DEVELOPING THEORY, RESEARCH, AND TOOLS FOR EFFECTIVE LAUNCHING: DEVELOPING A LAUNCH FRAMEWORK

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This working group continues to develop a research program on the practice of launching mathematical tasks and its resulting impact on learners. Our research agenda contains two strands of inquiry exploring (1) theory and framework building concerning effective launches and (2) empirical examination of the link between launching and opportunities for students to engage in "productive struggle" while solving worthwhile mathematical tasks. Participants will (a) examine empirical data collected from K-12 mathematics teachers in order to further develop our emerging Launch Framework and (b) discuss the next steps to be taken in the development of an empirical research agenda examining launching and high demand tasks. Participants will collaborate to shape the development of the emerging research agenda and plan future research and dissemination.

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The new *Standards for Preparing Teachers of Mathematics* calls for supporting new teachers in building a foundation of "effective and equitable mathematics teaching practices" including introducing, or "launching" demanding tasks (AMTE, 2017; p. 6; 14). When doing so, teachers need to activate prior knowledge, ensure understanding, establish expectations, and remove barriers to productive engagement (Van de Walle, Lovin, Karp, & Bay-Williams, 2014). However, there is little research that describes, in detail, what effective teachers do when launching, and how what they do changes in response to changes in their teaching context.

Research has given some guidance to teachers seeking to launch tasks effectively. Initial descriptions of effective launches stress the importance of clear expectations (Stein, Smith, Henningsen, & Silver, 2009) and creating a shared understanding of the problem and the problem's context (Ball, Goffney, & Bass, 2005; Lubienski, 2000). Jackson and colleagues (2013) found that launches which supported students in developing a taken-as-shared understanding of the key ideas and quantities as well as a shared vocabulary to describe those ideas produced greater opportunities to learn in subsequent mathematical discussion. Despite this guidance, teachers and teacher educators continue to struggle with what constitutes an effective launch. Teachers wrestle with how to give exactly the right amount of support that provides access to students without taking over mathematical thinking (González & Eli, 2017). In

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addition, different goals for the launch may conflict with each other (González & Eli, 2017; Jackson & Shahan, 2013). Furthermore, the features and goals of a specific launch may depend on the task, the learning goal, and the needs and strengths of a specific group of students. In the face of this complexity, continued examination and discussion about the purpose and features of effective launches are necessary in order to help guide teachers and teacher educators as they work to develop launching expertise.

History of Launching Working Group

While the launching working group first officially met at PME-NA 2018 in Greenville, SC., this meeting was an important culmination of sorts for the group and its interests. The original impetus for the formation of this working group is based upon the work of mathematics methods instructors who designed a module to support prospective teachers' ability to launch cognitively demanding tasks. As these researchers sought to examine the theoretical underpinnings behind launching tasks it became evident there was a dearth of research or theory on the subject. "There were few common images of effective launches in the research literature, nor were there descriptions of the kinds of problems that students and teachers experienced during launches" (Wieman, Perry, et al., 2018, p. 1501). As a result, the content and design of the module was not a representation of "professional knowledge" which is established by the research community or as a result of empirical studies, but rather "practical knowledge" which is built by teacher educators as a result of doing the work of teaching and reflecting upon that work (Arbaugh & Taylor, 2008, p. 2).

At PME-NA 2016, the designer-researchers presented some early results of their empirical examination of their methods course module (Wieman & Jansen, 2016). The session was well attended and included a spirited discussion concerning the salient features and non-features of an effective launch. Several attendees shared examples of launches from their own methods course work, examples that contrasted starkly with each other, and the launch depicted in the module. Both presenters and several attendees continued the conversation after the conclusion of the session. After the conference the session organizers collaborated with a group of mathematics teacher educators to propose a symposium session at AMTE 2018 on launching (Wieman, Jansen, et al., 2018). This symposium brought together researchers who had studied launches, teacher educators who were teaching teachers to launch effectively, and professional developers with extensive experience in schools. In this session, we began a discussion that moves the field towards an explicit, shared understanding of how to effectively launch demanding tasks, including (1) What is the purpose of a launch? (2) What are the elements of an effective launch? and (3) What are common challenges in launching? Again, this symposium was well attended, and generated extensive discussion, as well as a striking diversity of thought and experience. Clearly, there was a need among mathematics teacher educators to examine the practice of launching more closely.

