Workshop/plan a future lesson that incorporates an authentic context

Guiding Questions

- Are the tasks we give to students disproportionately focused on skills and procedures?
- To what extent do we provide students with the opportunity to learn mathematics in a meaningful context?
- How do we plan a lesson that supports students' learning as they engage with an authentic mathematical task?

At a Glance

- Brief overview of traditional vs. contextual approach.
- *Half-plus-seven* activity – mathematical task. Each teacher works through parts 1 and 2 of task, and looks over part 3.
- Whole group overview and discussion of *Half-plus-seven* activity.
- Presentation of planning guide for *Half-plus-seven* task.
- Workshop time: planning for a future lesson with planning guide.

Materials

Handout M4 (Workshop: Problems in Context, 9 pages)

Procedure

Set-up: Arrange desks or tables so that teachers have a clear view of the PowerPoint.

Before We Begin:

Facilitator welcomes teachers as they arrive.

- Encourage teachers to sit in pairs. They may work individually if they would like.

Introducing the Session's Focus: Problems in Context (5 minutes) (slides 2-4)

Facilitator goes through Slides 2-4 of the PowerPoint. The purpose of these slides is to frame the focus of this session (mathematical tasks in context). The facilitator should try to avoid presenting direct instruction as "bad" and contextual learning as "good," but rather utilize this portion of the session to point out limitations inherent to direct instruction and how it could be supplemented with contextual learning experiences.

***Half-plus-seven* Activity (20-25 minutes)** (pages 2-4, slides 5-14)

The half-plus-seven activity is adapted from the Mathalicious lesson "Datelines" (https://www.mathalicious.com/lessons/datelines)

Facilitator asks each teacher to work through parts 1 and 2 of the *Half-plus-seven* task (page 2), keeping the PowerPoint on Slide 5 or 6 while they work. When teachers have finished with parts 1 and 2, teachers should read through part 3 of the task (pages 3-4). Teachers can work individually, however the facilitator should encourage teachers to work with a partner. **(6-7 minutes)**

Facilitator then goes through Slides 6-14, explaining various components of the task. **(14-18 minutes)**

- Slide 7: Most students should have little difficulty completing this part of the task, until the last column of the table. This begins to get students thinking about how to use the half-plus-seven rule to figure out one's own max age if the age of his/her date is given.
- Slides 8-9: This portion of the task asks students to represent the rule as an equation. It is a great opportunity for student discussion, especially when determining the reverse of the *half-plus-seven* rule.
- Slides 10-12 (pages 3-4): This portion of the task illustrates the *half-plus-seven* rule graphically as a system of inequalities. Students can be asked about the point of intersection, what the area to the left of that point represents (what does it reflect in this context?). Visually, students are able to see where actual couples fall, and whether or not they are in the "dating zone."
- Slide 13-14: Overview of the various ways students are able to interact with mathematics through this task.

Workshop (30 minutes) (pages 5-9, slides 15-16)

Facilitator has teachers look over pages 5-6. When teachers are looking over page 5, facilitator recommends to teachers that they work through a task themselves before giving it to students. Teachers can discuss their initial thoughts with a partner during this time. **(5 minutes)**

Facilitator goes through the planning guide, within the context of the *Half-plus-seven* task (page 6, Slide 15). Facilitator discusses the intent behind the guide, which is to help teachers: *evaluate* the task, *troubleshoot* misconceptions and difficulties, and *support* their students in completing the task. **(5 minutes)**

Planning a future lesson. (20 minutes)

Facilitator refers teachers to pages 7 and 8 of the handout for examples of additional lessons involving tasks grounded in authentic contexts. Facilitator presents the final slide (Slide 16) and gives teachers the remaining time in the session to complete page 9 of the handout.

Project-Based Learning

Objectives

The goals of this session are to:

- Present the project-based learning process, learning outcomes of project-based learning, the teacher's role in project-based learning, and variations of project-based learning
- Connect teachers with online resources for math projects
- Show project-based learning in action, via the documentary *Most Likely to Succeed*

Guiding Questions

- What is project-based learning?
- What types of project-based learning experiences can I give to my students?

At a Glance

- Reflection of Paul Lockhart quote
- The project-based learning process
- The teacher's role
- Project-based learning variations
- Activity – film viewing
- Online resources for project-based learning in the mathematics classroom

Materials

Handout M5 (Project-based Learning, 3 pages)

Film *Most Likely to Succeed* (with viewing access code for teachers)

Procedure

Set-up: Arrange desks or tables so that teachers are able to easily see the screen where the film will be shown.

Before We Begin: Quote "to do mathematics" (2 minutes) (page 1)

Facilitator welcomes teachers as they arrive

- Ask teachers to read and reflect on the quote on the first page of the handout.

Introducing the Session's Focus: Project-Based Learning (20-25 minutes) (pages 2-3)
Facilitator goes through pages 2-3 of the handout. This material is adapted from:

> Wurdinger, S. D. (2016). *The Power of Project-Based Learning: Helping Students Develop Important Life Skills* (Reprint edition). Lanham, MD: Rowman & Littlefield Publishers.

The project-based learning process - Facilitator unpacks the cognitive process inherent to a project (page 2). Facilitator asks for a teacher to describe a project they have given to their students and diagrams the PBL process on the board, having the teacher fill in examples of students having to cycle through the phases of "plan," "test," and "reflect." **(8 minutes)**

- Note: Consider reaching out to teachers about sharing a project in advance of the session, and/or having an example project to share should no teachers choose to share a past project during the session.

