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Animating Preservice Teachers' Noticing

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The incorporation of animation in mathematics teacher education courses is one method for transforming preservice teachers' practice and promoting practice-based education. Animation can be used as an approximation of practice that engages preservice teachers (PSTs) in creating classroom scenes in which they select characters, regulate movement, and construct conversations to generate playable animations. We focus on the role of animation as a practice-based expression to denote who, what, and how PSTs professionally notice within a mathematics lesson. The animation provides a mechanism for analysis that articulates PSTs' concepts of teaching to a perceptible reality. We examined the affordances and constraints of PST-generated animations as a means of supporting elementary PSTs' noticing.

Keywords Preservice teachers • noticing • teacher education • technology

Classrooms are complex settings with a variety of interactions taking place at any given time. Preservice teachers (PSTs) need experiences that help them gain knowledge about what they see and experience, but learning which interactions to pay attention to is a challenging task (van Es, 2011). Therefore, teacher educators must work to provide opportunities for PSTs to develop and support their professional noticing (Schack et al. 2013). As a fundamental practice of teaching, noticing allows one to attend, interpret, and reflect on classroom interactions. However, how these opportunities and interactions influence future practice can remain unknown. We examined three main aspects of PST noticing. First we wanted to gain insight into whether PSTs attended more greatly to the teacher or students (*who*). We also wanted to understand whether PSTs noted general or specific aspects of classroom interactions (*what*). Finally, we wanted to know *how* PSTs noticed aspects of the classroom. For example, did the PSTs just describe what they notice or did they take a more analytic approach to noticing? To examine the who, what and how of PSTs' noticing we made use of an innovative technology that also served as an approximation of the PSTs' practice (Grossman et al., 2009). In this paper we describe the affordance and constraints of animation as a means of supporting PST noticing.

Professional Noticing

Teacher educators working to prepare PSTs for the classroom must teach them "to be able to 'see' how a lesson is going and to interpret students' ideas in the midst of instruction" (Sherin, 2007, p. 383). The notion of understanding how a lesson unfolds and analysing the process stems from work on professional vision, which Goodwin (1994) described as "socially organized ways of seeing and understanding events" (p. 606). The roots of professional vision extend from the work of Dirkin (1983) who coined the term *cognitive tunnelling* as a way to describe how novices narrow their attention while performing a complex task. Dirkin's idea of intense focus on a specific entity compliments professional vision as a means for describing the focused work of situational awareness (Endsley, 2000) and the notion of awareness of awareness (Mason, 2002). For PSTs to 'see' how a lesson is progressing and make decisions on this basis, they must be cognizant of their awareness and act accordingly. Mason (2002) described this awareness with the term *noticing* to denote an attention to collecting practices, learning from experiences, and using this information to inform future practice. He explained, "since what we fail to notice is unlikely to have much influence upon our actions….it makes sense to work at broadening and deepening our sensitivities to notice different aspects of our professional practice" (Mason, 2002, p. 29).

Building on Goodwin's (1994) work on professional vision, Stevens and Hall's (1998) work on disciplined perception, and Mason's (2002) work on intentional noticing, the professional practice of noticing has expanded in teacher education, most notably in mathematics teacher education. Sherin and van Es (2005) have contributed considerably to research on teachers' professional noticing and studied how preservice and inservice teachers *learn to notice* what is happening in their classrooms. They distinguished between what is noticed and how teachers interpret these events. Based on this work, van Es and Sherin (2008) further studied professional noticing and developed a learning-to-notice framework to define the process as encompassing three aspects: a) identification of significant events in a teaching situation, b) using knowledge of context to reason about these events, and c) making connections between specific events and broader principles of teaching and learning. The development of professional noticing further expanded with the work of Jacobs, Lamb, and Philipp (2010) who defined professional noticing of children's mathematical thinking as attending, interpreting, and deciding how to respond to children's thinking. Collectively, we draw on the work of van Es and Sherin (2008) and Jacobs et al. (2010) to further define teacher noticing as attending to children's mathematical thinking, interpreting this thinking, and making decisions about future actions on the basis of children's thinking with awareness about effective practices for teaching and learning. We assert that PSTs must develop knowledge and skills related to these processes in order to understand how children think about mathematics. Relatedly, mathematics teacher educators (MTEs) must recognize and understand these processes to support PSTs' development of effective pedagogical approaches for ambitious teaching.