PME-NA 2018 Working Group

The launching working group was formed to give educational researchers and practitioners and opportunity and space to work toward the following long-term goal:

> Create shared, empirically-based knowledge about launching cognitively demanding tasks, that would support mathematics teachers in launching tasks effectively, mathematics teacher educators in supporting teachers learning to launch, mathematics education researchers in

generating knowledge about launching, and curriculum writers in supporting teachers' launching. (Wieman, Perry, et al., 2018)

The three working group sessions at PME-NA 2018 were consistently attended by a group of 10-12 mathematics teacher educators. Across the three sessions, participants engaged in a series of activities and discussions designed to answer the following questions:

- What is the purpose of an effective launch?
- What challenges do teachers face when planning, enacting and evaluating launches?
- What are typical experiences for students in launches?
- How do we support teachers and pre-service teachers in developing skill in planning, enacting and reflecting on launching (and how might we improve these efforts)?
- How do we support teacher educators and professional developers in helping others get better at launching (and how might we improve these efforts)? (Wieman, Perry, et al., 2018)

Day 1. After orienting participants to the prior work of the group, organizers and participants shared interests and questions concerning launches. After identifying some common questions and themes, participants were introduced to the following mathematical task:

> Last year the national weather service recorded _____ tornadoes in the United States. They recorded some tornadoes in other parts of the world. They recorded a total of ____ tornadoes. How many tornadoes were in other parts of the world?
>
> (18, 28) (26, 48) (22, 75) (83, 150) (95, 194) (101, 183)

We asked participants to consider and discuss how a teacher might launch this task and what other questions they might have about launching this task. We then viewed a video of a teacher launching this task to a class of second graders. While they watched, we asked participants to consider the following:

- What do you notice about the launch that you found especially interesting or surprising?
- What does the teacher think the purpose of a launch is?
- What supports does the teacher use to help students, and the teacher during the launch?
- What is the impact of this launch on students? How do you know?
- What mathematical activity do you predict the students will engage in?
- How might you evaluate the effectiveness of this launch?

After discussing these questions in relation to the launch of this task, we introduced participants to a second task, "*Write an equation that you can use to find the number of one foot by one foot square tiles you would need to make a one-foot fringe around an "n x n" square pool"*. Participants then discussed how a teacher might launch this task, and viewed a video of a teacher launching this task in an 8th grade classroom, considering the above set of questions. This was followed by a discussion in which attendees compared and contrasted the two launches, and how they informed our original interests and questions.

This final discussion resulted in five salient questions moving forward: (1) How do teachers balance support with maintaining the cognitive demand while launching? (2) What might be the

role of a "Precursor Task" and when should one occur? (3) Can students "internalize launch routines" or develop the capacity to make sense of problems? (4) Are there routines, steps, or structures for launches? (5) How do features of a task relate to features of a launch?

Day 2. In Day 2 we took up two versions of the final question listed above, "What is the relationship between key features of tasks and key features of launches?" and "Are there certain launch structures that go with certain tasks?" In order to begin examining these questions participants worked in small groups to sort a collection of 10 mathematical tasks according to how they would launch them – they were group together tasks that they would launch in a similar way and be ready to explain how that type of launch would support students doing that task. Once participants had come to a consensus within groups, we engaged in a gallery walk, in which groups struggled to make sense of other group's categories. The ensuing discussion illuminated a great diversity of ideas about task features, launch features, and the lack of a shared language or understanding about the details of launching.

Day 3. Our final session began with a review of the prior day's sorts in which we created a list of possible problem features and a list of launch types or structures which might be appropriate for the given tasks (e.g. three reads, act out the story/process, make a prediction, etc.)

Participants then were given this set of launch types and worked in groups to sort a second set of tasks according to which launch type they would use to launch it. From the discussions generated by the two task sorts we were able to begin work on a launching moves framework to support teachers' practice of effective launching for demanding tasks. We present these in our next subsection.

Progress Since 2018 Working Group

We extend our work from 2018 by presenting preliminary ideas related to the question, "What is the reciprocal relationship between central features of demanding mathematical tasks and central features of launches? or "What types of launches are effective for what type of problems?" One result of the discussions in the working group was a *Launching Framework*, which serves as an initial attempt to describe key features of different types of launches, as well as key features of demanding tasks that may inform choices about launching. We first unpack and define the key features of important launching types (Table 1). We then identify specific problem features and give illustrative examples (Table 2).

