RELEVANCE AS PERCEIVED BY HIGH SCHOOL STUDENTS IN DECONTEXTUALIZED MATHEMATICS LESSONS

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When mathematics educators work towards making mathematics more relevant, they often think about including more real-world applications into mathematics lessons. But what happens when a lesson is devoid of real-world contexts? In what ways can students find it relevant? This study explores how high school students perceived relevance when they were asked to describe their experiences during decontextualized mathematics lessons. Students highlighted how they found certain characteristics of the lessons to be useful in their learning and how they perceived relevance through different feelings experienced in the lessons. This, in turn, broadens our understanding of what relevance means to students.

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For many years, educators have attempted to incorporate relevant-increasing strategies and interventions in the classrooms, as they have been shown to increase student motivation and performance (e.g., Lazowski & Hulleman, 2016). However, mathematics educators often assume that to be relevant, mathematical content must be connected to real-life contexts with a wide emphasis on incorporating mathematical content that students can see and apply in the world around them (e.g., NRC, 2003; Wilkerson, 2021). While this association is important in its own regard in helping students connect with mathematics and see its importance in their everyday lives, it blinds us from looking at other ways of conceptualizing relevance. One way of expanding our understanding of relevance is to examine it from the perspective of students in order to develop better intervention strategies that will help them find meaning in what they learn (Albrecht & Karabenick, 2018).

This study forms a part of a larger research project which is studying the characteristics of decontextualized high school mathematics lessons that were specially designed to increase aesthetic opportunities for the students (referred to as *Mathematically Captivating Learning Experiences*, or MCLEs). Since the lessons were decontextualized, and because relevance is tightly connected with contextualization, we predicted that students would not find MCLEs relevant. However, surprisingly, using the relevance measure from surveys given to students after lessons, no association was found between the relevance measure and the type of lesson, suggesting that students viewed the decontextualized MCLEs to be as relevant as the non-MCLEs, some of which were contextualized (Dietiker et al., in progress). These results motivated us to look deeper into the views of the students regarding the decontextualized lessons to broaden conceptions of relevance from their perspective.

In this paper, we describe the different categories that emerged from student interviews conducted after the MCLEs, giving examples of their statements that explain what or how they found some aspect of the lesson as relevant, in order to begin to answer the question: *In what ways do students perceive decontextualized high school mathematics lessons to be relevant?* We end with a discussion on how the findings of our study can help expand perceptions of relevance, and what this can mean for the mathematics education community.

Theoretical Framework

Various definitions of relevance have surfaced within the past years (Albrecht & Karabenick, 2018). While some researchers relate relevance with utility value (e.g., Hulleman et al., 2017), others frame relevance in terms of meaningfulness (e.g., NRC, 2003) or the fulfillment of intrinsic and extrinsic goals (e.g., Keller, 1983). Schamber and Eisenberg (1988) argue that most of the notions used to describe relevance, such as usefulness and satisfaction, depend on the perception of an individual. By presenting relevance as a complex cognitive phenomenon which involves the relationship between an individual and their surroundings, Schamber and Eisenberg suggest exploring relevance by questioning the individuals to describe their own perceptions of how they form connections with the topic of information (Schamber & Eisenberg, 1988). In this paper, we define *relevance* as an individual's perception of how an experience was useful in meeting their needs and desires, such as how an activity evoked a sense of satisfaction, which further facilitated a student's learning. When the experience fails to fulfill the individual's needs or desires, then the perception of the relationship is defined as irrelevant.

