INVESTIGATING THE LEARNING PROCESS OF STUDENTS USING DIALOGIC INSTRUCTIONAL VIDEOS

John Gruver[1], Joanne Lobato[2], Mike Foster[2]

Michigan Technological University[1], San Diego State University[2]

The need for high-quality remote learning experiences has been illustrated by the COVID-19 pandemic. As such, there is a need to explore instructional videos that go beyond expert exposition as the main pedagogical approach. An emerging body of research has begun to investigate instructional videos that feature dialogue. However, this body of research has focused primarily on whether such videos are effective. In contrast, the purpose of our study is to investigate the dialogic learning processes involved as students viewing dialogic videos develop mathematical meaning. We employed a Bakhtinian perspective to analyse the learning of a pair of Grade 9 students who engaged with dialogic instructional videos. The results focus on ventriloquation as a learning process.

BACKGROUND AND PURPOSE

The explosive growth in the number of online mathematics videos and the dramatic need for such videos during the COVID-19 pandemic has allowed educators to reimagine how students can learn mathematics. However, the effort to increase access to high-quality learning experiences through online videos has been limited by their uniformity in expository presentation, emphasis on procedural skills, limited attention to mathematical argumentation, and missed opportunities to address common student difficulties (Bowers, Passentino, & Connors, 2012).

In response, our research team created online math videos featuring the dialogue of secondary school students. Alrø and Skovsmose (2004) define dialogue as a conversation that involves the quality of inquiry, referring to an interaction that aims to generate new meanings or ways of comprehending. Our videos are unscripted to capture authentic student confusion and resolution of dilemmas. Each video shows a pair of students (called the talent) next to their mathematical inscriptions (Figure 1), which allows other students viewing the videos (called vicarious learners, or VLs) to see both the talent and their work. "Vicarious" refers to indirect participation in the dialogue of others (Chi, Roy, & Hausmann, 2008). A teacher guides the talent and can be heard but is not seen, so that the focus remains on the talent's reasoning. The videos also feature annotations of the talent's work and occasional voice-overs that highlight key mathematical ideas the talent have voiced.

Dialogic videos have been used in a small body of interdisciplinary research, much of which has focused on quantitative studies of the effectiveness of learning vicariously (e.g., Muldner, Lam, & Chi, 2014). Much less work has sought to understand how this learning occurs. Observing the voicing of common misconceptions seems to play an

2022. In C. Fernández, S. Llinares, A. Gutiérrez, & N. Planas (Eds.), *Proceedings of the 45th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 2, pp. 323-330). PME.

important role (Muller, Sharma, & Reimann, 2008), as does the inclusion of an authentic learner who displays confusion and asks questions (Chi, Kang, & Yaghmourian, 2017). The purpose of our study is to contribute to this work by investigating the dialogic learning processes involved as VLs develop mathematical meaning.

