ELICITING DISPOSITIONS FOR TEACHING IN THE CONTEXT OF A VIDEO-BASED INTERVENTION FOR SECONDARY TEACHER CANDIDATES

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For years, teacher education programs have focused considerable effort on teacher knowledge and how to develop the types of knowledge that matter in teacher education candidates. Meanwhile, candidate dispositions for teaching have received little attention, particularly in mathematics courses for candidates. As developers and practitioners of a curriculum intervention designed to support candidates' mathematical knowledge, we are beginning to see how much disposition towards teaching mathematics matters in a candidate's ability to attend to students' ideas. In this paper we share results from a pilot study investigating the dispositional characteristics elicited in an online video-based curriculum focused on students' ideas on a figural pattern task. Results indicate that efforts to cultivate secondary candidates' disposition for teaching may have payoffs with respect to both dispositions and knowledge.

Keywords: Affect, Emotion, Beliefs, and Attitudes, Preservice Teacher Education, Teacher Beliefs, Teacher Noticing

Video-based instructional interventions have been used in mathematics teacher education for decades (Lampert & Ball, 1998; Philipp, 2008; Seago et al., 2004) and can have a positive impact on teachers and teacher candidates' (TCs') mathematical knowledge (Jacob et al., 2009), professional noticing skills (van Es & Sherin, 2008), and knowledge of students' conceptions of mathematics (Powell et al., 2003). Influenced by others' success with video-based interventions, two of the authors embarked upon a design-based research (DBR) project, VCAST (video case analysis of student thinking). From the beginning of the VCAST project, we hypothesized that engaging TCs in analysis of video and written evidence of student thinking could serve as a meaningful way to structure candidate engagement with a) key ideas of the secondary mathematics curriculum and b) a range of productive ways students might interact with those same key ideas. And while candidate data do support our initial hypotheses, themes related to candidate dispositions emerged. As a result, we recently turned our attention to how we might cultivate particular dispositions for teaching mathematics in TC in the context of attending to students' mathematical work.

An important part of DBR is the involvement of practitioners--those responsible for implementing the intervention (Amiel & Reeves, 2008). To that end, a team of practitioners (partner instructors) and VCAST curriculum developers (developers) collaborated to investigate the evidence of dispositions for teaching mathematics elicited as secondary mathematics TCs engaged in a curricular module focused on student thinking on figural pattern tasks. Our research question is: *What do partner instructors and developers learn about candidate disposition towards teaching the mathematics of figural pattern tasks?* In this paper we share a summary of the results of our collective analyses, including interpretations from each partner instructor, along with implications for module revision and implementation.

Background

This is the fourth year of VCAST, a four-year DBR project funded by the National Science Foundation (Award #1726543) focused on designing video-based curriculum to improve secondary mathematics TCs' ability to attend to student thinking. In this section we provide an overview of the project and make connections to the literature relevant to the current study.

Mathematical Education of Teachers

The mathematical preparation of teachers has received significant attention over the last couple of decades, with mathematicians and educators collaborating on the educational expectations for beginning teachers at various levels of the school curriculum (CBMS, 2012). A repeated theme is the importance of being able to elicit and interpret students' ideas (NCTM, 2014). For instance, a TC's ability to complete a mathematical task, recognize the potential mathematical complexities for students, make inferences about a particular student's understanding based on the evidence students produce, and then decide on an appropriate response that builds upon, as opposed to simply redirecting or correcting, that student's thinking all rely upon various subdomains of candidate knowledge.

Dispositions for Teaching Mathematics

We think about dispositions for teaching mathematics as a set of interrelated habits of mind that teachers embrace to carry out their practice. Interestingly, professional standards documents for teacher education programs rarely address these habits of mind explicitly. Rather, they are implicit in the sets of knowledge and skills TCs are expected to acquire by the time they enter the teaching profession. However, one can readily see the influence of various fields of study with standards that advocate for 1) the use of culturally relevant pedagogy (Ladson-Billings, 1995), 2) the application of educational ethics and caring (Noddings, 2003), 3) attending to students' mathematical thinking (Author, 2017; Jacobs et al., 2010), and 4) understanding power and privilege in the history of mathematics education (Gutierrez, 2013).