Development of Teacher Noticing

Professional noticing is central to the work of teaching (Sherin, Jacobs, & Philipp, 2011). Prior research related to the notion of teachers' professional noticing refers to this construct as teacher noticing (e.g., Philipp, 2014), which is how we conceptualize *noticing* and what we intend with the use of this term for the remainder of this paper. Previous research indicates that novice teachers find noticing challenging and demonstrate less developed noticing than veteran teachers (Huang & Li, 2012; Krull, Oras & Sisask, 2007; Sabers, Cushing & Berliner, 1991; Sato, Akita, & Iwakawa, 1993). Choy's (2013) work investigated the characteristics of productive noticing with the aim that teachers "work towards improving their responses to instructional events more constructively" to better promote student learning (p.192). Advances in PSTs' noticing can occur in as little as one semester (Amador & Weiland, 2015; Star & Strickland, 2008; Stockero, 2014). Because of its centrality to the work of teaching and the possibility of improving PST noticing, we assert that teacher preparation courses should explicitly focus on improving PSTs' ability to notice (Star, Lynch, & Perova, 2011).

Teachers can develop noticing skills in various ways including lesson study, demonstration lessons, video clubs, and other practiced-based initiatives (Clarke et al., 2013; van Es & Sherin, 2008). Most research on the development (as opposed to the study of) teacher noticing has occurred through the use of video. Star and Strickland (2008) studied the extent to which PSTs attended to aspects of videos shown during teacher education programs as a method for improving observational practices and ultimately their ability to notice. Findings indicated that PSTs entered methods courses with minimal observation skills but were able to significantly increase their ability to notice features of the classroom environment, mathematical content of a lesson, and communication between the teacher and students. In a related study, Star et al. (2011) replicated the findings of Star and Strickland (2008) and confirmed that PSTs demonstrated improvements in their ability to observe classroom interactions. In both studies, PSTs showed development in noticing features of the classroom environment; however, as Star et al. (2011) indicated, improving these abilities did not eliminate the "subsequent need to help teachers develop the ability to notice and interpret *important* classroom features" (p. 131). These studies raise questions about developing noticing of significant classroom interactions, such as how students are reasoning about mathematical tasks during instruction.

Technology to develop noticing. As teacher educators work to develop noticing among PSTs, various forms of technology have been incorporated as support structures. The most common technological tool for developing noticing among PSTs is the use of video (Santagata, Zannoni, & Stigler, 2007; Star et al. 2011). Sherin and van Es (2005) used a software program named the *Video Analysis Support Tool* to engage teachers in examining excerpts of video from their classroom through a scaffolded, video analysis process. Teachers in the study noticed significant events and began to discuss their noticings from an interpretive perspective. They also cited evidence from the videos to support their claims. The authors of the study noted that continued research is necessary to further explore how technologies, such as video and software, may support the development of teacher noticing and called for the design and implementation of new video-based programs to support the development of teacher noticing.

Video clubs have also been a common technological approach to developing noticing among both PSTs and inservice teachers. Sherin (2007) incorporated video clubs into professional development as a means for developing professional vision among teachers. In this process, teachers selected excerpts from lesson recordings to view collectively and were asked to discuss what they noticed. Sherin claimed that teacher learning occurred as a result of video club participation; however, she did not analyse the role of the technology and how the function of the tool influenced the outcome. In a related study, van Es and Sherin (2008) studied the role of a video club for developing noticing among teachers. The teachers in this study selected segments of videos that focused on a particular aspect of a student or students' mathematical thinking. The teachers then discussed these clips. The researchers found that when the video club members repeatedly viewed these clips, the selected clips influenced what the teachers later noticed and discussed. Further, the authors found that some clips provided "greater access to student thinking than other clips" (van Es & Sherin, 2008, p. 263), thus highlighting the importance of teachers' initial video clip selection and the role of the technology in tunnelling teachers' attention. In more recent work on the role of video in developing PSTs' noticing, McDuffie et al. (2014) noted that the structures and prompts provided as part of a video analysis project afforded and constrained PSTs' depth of noticing. Findings indicated that teacher educators' choice of videos and prompting before, during, and after viewing are critical in developing PSTs' noticing. Such studies point to the importance of video selection and learning opportunities afforded by observing, interpreting, and reflecting on a recorded lesson.

Animation Technology

In recent years, animation has become a more prevalent technological tool in higher education disciplines outside of teacher education, such as the sciences (Lowe & Schnotz, 2008). We use the term animation to encompass "manipulation[s] of electronic images by means of a computer in order to create moving images" (Hobson, 2004, p. 23). This technology often replaces static graphics, which have been educational tools for centuries. However, while animation is increasingly used in content areas, including mathematics (Pierce & Atkinson, 2003), it is rarely used in teacher education. Indeed, beyond videos and video clubs, other technologies are not widely discussed in the literature related to the development of teacher noticing among PSTs; however, existing technologies are used in teacher education programs for other purposes and may be able to support noticing development (e.g., Lesson Sketch). Therefore, we investigated animation as a means of supporting PST noticing.