Recent educational studies that have incorporated student perspectives related to relevance reflect similar notions of fulfillment of an individual's needs and desires. For example, the concept of satisfaction formed the basis for a study that asked college students to produce a list of strategies used by their instructors that increased course relevance for the students (Muddiman & Frymier, 2009). Drawing from Keller (1983), Muddiman and Frymier (2009) define relevance to be a "student's perception of whether course content *satisfies* personal needs, personal goals, and/or career goals" (p. 131, italics added). They identified four ways educational activities could be viewed as relevant by students: how the content was linked to examples drawn from students' lives beyond the classroom, how the teaching style of the instructor helped students relate with the material, methods and activities that encouraged participation and group work, and course supports provided by the teacher that helped them improve their performance. Similarly, Dobie (2019) questioned middle school students about their perceptions of how mathematics lessons were "useful" (p. 28). Student responses from this study fell under two broad categories: *applicability of content* and *features of the learning experience*. Both these studies suggest that in addition to relating relevance with how the content was applicable in their outside lives, students also found relevance in certain teaching strategies, methods, and activities.

We aim to add to what is known about what can make mathematics learning relevant by looking at the perceptions of high school students on mathematics lessons which were specially designed to be decontextualized.

Methods

The current study analyzes perceptions of relevance from statements students made when asked to describe important aspects of their learning experience during an MCLE. Eighteen MCLEs were implemented in six different classrooms from three high schools in the Northeastern region of the United States. One school was a small charter school in the city with a predominantly Latinx student population, the second school was a large urban public high school with diverse racial and ethnic groups, and the third school was a large suburban public high school with a predominantly white student population. Immediately after each MCLE, two to five students were selected as a representative sample in terms of gender and ethnicity and interviewed about their aesthetic experiences during the lesson. The audio recordings of the interviews were then transcribed for data analysis. The current study analyzed a total of 44 interview transcripts from ninth to twelfth grades in the 2018-19 academic year.

During the interviews, students were asked to describe their lesson experiences with the aid of, but not limited to, a given list of positive, neutral, and negative aesthetic descriptors. While none of the questions asked by the interviewers concerned relevance, student perspectives on certain needs and desires often emerged from student remarks.

The data analysis consisted of three major coding passes through student interview transcripts. Each pass consisted of multiple cycles where two coders first independently scrutinized student utterances and then came together to align any differences. During the first pass, the researchers read through the interviews to identify student utterances that included elements of perceived relevance or irrelevance, asking, "In what ways is this student expressing how the experience met their needs and/or desires (or not)?"

The major criteria for evaluating utterances for this pass included highlighting the connections to relevance by placing primary focus on the quality of usefulness. One student's remark clearly reflected one of such instances:

> We told each other what we knew about trigonometry before we went into the lesson. ... It kind of gives you an idea of how people around you know and, like, how they understand the topic. It makes you feel more safe talking to people about it.

For this student, the interaction with their peers through the conversations on the topic prior to the main lesson was useful as a way to understand how others perceived the topic. Such an interaction fulfilled their need by rendering a sense of safety within the in-class discussions.

Also included were statements where students lamented the lesson's failure to meet their needs or desires, which in turn implied how a different aspect of the lesson could have helped fulfill those missing needs or desires. For example, a student explained how they felt less curious in the lesson as they already had an idea of what they were learning, indicating the missed opportunity where the lesson could have been relevant for this student if their desire to learn content outside of their prior knowledge was fulfilled.

On the other hand, while student utterances with positive aesthetic reactions were initially selected as potential candidates for reflecting relevance, many of them were excluded because of a lack of conclusive connection to relevance. For example, a student stated: "I actually really enjoyed this lesson because it was, like, something I never thought would actually occur during a math problem, and the calculator didn't actually have another solution." While this student expressed excitement and enjoyment over the unexpected outcome of the calculator, these reactions did not indicate how this desire was useful to the student. Therefore, this statement was excluded from further analysis.

The first pass resulted in the identification of 55 utterances where students highlighted different aspects of the decontextualized lesson as being relevant to them. After the student utterances relating to relevance were identified, the researchers made a second pass at creating categories of relevance. Since our lessons were decontextualized, Dobie's (2019) major category of *applicability of content* was excluded from our framework and we started with her four subcategories: *method of interaction*, *structure of the activity*, *representation being utilized*, and *value of learning new or important things*. However, unlike Dobie's (2019) study, our student population was not asked explicitly about the ways in which they found the mathematics lessons relevant. In addition, all the MCLEs involved particular characteristics of sequencing activities in order to spark student curiosity with some portion of collaborative small-group problem solving. With such differing characteristics of our study, all of Dobie's (2019) categories needed adjustment to accurately represent the themes that emerged from the student statements. In particular, we modified the subcategory *structure of the activity* because, while some students

found particular activities to be useful, a greater number of utterances highlighted that the *sequence* of activities throughout the lesson was perceived as relevant. Since the sequence of the activities was a feature of the entire lesson and not of a particular activity, we broadened the category as *structure of lesson*.