Given the focus of VCAST, this study is centered upon dispositions associated with attending to students' mathematical reasoning. That is, we are concerned with the habits of mind needed to put a candidate in the best position possible for analyzing and interpreting student thinking. We have tentatively identified two such habits of mind: *awareness of differences in reasoning*, and *adaptability in one's own thinking*. Awareness of differences in reasoning is about acknowledging that individuals will necessarily have different ways of reasoning in sensible ways about mathematics. Such awareness involves considering any evidence of student reasoning on its own merits and places great value on individual student perspectives. With awareness, the expectation is that students' ways of reasoning are sensible and it is up to the TC to identify how the student is making sense of the ideas. Adaptability in one's own thinking is about being willing to revise one's knowledge and assumptions when presented with additional evidence that warrants such a change. Adaptability involves recognizing that all knowledge is tentative and the active pursuit of additional information and evidence in an attempt to more fully understand. In the context of attending to student mathematical reasoning, TCs demonstrate adaptability when they recognize that additional information about a student's reasoning may alter their perceptions about what the student understands and is able to do. These habits of mind provide the foundation for our coding framework.

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The Intervention

From a design perspective, we focused on featuring nonstandard mathematics tasks, collecting evidence of secondary students working on those tasks, and then selecting artifacts of student evidence that revealed a range of productive approaches and strategies to solving those tasks. The intent was to introduce TCs to new ways of thinking about the featured tasks and to support the development of attentiveness (Carney et al., 2017). Developers also purposely selected artifacts to illustrate how students' productive struggle can lead to important insights.

Design and context. The intervention consists of four modules, each of which features an asynchronous online component, a synchronous in-class component, and an asynchronous exit ticket. TCs engage with the asynchronous components via the project's digital platform and instructor support materials are made available through the project's website. The in-class component can be completed in a variety of synchronous formats and leverages social learning through group activities. The modules are designed for use in the Functions & Modeling course, a mathematics course for secondary mathematics TCs taught at replication sites of the UTeach teacher preparation program. The case studies reported on here involve partner instructors from the third and fourth year of implementation.

The hexagon task module. The Hexagon Task (see Figure 1) is a figural pattern task designed to encourage far generalizations which can be determined using a variety of approaches. For example, a student might choose to focus on how the configuration of hexagons contributes to the perimeter, on how the perimeter increases from one figure to the next, or perhaps a combination of these and other approaches. The range of approaches that can be productively leveraged while completing the Hexagon Task afforded multiple opportunities for TCs to examine a variety of students' mathematical reasoning (Cavey et al., 2018). The task also requires students to attend to three interrelated quantities: the figure number, the perimeter of the figure, and the number of hexagons in the figure.

The start of a sequence of figures is shown in the diagram below. Describe how the perimeter of the figures changes from one figure to the next. What is the perimeter of the 100th figure?

Figure 1: Adapted Hexagon Task; Hendrickson et al. (2012)

The module features video and written evidence produced by three students who approached the task differently and exhibited productive struggle in a range of ways. The pseudonyms and images of each student, along with their final written work included in the module, are provided in Figure 2. Ashley focused on geometrical aspects and developed a function for the perimeter of a figure based on the number of hexagons in the figure. Maria began her work on the task using an approach similar to Ashley's but then switched to an approach that focused on using the increase in perimeter from one figure to the next to determine the relationship between perimeter and figure number. Brandon, like Ashley, remained focused on the relationship between perimeter and the number of hexagons. He made a more explicit assumption that there are 100 hexagons in the 100th figure, recognized his error, and then tried to correct his final answer by using recursive reasoning to determine the number of hexagons in the 100th figure.

The in-class component features written student evidence from an additional six students. This work was selected for candidate group analysis and discussion. Providing this broader range of student thinking affords social construction of candidate knowledge related to the mathematics of figural pattern tasks and how students think about and reason with that mathematics (Franke and Kazemi, 2001). By highlighting areas of secondary student struggle, our intent was to help TCs gain an appreciation for the complexity of figural pattern tasks and to foster empathy for how each individual student navigated that complexity.