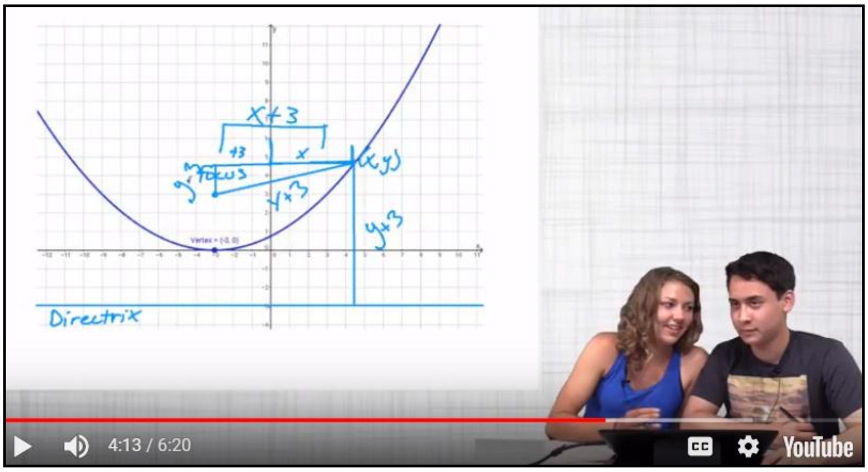

Figure 1: Screenshot for an online dialogic mathematics video

THEORETICAL FRAMEWORK

To investigate the learning processes as the two VLs engaged with the dialogue of the videos, we turned to Bakhtin's (1981) theory of dialogism. According to Bakhtin, the origin of our personal ways of reasoning is others' expressed thoughts, what he calls *voices*. Specifically, voices are words or actions and their associated meanings (Kolikant & Pollack, 2015; Silserth, 2012). As learners express their own voices, Bakhtin (1981) would suggest the words they use are only partly their own. "The word in language is half someone else's. It becomes, 'one's own' only when the speaker populates it with his own intention, his own accent, when he appropriates the word, adapting it to his own semantic and expressive intention" (p. 293). As this quote suggests, Bakhtin's claim is not simply that learners mimic the words and phrases of others, though at times this can occur. Rather, learners appropriate another's voice, including the meanings associated with that voice, for their own purposes. In this way, this voice influences their thinking.

The learning process in which a learner appropriates a voice is called *ventriloquation.* We are particularly interested in instances of ventriloquation when learners go beyond a simply repeating the words or actions of others, but when the voices of others begin to influence the learner's thinking. In these instances, the learner needs to integrate the new voice with their collection of previously internalized voices—those that already influence their thinking. This collection of voices forms the learner's *personal narrative*.

The process of integrating a new voice with the voices in a learner's personal narrative is not always straightforward. Learners may resist a new voice. For example, Taylor

(2003) illustrated resistance during a math methods class for preservice elementary teachers, in which she had been trying to shift the focus of the class from memorizing procedures to proving and justifying. She recounted how a student, Lee, who did not yet see the purpose of or need for proving flouted the teacher's request for a proof and instead responded with a sarcastic remark. The student's demeanour, facial expressions and tone indicated resistance to the integration of "proving" with the voices forming her personal narrative around the nature of mathematics.

METHODS

We investigated the ventriloquation process as two grade 9 students (14-15 years old) watched dialogic instructional videos we created. The two VLs recruited for this study, Desiree and Belinda, had participated in a previous study, which focused on the range of orientations that a larger group of students (26 students) had towards these video lessons. In the previous study, Desiree and Belinda had made good mathematical progress with the first lesson, suggesting they would be good candidates to the continue on with the lessons. They were recruited from an ethnically diverse school in the United States. In their regular Algebra 1 class, they were earning grades in the B to D range. Both were fluent in English and Spanish.

The videos the VLs watched were part of a 10-lesson instructional unit on parabolas. The overarching goal of the video unit was to support the derivation of the vertex form of a general parabola as $y = \frac{(x-h)^2}{4p} + k$. The unit began with the talent being given the geometric definition of a parabola, which is the set of points that are equal distance from a fixed point (called the focus) and a fixed line (called the directrix). Over the course of the 10 lessons, the talent used this definition to first, find the equation for the family of parabolas with vertex at the origin, namely $y = x^2/(4p)$, where p is the distance from the vertex to the focus, and then leverage this equation to derive the general equation of a parabola, with vertex at (h, k). A major focus of the unit was on quantitative reasoning, where a quantity is one's conception of a measurable attribute of an object (Thompson, 2011). In particular, the quantitative meanings of the variables and parameters in the derived equations as distances were emphasized in these lessons.

The VLs participated in 9 research sessions, which occurred after school in a classroom at the VLs' school. Each session lasted 75-90 minutes. In these research sessions the VLs were asked to engage in mathematical tasks that mirrored those given to the talent in the instructional videos. When the talent's task was complex, the same task was given to the VLs. In other instances, similar tasks were given (e.g. some numerical values were changed) to ensure a high level of problem solving for the VLs.

Two researchers participated in these sessions. One operated two camcorders, one focused on the VLs' written work and one focused on the VLs as they interacted with each other. The other researcher interacted with the VLs. She sat on the other side of the room from the VLs while they worked on the math tasks and watched videos, but would come over when they were finished or stuck so the VLs could explain their thinking. The researcher's purpose was to understand the VLs' reasoning as they engaged with the dialogic instructional videos, rather than to provide new information. As such, she left many areas of confusion unresolved.