On the occasion of encountering utterances that expressed needs and desires that were not captured by the modified categories, we developed new categories to reflect the new themes, by looking for patterns across the interviews to find expressions of similar needs and desires. For example, when we noticed that multiple students described how they valued making meaningful progress in the lesson on their own, we created the category: *sense of accomplishment*.

With a new set of categories, a final coding pass of the data was carried out to solidify categories that captured the emerging themes of the selected utterances. We then selected representative student utterances for each finalized category.

Findings

The student perceptions of the relevance of decontextualized mathematics lessons can be classified into two broad categories: *characteristics of the lesson students perceive as relevant* and *ways in which relevance is experienced by students during the lesson*. Each of the broad categories consist of multiple subcategories. While there were many instances where students talked about what or how something was relevant, there was at least one instance in each subcategory where students expressed a lack of fulfillment of their needs or desires. Many ways students discussed relevance also fell under several subcategories, both within and across the two main categories. We now describe each category in greater depth.

Characteristics of the Lesson Students Perceive as Relevant

This category describes aspects of the lesson that students identified as enabling them to develop a deeper understanding of and connection with the subject of the lesson. Four subcategories emerged under this category: *interaction with others*, *representation*, *structure of lesson*, and *learning new and unexpected ideas*.

Interaction with others. Students stated that small group interactions with their classmates or guidance from their teacher was often useful in furthering their understanding or helping them get closer to an answer. This interaction was sometimes in the form of a remark or question from either their teacher or one of their peers, or even both, that redirected them to better ideas for solving a problem. For example, a student mentioned, "[The teacher] gave me an idea when she told us how to draw the figure, she came to my group and said, 'try to describe it like you're trying to describe it over the phone.'" Many students also valued collaborative activities that helped them discuss ideas and share thoughts with each other, as evident in this statement: "it was enjoyable too, cause I got to talk about it with the people in my group, … it helped me understand it better." This utterance highlights interactions with other students as an effective medium to fulfill the student's need for greater understanding.

Some students, though, further explained how certain features curtailed the effectiveness of these peer interactions. As one student stated: "When a student describes it, it actually confuses me more. And, like, the way that they explain it is confusing because they put a lot of words into it." For this student, the wordiness and ambiguity in the explanation provided by a fellow student did not allow the interaction to be effective. Thus, having clarity in the exchange of ideas and thoughts emerged as a feature that supported the interactions to be relevant for the students.

Representation. The different ways in which mathematical ideas were presented were often perceived by students as useful in helping them build conceptual understanding and figuring out

how to solve problems. The following utterance highlights a student's appreciation for physical representations in developing understanding of the meaning of a formula:

> I like using the little triangles and the diagrams because it showed you how it was going to work instead of just saying "oh, this is the formula that she showed on the board with the 2x thing." Instead of showing us that and how it works, we get to see and physically feel how that works.

This student statement reflects the fulfillment of their need of a visual and tangible representation to understand the concept rather than simply being given a formula with which to work.

In addition, students also appreciated forms of representation that facilitated pattern recognition. For example, a pattern apparent in area models helped one student make sense of polynomial division. Other students highlighted how finding patterns usually meant that "something's right." A student avoided having "holes" (i.e., gaps) in tile patterns because "it wouldn't have looked nice I feel like. … it would have been like 'oh that looks wrong or something.'" One student struggled with "letters and words" that came up in a lesson on logarithm identities, but eventually figured her way out "because of the pattern that makes sense." For these students, finding patterns in these different representations turned out to be a useful way to evaluate their strategies while solving problems.