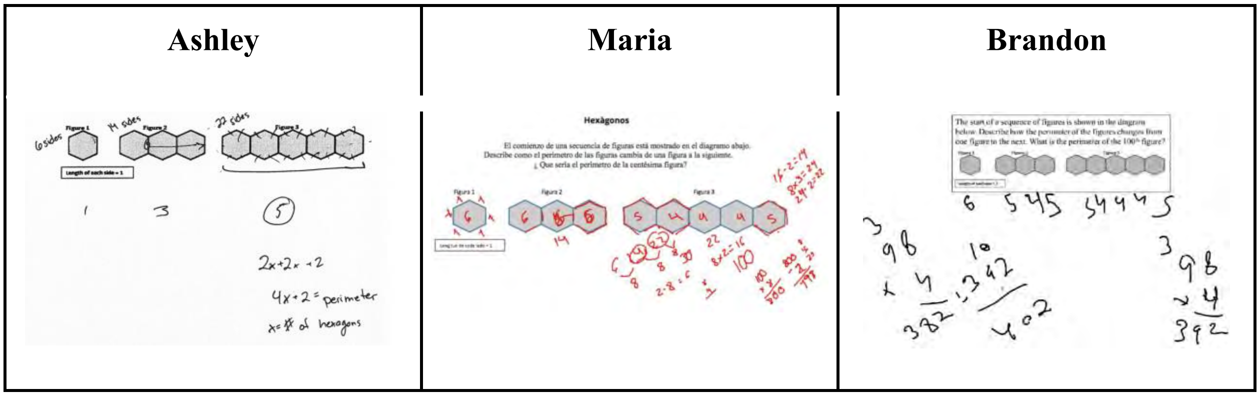

Figure 2: Student evidence featured in the asynchronous components.

Methods

Participants and Settings

Partner instructors for project X were recruited using the UTeach email listservs and during annual conference presentations for Functions & Modeling instructors at the UTeach conference. Both instructors for this study are faculty at mid-size, public university UTeach replication sites located in the United States. Instructor K implemented the year 3 version of the VCAST curriculum materials in fall 2019, whereas Instructor N implemented the year 4 version in fall 2020. As such, Instructor K was in the first group of partner instructors and was able to meet with their students in a standard face-to-face classroom setting for the in-class component. Instructor N was in the second group of partner instructors, who had the benefit of improved materials based on the lessons learned in year 3, but implemented the in-class component remotely due to the ongoing COVID-19 pandemic. Both instructors used the same order of modules during their implementation, with the Hexagon Task as the second. Candidate participants who elected to participate in the study were undergraduate students enrolled in the partner instructors' courses. See Table 1 for summary information about each instructor.

Table 1: Partner Instructors and Their Candidate Participants

	Participation Year	# of TCs	In-Class Format
Instructor K	Year 3 (fall 2019)	8	face-to-face
Instructor N	Year 4 (fall 2020)	13	remote

Data Collection

Data for these case studies were collected using observations, instructor reflection surveys, digital captures of candidate work produced during the in-class component, and the online platform designed specifically for VCAST's delivery of asynchronous module content. Instructor K's in-class session was recorded by a VCAST research team member. Instructor N's class was captured via Zoom, as its synchronous enactment occurred online during the COVID-19 pandemic. Following implementation, each instructor submitted reflection feedback via a Google Form. Each reported their perceptions regarding candidate engagement with the module content and uploaded candidate artifacts produced during the in-class session. Candidate data consisting of responses to asynchronous module prompts were collected digitally via the VCAST digital platform and then downloaded for analysis.

Data Analysis

Candidate data were analyzed using a coding framework derived from the literature on professional noticing (Jacobs et al., 2010; van Es, 2011) and attentiveness (Carney et al., 2017; Carney et al., 2019) that focuses upon the two habits of mind outlined earlier for dispositions associated with attending to student thinking. With respect to awareness, we looked for evidence that the candidate was able to focus explicitly on a student's way of reasoning with the Hexagon Task rather than imposing their own ideas or that the candidate engaged in making sense of student reasoning. With respect to adaptability, we looked for evidence that the candidate was receptive to new information about a student's reasoning and for evidence that the candidate was willing to acknowledge when their own original ideas were proven incorrect.