A variety of computer programming structures and online software platforms can be used to create animated scenes that include a setting and sprites, which are animated beings (Amador & Soule, 2015). Visual icons are linked with audio commands and programmed for movement, allowing users to manipulate movement and create scenes. Through this process, users construct computer-based, animated scenes in which sprites interact and talk to others. As animations are created, classroom scenes can be depicted with multiple students, teachers, and learning support materials. In essence, these animations serve as means of approximating practice because they depict classroom scenes similar to videos. They are a designed instructional activity aimed at supporting the development of ambitious mathematics teaching (Lampert, Beasley, Ghousseini, Kazemi, & Franke, 2009). However, little research has focused on how the creation and use of such animated scenes as a practice-based routine may support teacher learning. As a result, we were interested in understanding the affordances and constraints of animation use in teacher preparation programs for supporting the teacher noticing of PSTs, with a specific focus on PSTs as the animation creators.

Methods

MTEs from six universities enacted an animation-based innovation on teacher noticing in their elementary mathematics methods course. The 6 MTEs collectively designed the task to understand how PSTs would animate who, what, and how they professionally noticed. The task was purposefully designed for the PSTs to complete the first part during the methods class and the second part outside of class.

Task

The basic premise of the task was that PSTs watched a video of a third grade (children aged 8-9) classroom lesson on division involving fractional pieces and then recorded their noticings in writing and through animation. To initiate the task, PSTs were given the following directions: "Step 1: As you watch the video for the first time, use this space to note any and all *pivotal moments* you notice during the lesson." While watching the video, the PSTs took notes to complete Step 1. Following this, they were prompted again: "Step 2: Now look over your list and select one of those moments that you described. In the space below list the moment and discuss why you chose this particular moment." Then, they watched the same lesson again with the following directions: "Step 3: Now, as you watch the lesson for the second time note as much detail in the space below as you can about your selected moment to use for the remainder of this assignment." This concluded the in-class portion of the task.

Then, the MTEs directed PSTs to use their notes to animate the salient moment they identified using a free, web-based video animation software platform called *GoAnimate* (www.goanimate.com, Figure 1). The MTEs provided a brief written and in-class overview of how to use the software, but did not provide input on the content of the animations. For further details about this task, please see (Estapa et al., under review). Following the creation of their animation, the PSTs provided written responses to the following questions: "How would you characterize (i.e., describe) your animation? What was the most salient part of the classroom teaching that you selected? How well did you represent that portion of the lesson? Why was that portion of the lesson the most important?" The animations were typically about one minute and thirty seconds in length.

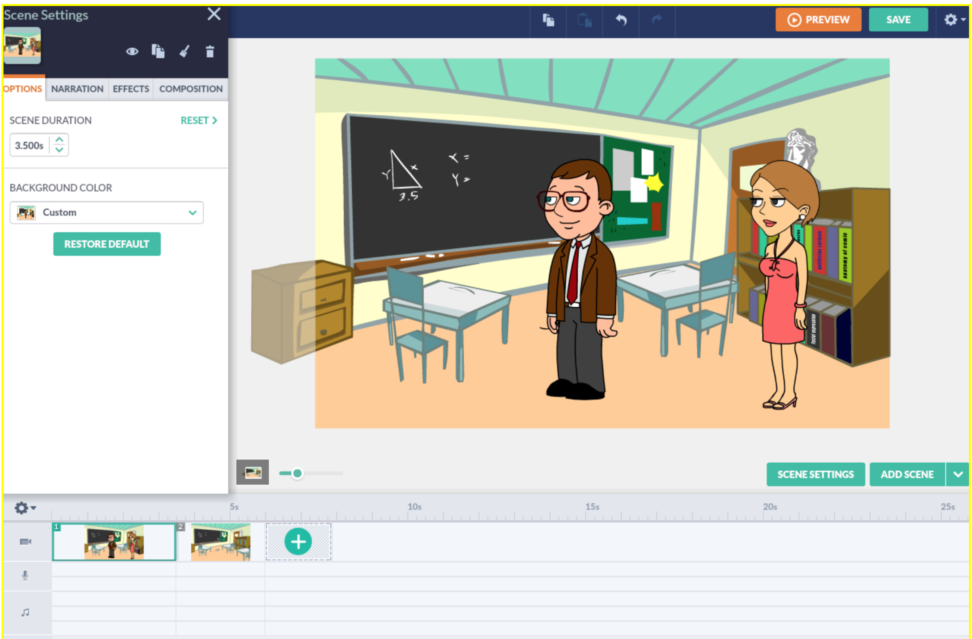


Figure 1. Screenshot of the www.goanimate.com control panel.