Structure of lesson. Students expressed how they valued several features involving the way mathematical content (e.g., statements, activities) unfolded across the lesson. They explained how revisiting a topic before diving into the actual lesson, how seeing their teacher perform a calculation, or how being able to derive formulas on their own instead of having them being written on the board increased their understanding of a topic. Several students appreciated having a "hands-on" activity in the lesson which involved cutting, drawing, or playing with shapes, as it increased engagement in the activity, which in turn facilitated their learning process. For instance, a student stated, "I like what we're doing, like, all these different activities and stuff, because if you make it fun then it helps us learn even more."

While these students described particular structural aspects of the lesson, such as a fun activity or a good launch, as being useful in furthering their learning, other students highlighted how the overall flow of the lesson contributed to a meaningful lesson experience. A student particularly pointed out how the slower pace of the lesson helped him process the new concepts: **"**It was, just, like, a smoother class. It went, like, slower, and, like, we actually took time to explain. And I'm like, 'okay, I understand this,' and I knew the new formula and all the stuff."

Students also described how their teacher can misdirect them into mistakenly assuming something which later results in a surprise or can question them in ways that build their curiosity, as captured by the following student remark: "I felt this lesson was pretty interesting because, like, we have expectations, and she, like, leads into our expectations and then we find out, like, it's wrong. And I'm like, 'now we need to learn why it's wrong.'" This element of unexpectedness that was achieved through the ways these lessons were structured turned out to be important in captivating students as it satisfied their desire to be curious about what they were learning.

Learning new and unexpected ideas. Many students expressed a desire to learn about new and surprising content and valued lessons that presented them with such opportunities. For example, a student mentioned how not knowing about the content beforehand pushed them to want to know more about a new idea: "Today I was a little bit curious because we didn't really know a whole lot about the material." Other students described how the mathematics lessons had

shown concepts that were contrary to their previous understandings, therefore finding the value of unexpected ideas. Below is one example of such an instance:

> I would say [the lesson was] surprising because we had two solutions, and the calculator said something else. I would say, for once the calculator disagrees with us, or something like that, where the calculator's right, and we're wrong, or something like that. And I guess I would say [I was] frustrated at some points because it was like, "wait, but, like, how does that work?", which made me want to listen to [the teacher] more.

Notice that, in these student statements, their curiosity (i.e., their desire to learn more) was spurred through learning *new* (i.e., not knowing about the material) or *unexpected* (i.e., discrepancy between the solutions derived by the students and their calculator) ideas. In particular, as shown in the utterance above, such new and unexpected ideas can accompany the element of surprise.

On the other hand, the inverse of such instances also emerged in one interview, where one student explained how their existing content knowledge interfered with their learning experience:

> It was interesting to kinda, like, learn them, but at the same time, I kinda had a guideline already of what I was learning ... because, to find triangles, it's always base times height divided by 2. [Having prior knowledge made me] less curious, because, like, I already knew what it was.

Had the element of new and unexpected ideas been present in this lesson, this student's desire to learn something outside of "the guideline" may have been fulfilled.

Ways in which Relevance is Experienced by Students during the Lesson

This category explains the ways in which students perceived a lesson experience as useful or satisfying. All such remarks emerged as feelings, which were subcategorized into: *sense of accomplishment* and *sense of belonging*.

Sense of accomplishment. Many students perceived resolving challenging tasks on their own or getting them right as a feeling of accomplishment. In particular, while getting the correct answer was mentioned and valued by many students, the sense of achievement was not simply derived from getting the correct answer; it also involved making meaningful progress in spite of prior negative feelings (e.g., fear, frustration). The student utterance below highlights one such instance:

> I began the class period very frustrated and uninteresting because I didn't get the answer right away, like I usually do. But then, towards the end, I was mostly amused. … I actually got an answer at the end. … Any time that I have a problem, and I don't get it right away, and it takes me some time, like it did today, I feel like once I get it right, even if it's something small, then I'll get excited."