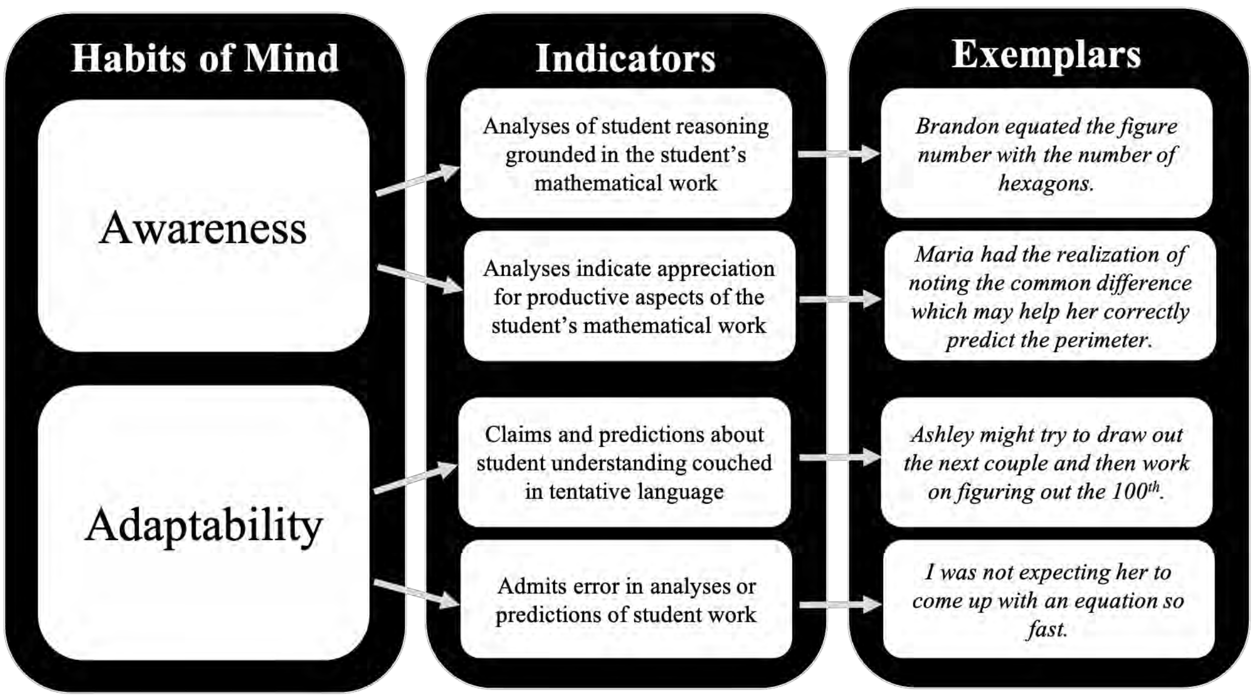

Figure 3: Selected Indicators of the Candidate Dispositional Coding Framework

To start, researchers decided on the unit of analysis to be coded using a methodology similar to that used by van Es and colleagues (van Es et al., 2014). Because we were interested in analyzing evidence of candidate disposition elicited through sequences of student work analysis, we first identified the particular segments of data, or units of analysis, we felt were most likely to provide this evidence. Pairs of researchers then applied the coding framework to a selection of data for each instructor, then met to calibrate codes and reach consensus on the meaning of framework indicators. Following these conversations, all four researchers met to share results of calibration conversations and to collectively refine indicators and interpretation of the framework. The original researcher pairs then coded and calibrated the remaining data for their

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assigned instructor. Each unit of analysis was independently coded by two researchers and calibrated until consensus was met.

In the following section, partner instructors present emerging findings from their case studies. We deliberately use a first-person narrative so as to enable readers to gain deeper insight into individual perspectives and lenses that instructors used to interpret candidate data.