Analysis began with the creation of descriptive accounts of the 9 research sessions (Miles & Huberman, 1994). From these descriptive accounts, we identified 9 candidate topics where the VLs showed progress in their understanding. We selected the VLs' meaning for the parameter p in the equation $y = x^2/(4p)$, because it is complex for learners and is also important mathematically. We focused our analysis on Research Session 6, because it was during this session that the VLs were able to articulate the meaning for p as the distance between the origin and the focus. Prior to this, the VLs had used p as they derived the equation $y = x^2/(4p)$, but not with this quantitative meaning. Instead, they managed other meanings for p, such as a particular number used in the calculations when finding the equation for a specific parabola or the y value of the focus.

In Research Session 6, the VLs were given two p values, p = 1.5 and p = 2.5, and were asked to graph the parabola, write its equation, and label p, the focus and the directrix. This tasked mirrored a task that was given to the talent in the instructional videos, though the talent were given p = ¼ and p = ½. In the previous research session, the VLs had derived the general equation for a parabola with vertex at the origin, $y = x^2/(4p)$.

We analysed the VLs' learning process using a Bakhtinian lens. In particular, we identified the voices that the VLs used as they worked on the task. We also coded for aspects of ventriloquation from the literature, such as repetition, resistance, and integration.

RESULTS

In this section, we will present evidence to support the claim that the VLs came to understand the p-value of a parabola as a distance by ventriloquating a voice of "p as a distance" from a dialogic instructional video. However, this process was not simple. It only happened after they had watched the video twice. The first time they watched the video they were unable to engage with the voice "p as a distance," as they said the video was too confusing. We will provide evidence that they were eventually able to make use of the voice after watching the video a second time, but only after initially resisting the voice and relying on their personal narrative, repeating the voice, and finally integrating it with their personal narrative.

Description of voices in the dialogic instructional video

In the video that the VLs watched, the talent grappled with a task similar to the one given to the VLs, in which they were to place the focus of a parabola with p = 1/4. Initially, the talent were confused about how to do this, but they eventually decided that the focus should be placed at (0, 1/4), since this is 1/4 units away from the vertex at (0,0) and p = 1/4. The idea that p is the distance from the vertex to the focus was then reemphasized in a voice-over and with an annotation over the talent's work. In the video, the talent expressed two voices that the VLs eventually repeated. The first is "once you know the p value, you know the focus's location" and the second is "p as a distance." The talent expressed both voices as they determined the location of the focus.

Resisting the voice "p as a distance" and relying on personal narrative

After the VLs finished watching the video the second time, the researcher asked them what they noticed about p, the focus, and the directrix. Desiree responded, "It's getting harder, intense." Then, instead of engaging with p, the VLs graphed the parabola with p = 1.5 using point substitution. They did so by finding the equation for the parabola by plugging 1.5 into the general equation $y = x^2/(4p)$ for p, which yielded $y = x^2/6$. They then used this equation to generate a table of x and y values that satisfied the equation and then plotted the points. This systematic process to graph the parabola was a significant detour from locating p, taking about 5 mins and 30 seconds to complete.

We see this departure from engaging with p as an instance of resistance in that the VLs set aside the voice expressed in the video of "p as a distance," in favour of a voice that appeared to already be a part of their personal narrative, that of "graphing a parabola by point substitution." Notably, graphing the parabola did not help them locate p. However, it was a familiar voice, unlike the voice "p as a distance."

Repetition of two voices related to p

Once the parabola was graphed, the VLs read the task prompt again, which asked them to mark in p, the focus, and directrix. In response to the task, Desiree suggested that the focus would be at (0, 1.5), justifying the location by saying "because it's 1.5," presumably in reference to the p value. She then labelled the point (0, 1.5) as the focus and drew in a line at y = -1.5, which she labelled the directrix. However, the VLs had not yet marked in p, as the task requested. At this point they explained their reasoning to the researcher, recounting their point substitution method. The researcher noted that they were able to find the equation and graphed the parabola, but asked where p would be in their graph.

