THAT'S CRAZY

AN EXPLORATION OF STUDENT EXCLAMATIONS IN HIGH SCHOOL MATHEMATICS LESSONS

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In this study, we explore the relationships between the types of student exclamations in an enacted lesson (e.g., "Wow!") and the varying dramatic tensions created by the unfolding content. By analyzing student exclamations in six specially-designed high school mathematics lessons, we explore how the dynamic tension between revelations of mathematical ideas at the moment and what is yet to be known connects with the aesthetic pull to react by the student. As students work through novel problems with limited information, their joys and frustrations are expressed in the form of exclamations.

Keywords: Emotions, Classroom Discourse, Mathematical Story, Exclamations, Tension

Historically, mathematics is not perceived as a popular subject among young people (COAG, 2008). National surveys show that students lose interest in mathematics as they progress in school and that by Grade 8, most report their experiences in mathematics class as unengaging and boring (Mullis et al., 2012, 2016; National Center for Education Statistics, 2015). However, students' experiences in mathematics classrooms are largely understudied (Martínez-Sierra & García González, 2014, 2015; Larkin & Jorgensen, 2015; Lewis, 2013). These studies explained students' emotions in the classroom either analyzing their interview responses (Martínez-Sierra & García González, 2014, 2015) or their responses in surveys and interviews (Dietiker, 2015; Lewis, 2013). Larking and Jorgensen (2015) allowed students to use an iPad as a video diary tool to record their experiences in the classroom. However, in this brief, we are analyzing students' experiences by observing their exclamations at different points of the lesson using the transcript, video recordings and the observation notes of each lesson.

Teachers designed lessons for Mathematically Captivating Learning Experiences (MCLE) to spark student engagement by attracting and maintaining students' attention and enhancing their curiosity and creativity. This is accomplished by withholding information from students, increasing the tension during the lesson. As tension rises and falls during the lesson, students feel compelled to shout exclamations expressing their reactions to the tension. Unlike traditional lessons, where teachers usually disclose the information too soon limiting the tension build up, MCLEs encourage students to explore relationships between mathematical ideas and make meaning. The purpose of this paper is to address: *What is the relationship between students' exclamations and the build-up of tension throughout these MCLE lessons?*

Theoretical Framework

Teachers designed lessons using the Mathematical Story Framework (Dietiker, 2015) with different aesthetic reactions. The framework considers the characters, setting, and plot within the context of a mathematics classroom. The characters are typically the students and those interacting with the lesson while the setting is the lesson materials such as, on a graph, paper, or computer screen. The plot describes how the content unfolds. We used Freytag's five-stage

model (1863) to describe the development of mathematical stories and associated a degree of tension to each stage (Figure 1).

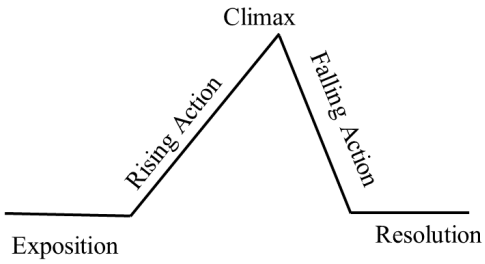

Figure 1. Freytag's Model of story development

The first stage, an *exposition,* is usually in the form of a Do Now or introductory problem that sets the narrative of the lesson. The story begins at equilibrium, that is students know the tools required to solve the given problem and there is either none or the lowest tension. The equilibrium is later disrupted as the story develops and the tension begins to rise and is propelled by a crisis during the *rising action*. At this stage, the ratio of what is unknown to known begins to increase and students wrestle with a concept and continuously make efforts to restore the equilibrium. The tension reaches its peak at the *climax* where students possibly have many questions they have yet to figure out. In the *falling action* stage*,* the level of tension quickly falls towards the *resolution*. Students use the new insights to help uncover answers and thereby creating a new equilibrium. During these stages, certain student exclamations arise. This model helps us identify the types of students' exclamations associated with the level of tension at certain points of the lesson.

Method

The students in this study were from six high school classrooms from the Northeastern region of the United States studying topics from Algebra One to AP Calculus AB. All students willingly participated in the study and the exclamations were recorded anonymously. Researchers monitored a focus group during the lesson to observe the levels of tension. The video and audio were recorded and the tone of a students' response was noted in the transcript.

We used thematic analysis to identify and analyze the patterns of meaning in a data set (Braun & Clarke, 2006). Throughout this data analysis process, the first author reviewed the lesson transcripts and noted the context and timestamp of each exclamation, and identified a pattern that relates to the levels of tension in a lesson. Four themes emerged around the tension that aligned with the Freytag model (see Table 1).