Instructor K's Results

As a mathematics educator who prepares TCs to teach students with diverse backgrounds and experiences, my goal is to implement strategies that increase their mathematical knowledge, skills, and dispositions for teaching all students. Thus, when approached to participate in VCAST, with its focus on student thinking, I saw it as an opportunity for TCs to develop an awareness of various student approaches and openness towards multiple forms of reasoning. Additionally, I hypothesized that engaging in the cognitively demanding tasks and productive struggle could lead to an increase in TCs' content knowledge and an appreciation of their future students' struggle. My experience as an instructor, coupled with the recent analysis of the Hexagon Task data, indicates growth in the TCs' awareness of student thinking and evidence of their ability to predict student moves and admit when those predictions were incorrect.

Growth in Awareness of Student Thinking

Initially, when TCs reviewed written students' responses to the task associated with the first module, they focused their analyses on whether students' work was correct or incorrect. However, to develop their attentiveness, I prompted my TCs to look beyond correctness by focusing on the students' explanations. By the second module, 4 out of 8 TCs commented on how the module made them aware of the multiple solution paths, and all of the TCs were describing, discussing, and making comparisons between the various students' approaches or comparing their approaches to those of the students. For example, TC4 wrote "In my process, I did not use the number of hexagons to calculate the perimeter. [Ashley] took the number of hexagons times 2 for the bottom perimeter and did the same for the top then added the other sides." TCs were also able to analyze and interpret student thinking based upon evidence. Consider the following statements by TC3 and TC9:

- TC3: Maria wrote 6, 14, 22. Then drew a line in between them to show the increase of 8. This is the increase per figure …, to find out the perimeter per figure.
- TC9: So, by multiplying 4 by 98 and adding the extra sides for the end [h]exagons [Brandon] is assuming there are 100 Hexagons in the 100th figure.

Evidence of Adaptability

When making predictions about students' thinking, TCs demonstrated adaptability in both their tentative language and their willingness to revise their assumptions. Most of their speculations began with the phrases "I think …", "I believe …" or "She may or might..." indicating the TCs' were trying to identify how the student is making sense of figural patterns. The data analysis revealed that 7 out of 8 TCs admitted to incorrectly predicting Ashley's next move, while only 3 out of 8 admitting errors with Maria, possibly because their approach was more similar to hers. When the students' actions did not match the prediction, the TCs would either acknowledge the error or adjust their interpretations. The TCs made comments like "I'm surprised!", "My prediction was completely wrong with what Maria actually did," and "[Ashley] … pulled in the number of hexagons in the figure …, which I did not anticipate."

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As the Hexagon Task was only the second of the four modules, the TCs were already showing evidence of important skills necessary for effective mathematics teaching. They were able to shift their focus from the correctness of students' answers to an awareness of diversity in students' mathematical reasoning. They were able to assess, compare, and make predictions about students based on video and written work, and became open and willing to learn and revise their assumptions when presented with new evidence. Even the two TCs who initially incorrectly solved the task themselves exhibited these skills. This suggests that giving TCs opportunities to examine, discuss, and predict student thinking may help them develop effective teaching practices to use in their classrooms.

Instructor N's Results

As a mathematics teacher educator who focuses on equitable teaching and culturally responsive pedagogy, I emphasize the importance of treating all students as capable learners. Thus, I was interested in how the VCAST materials, with their emphasis on the analysis of student evidence of mathematical reasoning, would provide opportunities for me to surface and support the dispositional development of my TCs. Analysis of their data from the Hexagon Task module illuminated several interesting areas of potential insight and growth for my TCs. I discuss two themes in particular that emerged from my TCs' engagement with student work analysis: (1) TCs appeared to grow in their own mathematical understanding and (2) TCs appeared to develop a more empathetic stance toward the students whose work they analyzed.

Growth in Mathematical Understanding

Data analysis indicates that 6 out of 13 students exhibited growth in their own mathematical understanding, either by improving the quality of what they noticed and described in student strategies, articulating that a featured student strategy was something they had not initially thought about, or by solving the adjusted version of the task correctly after submitting an incorrect answer for the Hexagon Task. For example, TC3 responded, "I realized that Maria's way of thinking also works and makes a lot of sense, even though I hadn't initially considered thinking the way she did" and TC13 observed, "Some of the strategies used by different people for this task surprised me because I did not think of the problem in those ways." For TC5 and TC14, both of whom initially solved the Hexagon Task incorrectly, analysis of student thinking not only appeared to reinforce their dispositional traits, but also appeared to enable them to correct their own mathematical errors and solve a related task, presented later in the module, correctly.