Researcher: Where is p?

Belinda: This [sweeping gesture from the origin to directrix] and this [sweeping gesture from origin to focus].

Researcher: Can you label those [the p values]?

Desiree: You do that [hands Belinda the pen].

Belinda: This is p [draws and labels line segment from origin to line y=-1.5] and this is p [draws a labels line segment from origin to focus at (0,1.5)].

The researcher then asked what they had learned and Belinda explained why knowing p is useful, claiming "when you're given p, you know the focus and directrix".

In this episode, the VLs began to engage with p as they repeated two voices from the video. The first is "once you know the p value, you know the focus's location." This voice was expressed by Desiree when she justified the placement of their focus at (0, 1.5) and by Belinda when she said "when you're given p, you know the focus and directrix." They then further engaged with p as they repeated the action associated with the voice of "p as a distance" when they drew in segments from the origin to the focus and from the origin to the directrix to indicate p, which are similar to the annotations in the video. However, while the voice of p as a distance was beginning to emerge, the VLs were still struggling to articulate verbally that p is a distance.

Integrating the voice "p as a distance" with the VLs' personal narratives

The VLs then moved on to another task, where p = 1/2. In contrast to their previous method, they seemed to use p immediately to find the focus and directrix. In response to the task, Belinda promptly drew in the directrix at y = -0.5 and labelled the segment between the directrix and vertex as p. Similarly, she then drew in the focus at (0,0.5) and labelled the segment between the focus and vertex as p. Meanwhile, Desiree started to create the graph using the point substitution method. Belinda then described their work to the researcher.

> Belinda: Since we know that p is the distance between the focus [and vertex] and directrix [and vertex] we put .5, because ½=.5.

In this episode the VLs clearly articulated the voice of p as a distance. Belinda said "p is the distance..." and marked in and labelled the extents between the focus and the vertex and between the directrix and vertex as p. While the VLs made similar inscriptions while working on the previous task, they made the inscriptions more quickly in this episode. Furthermore, not only are the VLs able to describe p as a distance, but this meaning for p seemed to influence their thinking. Belinda explained that knowing p allows one to efficiently locate the focus and directrix. Instead of first needing to graph the parabola with a point substitution method, they quickly mark in the focus and directrix, using the fact that p = .5. At same time, however, they did not abandon the point substitution method, as Desiree continued to use it create a graph. Rather, these voices were integrated together as the VLs used both to engage in the task. As such, we claim this voice was integrated with their personal narrative, not only because it became influential in their thinking, but also because it was coordinated with another voice that was already part of their personal narratives.

DISCUSSION

The results of this study illustrate the complexities of the ventriloquation process. Rather than simply adopting a voice as it was presented in the videos, the VLs first resisted the new voice. However, unlike in Taylor's (2003) example, the VLs in this study did not seem to be actively antagonistic towards the voice expressed in the video. Rather, they seemed confused by the voice and were unable to make use of it until they invoked their personal narrative. By evoking voices in their personal narratives, they made space that allowed them to integrate the voice of "p as a distance" with those. We see personal narratives as a tapestry of voices, meaning learners need to understand how the voices in the personal narratives relate to one another. By using the point substitution method to create a graph alongside the voice "p as a distance," the VLs had the opportunity to begin to explore the connections between the equation, the graph, the focus, the directrix, and p.

IMPLICATION

As video developers create dialogic instructional videos, they should consider how to support VLs in ventriloquation. VLs need opportunities to integrate new voices into their existing personal narratives. The results from this study suggest that this may mean they need opportunities to evoke voices in their personal narratives and explore the connections between these voices and those presented in the videos. One support for the VLs in this study to explore these connections seems to have been the opportunity to explain their thinking to a partner. We suggest that VLs be given opportunities to discuss with other students, whether in-person or virtually, how they are reasoning about tasks related to those explored in the video and the connections between how they are reasoning and the ways of reasoning presented in the videos.

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