Although this student was initially frustrated, their progress towards the solution, despite being small and time-consuming, evoked a sense of accomplishment.

Likewise, the emergence of a self-belief that they were able to "figure it out" (i.e., the belief that the fear of getting something wrong could be surmounted) was the main element that contributed to students' sense of accomplishment. One student, after explaining how they were "just kind of nervous" and worried "what if that was wrong?", continued:

> And then I was like, "look! this is, like," I'm thinking, "this is similar to what we were looking for, even if it was wrong," I was thinking. And I figured out something, and I was like, "oh, that's interesting" … I was proud.

This student came to a realization that even if their answer was wrong, it could work as a meaningful aspect of problem-solving. Such remarks often involved explanations of how they were "proud" that they were able to do something on their own and contribute to something worthwhile.

Sense of belonging. Having a sense of belonging within the classroom or a student group was also identified as a way for students to perceive relevance. Their desire to not be alone was fulfilled by finding common interests or sharing a wholesome and engaging class experience with their peers. One student explained how often their peers' disengagement to the class prevented their learning: "some people are just, like, sleeping, they're just tired, ... some people have side conversations [when] I'm trying to learn." However, they proceeded to indicate how, in this particular lesson, their classmates were more engaged, which created a "drive to actually understand [the lesson]." In other words, for this student, what they desired and needed was to be in sync with their classmates and to have a sense of community.

Other times, such a sense of belonging accompanied other aforementioned categories such as *interaction with others* or *structure of lesson*. For example:

> I felt more comfortable with [this way of teaching], and helped me learn, and like working in groups helped me, like, interact with other students, and, like, hearing their ideas and, like, make everything, like, make sense, putting it all together. … So, working, like, with other students and the teacher going back and forth, like, working in pairs and the teacher explains and then, like, discussing with the whole class. It, like, makes me feel comfortable in the class. Like, sometimes I'm in class, [it] can get kind of stressful, and it makes you feel like you're with other people and you're not alone, and it just feels like relief. … We had, like, different ideas and points of views, and then going on the paper and actually doing it out and realizing, like, what each person was thinking and seeing what they thought and what I thought, like, I feel like that really showed how people think and how you can, like, come together as a team, as a group.

The above statement captures the way in which the structure of the lesson (i.e., collaborative work followed by teacher explanations and then a whole class discussion) facilitated interaction with other students (i.e., a discussion of different thoughts and ideas), leading to a sense of belonging (i.e., feeling comfortable and relieved):

Overall, this category highlights the importance of having a community where students can come together, even with different perspectives, leading to a sense of relief and comfortableness.

Discussion

We are gratified to see that high school students can find mathematics lessons meaningful and are able to connect with them, even when the content is decontextualized. While we do not discount the importance of using real-world applications in our mathematics lessons to allow students to see mathematics in the world around them, our research sheds light on other ways mathematics can be perceived as relevant by students. This new way of looking at relevance opens up ways for mathematics educators to rethink pedagogical approaches that aim to increase relevance in classrooms. For example, teachers can structure lessons in ways that present elements of surprise, as our research suggests that students tend to value content that goes against

their expectations, and that surprise often led to an increased curiosity in what they were learning. Moreover, since our study concentrated on high school lessons only, the varied perceptions of relevance pave the way for making even abstract advanced mathematics content meaningful to students, without necessarily making a connection to the real world — especially when such a connection is difficult to make or is divergent from students' actual life experiences. Furthermore, many of the students connected relevance with positive aesthetic experiences and identified irrelevance with negative or neutral feelings, suggesting a potential connection between aesthetic experiences and perceptions of relevance.

While our study identifies varied perceptions of relevance, the nature of our study presents some limitations. Although our schools had diverse student populations, our data only comes from schools located in the Northeastern region of the United States. Furthermore, since we were able to interview only a few students after each lesson, our study potentially limits the number of different views obtained. More research with varied school settings could help expand these findings.

We hope that this research study will help the mathematics education community recognize the ways relevance can be conceptualized from the perspectives of students, in turn making mathematics more meaningful for all students.

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