Growth in Empathetic Stance

Data analysis indicates that 10 out of 13 students exhibited growth in their ability to empathize with students' struggle with the task. For instance, TC13 acknowledged, "Pattern tasks are really easy to get confused on if you do not know what to look for," while TC10 noticed, "Brandon is focusing on how many hexagons each figure has, and he is struggling to find the pattern to find the number of hexagons in the 100th figure." Developing more empathy towards students' mathematical reasoning also allows for more flexibility in their interpretations and helps TCs recognize that students' mathematical thinking is fluid. As TC13 notes, "Predictions are predictions, they are not factual. Always be ready for any reaction or questions asked by the students."

TCs across the board agreed that 'brief isolated episodes' may not portray a complete picture of students' thinking and that it is necessary to initiate and engage in an ongoing mathematical discourse to gain insight into their thinking. This is evidenced by TC5, who observed, "It helped me make sure that I try to understand each student's thinking and why they did [a] certain mathematical process" and TC6, who realized, "Students need to be given time to show their mathematical process, thinking, and reasoning before making assumptions."

During my implementation of the Hexagon Task module, I noticed my TCs shift from attending to students' ideas for the purpose of evaluating student work to a desire for understanding students' mathematical ideas. The analyses of TCs' responses to the Hexagon Task module not only support my impressions during implementation but also highlight other areas of growth. From an equity standpoint, I am excited about the potential to cultivate TCs' dispositions for teaching mathematics while also supporting TCs' mathematical knowledge.

Discussion and Implications

Instructors and developers, alike, observed shifts in the evidence of TCs' dispositions as TCs engaged with the VCAST materials. Our curiosity about this phenomenon led to a shared interest in investigating the extent to which TCs' dispositions for teaching mathematics were elicited with a single module. Since none of us had previous experience researching dispositions for teaching, one primary aim was to settle on a framework that would allow us to capture the nuances we observed in the language TCs used when analyzing and reflecting on their analyses of student evidence for reasoning. By doing so, we not only have a framework for future analyses, but we also uncovered several potential directions for future research across all partner institutions as well as implications for module revisions.

For one, we did not expect to see marked shifts in evidence of TCs' dispositions within a module. Moreover, we observed shifts in TCs' dispositions in two distinct ways. The data from Instructor N's TCs showed impressive gains in disposition from the beginning to the end of the online component, with all TCs demonstrating evidence of awareness and adaptability by the end. For Instructor K, we observed shifts in evidence of TCs' dispositions in relation to the students featured in the module. Naturally, we wonder, *In what ways does the evidence for TCs' dispositions for teaching mathematics shift when engaging in a video-based intervention focused on student thinking on figural pattern tasks?*

Second, while the focus of this pilot study was on TCs' dispositions, our work has led to a hypothesis about the relationship between disposition and the ability to learn from students' mathematical work. Of the TCs who started the module with an incorrect solution, those who exhibited multiple indicators from both habits of mind were more likely to correct their mathematical errors by the end of the module. As a result, we wonder, *How are TCs' disposition for teaching mathematics related to their ability to learn mathematics from students?*

Lastly, our analyses revealed a gap in module questions about Brandon's reasoning evidence. In particular, the current questions are not structured to elicit evidence with respect to one of the indicators for adaptability. Thus, the developers must now decide whether that type of evidence is desired and how to restructure the questions to elicit that evidence.

In summary, what began as a trend in TCs' module responses about student thinking has evolved into a list of potential lines of inquiry into TCs' disposition for teaching mathematics. And while we have more questions than answers at the end of this study, we hope this work sparks interest from the larger field of professional noticing.

Acknowledgments

The larger study referenced is supported by the National Science Foundation (Award No. 1726543).

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