Learning outcomes of PBL - Facilitator reads through the list of learning outcomes. **(2 minutes)**

The educator's role in project-based learning - Facilitator discusses role of the teacher being more of a guide rather than leader throughout the project-based learning process (page 2). It is important that students have opportunities to generate their own plans, test those plans, and reflect on their mistakes; doing "too much" can interfere with this process. In project-based learning, the teacher is there to support students in obtaining the information/materials/resources they need to be able to advance from one step to the next in the PBL process. **(5 minutes)**

Five variations of project-based learning - Facilitator gives teachers time to look over page 3 of the handout. The facilitator shares with teachers that depending on teacher experience, the learning objective, and context, different variations of projects may be more appropriate than others. **(5 minutes)**

Film (25 minutes)

Facilitator shows the first 25 minutes of the film. Facilitator then gives teachers the online access code to finish the film (they have one week to view the film before the access code expires).

Film access: https://teddintersmith.com/mltsfilm/

Connecting Teachers with Project-Based Learning Resources (5 minutes)

Facilitator shares with teachers the following link:

https://www.ct4me.net/math_projects_2.htm

This website inventories various sites known to contain high-quality mathematics projects. This website also provides teachers with other resources geared towards supporting those new to PBL.

Note: Facilitator should explore and become familiar with the website and its offerings prior to session.

Supporting Academic Tenacity in Mathematics: Teacher Questioning and Feedback

Objectives

The goals of this session are to:

- Look back on the full PD series – providing context to mathematical content: the how and why
- Have teachers reflect on how much opportunity they are currently providing to students to reflect on their learning and track their progress
- Expose teachers to mathematical tasks that support academic tenacity

Guiding Questions

Part 1: Looking Back on this PD Series

- How does placing course content in the context of a real-world scenario help make the mathematical content and processes enticing, meaningful, and memorable?
- How does applying mathematical learning to real-life situations *now* help students develop the skill of transferring such learning to the problem-solving, projects, and tests they will face *in their future*?
- Why move from "telling" to realistic problem-solving, sense-making, and discovery?

Part 2: Academic Tenacity

- What is academic tenacity?
- What types of tasks and questions promote academic tenacity?
- How do students' responses to high-quality questions give us insight into their learning?
- What types of feedback should we be giving students?

At a Glance

Part 1:

- Ted McCain quote reflection
- Return to Jo Boaler's six different ways of working with mathematics
- Review of teacher planning guide and student graphic organizer for working through tasks
- Present additional resource for rich mathematical tasks (Problem of the Month)

Part 2:

- What is academic tenacity?
- Review reflection and progress tracking handouts
- MARS task activity and discussion

Materials

Handout M6.1 (Authentic Problem Solving, 4 pages)

Handout M6.2 (Supporting Academic Tenacity, 11 pages)

Handout M6.3 (Problem of the Month example)

Handout M6.4 (*House Sales* MARS task, one per pair)

Handout M6.5 (MARS task descriptions)

Procedure

Set-up: Keep all handouts separate so as to not have too much material given to teachers at once. Have part 1 PD handouts available for teachers as they arrive. The remaining handouts will be distributed throughout the session.

Before We Begin: Quote "tasks in the form of a problem" (2 minutes) (page 1)

Facilitator welcomes teachers as they arrive

- Ask teachers to read and reflect on the quote on the first page of handout M6.1.

Introducing the Session's Dual Focus: Review Big Ideas from Entire PD Series; Supporting Academic Tenacity (15 minutes)

Facilitator goes through each of Boaler's six mathematical competencies explored in this series (page 2). Tasks given to students should, whenever possible, provide students with the opportunity to develop multiple competencies. **(4 minutes)**

Facilitator reviews two handouts provided at earlier sessions: the student handout for working through authentic tasks, and the teacher planning guide (pages 3-4). **(2 minutes)**

Facilitator passes out handout M6.3, the Problem of the Month handout from the Silicon Valley Mathematics Initiative (http://www.svmimac.org/problemsofthemonth/problemsofthemonth.html), as an additional resource available to teachers. **(2 minutes)**

Facilitator introduces/segues to concept of *academic tenacity*. Facilitator hands out handout M6.2 and allows teachers a moment to read definition of academic tenacity (page 1; from Dweck, Walton, & Cohen, 2014). Teachers take a couple of minutes discussing with a partner/in a small group their experiences/struggles with developing students' academic tenacity. **(7 minutes)**

Opportunities for Students to Reflect on Learning/Track Their Progress (10 minutes)

Facilitator asks teachers to share with each other the ways in which their students reflect on their own learning and monitor their progress. Facilitator then has teachers review to the three included handouts on pages 3-6 (assessment corrections, tracking my progress in mathematics, and unit assessment feedback). Facilitator makes clear that these handouts are *examples* of ways in which students can reflect upon their own work and monitor their growth over time, and to think of if and how they may be useful to each individual teacher.

House Prices and Payments MARS task (30 minutes)

Facilitator passes out to teachers handout M6.4, the *House Prices and Payments* task from the Mathematics Assessment Resource Service (http://www.scoe.org/mars, one task per pair, two for a group of three), and asks them to work through the task. **(5 minutes)**

Facilitator prompts teachers to turn to page 7 of handout M6.2, and, with their partner/small group, to check off which competencies this task included. Facilitator has teachers share out. **(5 minutes)**

Facilitator prompts teachers to look at the student work and to discuss and answer the questions about the student (pages 7-9). Facilitator encourages teachers to share their thoughts as a whole group. **(10 minutes)**

Facilitator has teachers turn to page 10 and highlights the merits of MARS tasks in eliciting student thinking. Facilitator indicates that each task comes with a scoring guide (page 11). Facilitator then passes out handout M6.5, containing the MARS task descriptions for the 2014 Algebra 1 series. **(10 minutes)**