Table 1: Launch Types

Launch Types	Example/Description
Act out the process	Eric the sheep: Act out Eric skipping two places whenever a sheep gets sheared.
Provide a visual representation of the context	Create a representation of the task - i.e. showing a picture of two punch bowls with different amounts of Orange Juice and Ginger Ale next to them for a comparing rates problem (Which tastes more like Orange Juice?)
Noticing	Three-act lesson: Show a video, ask what they notice, what they wonder

Three Reads	First Read: What is this about? Second Read: What is the question? Third Read: What is important information/quantities?
Make a prediction or conjecture	Ask students to make a guess about the answer
Evaluate an incorrect answer	Johnny had some money, he went to the store and worked until he had twice as much as he started with. Then he went to the diner and had dinner, for $12. He now has $34. How much did Johnny start with? I say he started with $50. Am I right or wrong? How do you know? Then how much DID he start with?
Engage students in Precursor Tasks: (i.e. a number talk or routine for reasoning)	Contemplate then calculate: What do you notice about this figure? How many tiles in this figure without counting? Then, can you come up with a rule for the number of tiles in the "nth" figure?
Set Expectations	Remind or create expectations for how to work together in a group, how to address logistical concerns, and the nature of the final product

Table 2: Problem Features and Sample Tasks/Descriptions

Problem Features	Description and Sample Task
Process with end-point given	Golden Apples (Start with some apples; Meet three trolls, each one takes half your apples and two more. You end up with 3 apples. How many did you start with?
Process with beginning point given	Eric the sheep is 50^{th} in line to get sheared. Each time a sheep gets sheared, Eric cuts two sheep in line. When will Eric get sheared? (How many sheep will get sheared before Eric is at the front of the line?)
Graph/Diagram Focused	Match the picture of people at a bus stop with a graph of age versus height.
Familiar context	Context that draws on student experiences
Unfamiliar context	Context that may be foreign and confusing to students

Context free problem	Explain why $\cos(x) = \sin(90-x)$

An Illustrative Example

As an example, suppose a teacher wanted to pose the Eric the Sheep problem:

> It's a hot summer day, and Eric the Sheep is at the end of a line waiting to be shorn. Each time the shearer takes one sheep from the front of the line, Eric sneaks past two sheep to get closer to the front.
>
> 1. Suppose there are 10 sheep in front of Eric. How many sheep will be shorn before Eric gets to the front of the line.
> 2. Suppose there are 25 sheep in front of Eric. How many sheep will be shorn before Eric gets to the front of the line?
> 3. Suppose there are 50 sheep in front of Eric. How many sheep will be shorn before Eric gets to the front of the line?
> 4. How could you predict the answer for any number of sheep in the line?
> 5. What happens if Eric sneaks past 3 sheep? 4 sheep?
> 6. What happens if there are 2 shearers? 3 shearers? (Driscoll, 2001).

The teacher may anticipate that students may have trouble making sense of this particular situation, so she may decide to act out this specific situation, having students take the place of sheep, and physically acting out the process of getting shorn, moving up in line, and, for Eric, cutting in line each time a comrade is shorn.

This task would be categorized as a *Process with a beginning point given*. A process is described and students are asked to explain what will happen as this process unfolds. The teacher employs an "Acting it out" launch, by having her students act out the shearing. One could also argue that the task itself employs a "precursor task" structure, asking students to solve specific cases of the process before engaging in the task of generalizing. It is key however to consider what number(s) might make for good examples without reducing the cognitive demand of the task. For example, if Eric is in a line with 6 sheep, 2 will be shorn before him. If Eric is in a line with 7 sheep, there are still 2 sheep shorn before him. Revealing the idea that multiple starting numbers have the same answer in the launch of the problem would not be beneficial as it can be a somewhat surprising outcome and one students have to consider when answering the generalizable questions in the task. If the teacher wanted to show an odd number example and an even number example, 7 and 8 would be better number choices than 6 and 7.

Once we have begun to identify important launching types and important problem features, we can begin to empirically determine if curriculum writers and teachers tend to launch problems with specific features using specific types of launches. For instance, we can ask teachers to engage in the same kind of sorting exercise as we described above, and then keep track of their responses on a grid.

Figure 1: Launch Framework - Matching Problem Features and Launch Types

Launching Framework		Launch Types							
		Act out process	Provide a visual representation of the context	Noticing (I notice, I wonder)	Three Reads	Prediction/ Conjecture	Evaluate an incorrect answer	Precursor Tasks	Setting Expectations
Problem Feature	Process with Starting Point Given								
	Process with Ending Point Given								
	Graph/Diagram focused								
	Familiar Context								
	Unfamiliar Context								
	Context Free								
	Other								

Plan For PME-NA 2019 Sessions

Day 1

Prior to the meeting we will send potential attendees a file of mathematical tasks along with instructions how to complete the launching task sort described above. The goal of this is to help those unfamiliar with the sort to understand the task sort activity prior to our first session. We will begin session 1 with a quick introduction of the participants and their interests in examining the practice of launching demanding tasks, followed by an orientation to the previous work and progress of the group. Our main activity for the first session will be to engage participants in examining data and or/results from an enactment of the launching task sort activity with inservice teachers. Our session organizers are planning a professional development activity in the spring of 2019 in which they will engage a group of K-12 in-service mathematics teachers in the launching tasks sort activity, and collecting data on the choices they make and their rationales. This will enable leaders and participants to both make sense of the launching framework and examine teacher perspectives on launching. We also hope to discuss revisions and additions to the framework based on this data analysis.