Findings

A thematic analysis of the data suggested that students' exclamations varied with levels of tension because of the information disclosed at that point in the lesson. This table shows the generalization of the exclamations found in the MCLE database organized by relative tension and their occurrence in a lesson related to the Freytag model. Areas of *low tension* occurred when students solved familiar problems, typically during the exposition of the lesson. We found students groaning or saying, "this is boring" as they applied known facts and procedures.

Growing tension occurred when teachers introduced a new problem where students could not directly apply previous knowledge. At this point, students began to question their understanding and made connections from previous mathematical ideas to make sense of this new problem. The tension grew until the point of *highest tension* (*climax* of the mathematical story) where vital information was disclosed to students. This is where students exclaimed shouts (see Table 1) in disbelief. The mathematical story ended with students saying, "wow" and *relieving tension* as they learned the applications of this new skill or topic.

Table 1: Students' Exclamations Categorized by Tension in MCLEs

Tension	Student Examples	Description	Moment in Freytag's Model
Low Tension	"This is boring" ** groans	Students are completing problems using prior knowledge in the form of a Do Now.	Exposition
Growing Tension	"I think I see a pattern" "Oh!!!! Wait"	Students are working through the investigation and a relationship or key piece of information is disclosed.	Rising Action
High Tension	"I'll bet money" "That's Trippy!"	Students react in disbelief with a new solution or tool.	Climax
Relieving Tension	"Wow"	Students are making sense of this new mathematical concept or idea.	Falling Action

The following is a breakdown of students' exclamations in an Algebra 2 class in correlation to the tension regarding the Introduction to Inverses lesson.

Low Tension "Yeah." Students worked on the Do Now problem individually and occasionally checked answers with their group members. In this scenario, the "yeah" was an affirmation to the group that the answer was correct and no follow-up discussion was needed.

Growing Tension "I'm having a brain aneurysm" In this scenario students were plugging values for x into the functions $h(x)=(5x-27)/2+1$ and $k(x)=(2(x-1)+27)/5$ and $h(k(x))$. You also heard students say "Oh Jesus Christ!" and "Woah there!" Up until now, the students only had to compose functions like $f(x)=2x+5$. The tension built because they were using their prior knowledge on this new situation. Later in the lesson when the teacher checked the students' work and left them saying "interesting." Then students said, "We definitely did something wrong then. She does not say 'interesting' often. The tension rose as they double-checked their work and ensured everything was correct.

High Tension "Oh my god, everything cancels out!" During a full class discussion, the teacher wrote $h(k(x))=(5((2(x-1)+27)/5)-27)/2+1$ on the board and had students simplify it.

Students said “Oh! oh! Oh!” and “I see it!” as students figured out that the solution simplified to x. Students said, “All that time it was x? So why do we need to go over this as a class?” This was a high-tension moment because the students did not yet understand and were wondering what was so special about the solution $h(k(x))=x$. At this moment the teacher claimed that this was a special relationship called inverses. Soon after a student exclaimed, “Wait! IT'S THE SAME THING!” referring to the fact that the composition of a function of a variable (x) and its inverse is always the variable (x). This was the highest point of tension because students were starting to see the relationship between a function and its inverse.

Relieving Tension “I’m even curious” Students were working together to see if two functions were inverses using composition. They were given a list of functions and tried to match the two that were in fact inverses of one another.

There were certain instances where students become frustrated and say, “this is boring” or “I give up” but with some input and encouragement from the teacher, students were re-engaged or followed along enough until they were convinced that a process worked. For example, in one lesson, students were given the near-impossible task of finding logarithms without using a calculator! Many students initially found the process tedious and boring. However, by the end of the lesson, students said “Ohhh!” and “I get it now!” The students struggled through the tension and were rewarded with a positive outcome.

Discussion

In some instances, an exclamation was heard at multiple points of tension. For example, a student said, “Ah” to convey that they made a mistake. This was a low tension moment and was quickly resolved. However, in another lesson, a student said “Ah” in confusion and frustration. This is a high tension moment because the student struggled with the concept. These claims were grouped according to the tension in the lesson.

This study focuses on MCLE lessons because the aesthetics of the design are controlled for each lesson. So, the moment of tension when these exclamations occur aligns with parts of Freytag’s Model of story development (see Fig.1). The more students engaged with the tensions in the MCLE lessons, the more they were able to voice their confusions, understanding, and emotions. These findings are useful for practitioners and researchers because it gives the insight to create future lessons focused on tension buildup and the Mathematical Story Framework. In the MCLE Research project, we have found that these lessons are significantly more interesting to students than the traditional lessons from the same teacher. A future study could focus on examining ways these exclamations differ in MCLE designed lessons than traditional mathematics lessons.

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