Day 2

On the second day of our working group we intend to engage participants in two different launch related activities. In the first activity participants will utilize the *Launch Framework* to engage in small group examination of a curriculum series to identify relationships between high demand problem features and prescribed launches. Each group will examine the same curriculum materials so a common base of discussion can be had. Through this activity we hope to generate a protocol for utilizing the framework for curriculum analysis that could be used to continue this work in the months following the conference. The second activity will afford participants an opportunity to examine videos of teachers launching the same task utilizing different launch types and to consider the initial discussion of students following/during the launch. Discussion of this activity will help conceptualize a follow up study examining the relationship between categories of selected launch move, teacher enactment of launch move, and student reaction to the launch. At the end of the session participants will be asked to consider the two different lines of inquiry and to select one to discuss in small group the following day.

Day 3

The third day will begin by forming special interest groups (SIGs) (i.e. curriculum analysis, effect of launch types on student learning, etc.). Each group will be provided time to begin planning a research project to be carried out over the upcoming months for their topic. At the end of the session groups will have selected a SIG leader and will submit a brief outline of their plans moving forward including possible timeline. Each group will share these plans with the group as a final activity. We will encourage SIGs to plan for proposals to present at AMTE 2021 (proposals usually due in mid-May 2020).

Focus on Specific Framework: Rationale

Given the wide range of initial questions about launching that this working group was interested in, we have chosen to focus on examining and developing a specific framework related to launching structures and features of tasks for several reasons. First of all, we hope that a more focused discussion will provide access to new members of the working group while pushing the work of the group forward. Second, we think that this focus on launch types, task features, and the connections between them will provide numerous opportunities to talk about other important and interesting questions. For instance, we believe that discussing features of problems and launches will also involve discussing student thinking and creating hypotheses for the kinds of struggles students and teachers experience during the launch phase of a lesson. We think that anchoring these discussions in specific problems and launches will help participants more rigorously articulate questions and hypotheses that can drive research.

Connection to Conference Theme

The conference theme for the PME-NA 2019 Annual Conference, "Against a New Horizon," is an explicit acknowledgement of how a quest for progress can also reinforce systematic exclusion. The extant research has demonstrated that a teacher's launch has the ability to provide or deny opportunity and access for students to engage in worthwhile mathematics and as such it is paramount we understand what constitutes effective launch practices. The promise of problem-based learning remains unrealized for many mathematics students, especially those who have traditionally been under-served by larger educational institutions and systems. While we have come to understand there exists an unexplored variety and complexity to launching cognitively demanding tasks, we have been able to agree that the underlying goal of any launch is to provide "access and opportunity for ALL students to grapple with challenging mathematics" (Wieman, Perry, et al., 2018, p. 1502). In addition to access and opportunity, launching is also, fundamentally, about agency and empowerment. Effective launches support all students in drawing on their own funds of knowledge (Moll, Amanti, Neff, & Gonzalez, 1992) to make sense of problems, provides them with opportunities to engage in the productive struggle that results in deep conceptual understanding, and empowers them to decide for themselves what solution strategies to pursue. Learning more about launches will help us empower all of our students so that they can all build on the knowledge and experience they have to construct new mathematical understandings, and engage powerfully in a diverse mathematical community.

Anticipated Follow Up Activities

Following the completion of our working group sessions we foresee several follow up activities. Our first priority will be the completion and submission of a National Science Foundation DRK-12 Conference Grant Proposal for a 2020 conference focused on launching for

teachers and teacher educators. Second is the empirical examination of our hypothesized framework. We have three lines of inquiry for this: (1) Through collection and analysis of empirical data examining tasks, launches and student reactions to them we will attempt to verify and/or refine the framework in terms of student effectiveness; (2) We intend to utilize a survey approach to gather more Launching Task Sort data from MTEs in order to further refine the *Launch Framework*; and (3) We will continue the empirical examination of curriculum materials begun at this working group. As mentioned above we will be encouraging members of the SIGs forms at this working group to plan proposals for AMTE 2021.

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