Data Sources and Analysis

Data for this project were collected from PSTs (n= 126) across the six universities. All of the PSTs were undergraduate, elementary (roughly grades K-6 or children ages 5-12) education majors. Because the study was conducted across six universities, the PSTs differed in terms of the number of years they had been in their respective programs, however the vast majority were in year three of a four year program and enrolled in their first mathematics methods course (Table 1). Evidence is comprised of PSTs' written descriptions and justifications of the salient moment they selected (Step 1 and Step 2), the animated videos they subsequently produced, and PSTs' written reflections about the process. One of the methods courses did not complete the animated component of the task, resulting in 106 animations and reflections as compared with 126 written accounts of who, what, and how noticing occurred.

Table 1
PST Background Information

University	Number of PSTs	Course Alignment within Four-Year Teacher Preparation Program[1]
A	20	Fourth year, second of two math methods courses
B	19	Third year, first of two math methods courses
C	17	Third year, first of two math methods courses
D	28	Third year, only math methods course
E	23	Third year, only math methods course
F	19	Third year, only math methods course

In addition to the PSTs' data, following the lesson each MTE wrote a reflection that addressed his or her perceived affordances and constraints of the animation software as a means of facilitating PSTs' noticing. The MTEs' reflections addressed the following questions: "1. What were the main affordances of the animation in terms of facilitating PSTs' noticing from your perspective as an instructor? Give examples to illustrate your point." In contrast, the second question focused on constraints: "2. What were the main constraints of the animation in terms of facilitating PSTs' noticing from your perspective as an instructor? Give examples to illustrate your point." Next, the MTEs responded about noticing in relation to PSTs' knowledge and the use of written and animated mediums: "3. Discuss any particular insights into the PSTs' noticing, PCK (pedagogical content knowledge), and MKT (mathematical knowledge for teaching) you may have gained from the PSTs' animations that may not have been possible with traditional paper and pencil. Please provide examples if possible." The final question focused on possible limitations: "4. Discuss any potential limitations to your insight on the PSTs' noticing, PCK, and MKT that may not be as pronounced as in written work. Please provide examples if possible."

All PST written responses were converted to digital files and each of the animations was transcribed. Drawing on our framework (For details on this process, please see Estapa et al., under review) derived from mathematics education literature on noticing (e.g. van Es & Sherin, 2008), we conducted a deductive, content analysis (Bernard & Ryan, 2010) of the written and animated data, coding for *who* and *what* was noticed (Table 1). *Who* referred to whether the PST attended to the *teacher* or *student*. For example, some animations contained only students while others focused exclusively on the teacher. *What* pertained to whether the PST described/animated *general* or *specific* aspects of the moment. For example, some PSTs wrote about general teacher strategies they noticed such as questioning, whereas others wrote about specific teacher responses to a particular student that clarified the meaning of a particular concept. We also analysed the written data for *how* the PSTs noticed, meaning the degree to which they were *descriptive*, *evaluative, interpretive*, or *reflective*. It was not possible to analyse the animated data for *how* noticing occurred due to the nature of the medium.

Table 2.
Coding framework.

<table>
<tr><th rowspan="2">WHO</th><th colspan="2">Teacher</th><th colspan="4">Student</th></tr>
<tr><td colspan="2">Attend to the Teacher</td><td>Attend to Whole Class</td><td colspan="2">Attend to a Group of Students</td><td>Attend to a Student</td></tr>
<tr><th>WHAT</th><td>Focus on General Teaching Strategies, Pedagogy, Content of a Lesson, Context of a Problem</td><td>Focus on a connection between the teacher and another person(s) or aspect (e.g. pedagogical strategies, interactions with others, or students' thinking)</td><td colspan="2">Focus on general actions, aspects, ideas, topics, lesson structure or contextual features (e.g. physical environment, home environment, dispositions, behaviour, etc.)</td><td colspan="2">Focus on a connection between a student and another person(s) or aspect (e.g. his/her mathematical thinking, his/her interactions with others, or specific teaching strategies).</td></tr>
<tr><th>HOW</th><td>Descriptive: Recount or explain what was noticed.</td><td>Evaluative: Judge or analyse what was noticed.</td><td colspan="2">Interpretive: Understand or make sense of what was noticed.</td><td colspan="2">Reflective: Internalize or apply what was noticed to future practice.</td></tr>
</table>

In order to understand the PSTs' and MTEs' perspectives on the use of animation, we inductively coded their written reflections. The research team employed an inductive approach (Thomas, 2006) to analyse the data. We first open coded the data (Strauss & Corbin, 1990). The open coding involved the research team reading through the data multiple times to identify initial themes related to the PSTs' and MTEs' perspectives on the affordances and constraints of the animation medium. These initial themes were discussed among the research team until consensus was reached. We then employed axial coding (Strauss & Corbin, 1990) which led to the further refinement of the initial themes as we analysed across all the data.

Findings & Significance

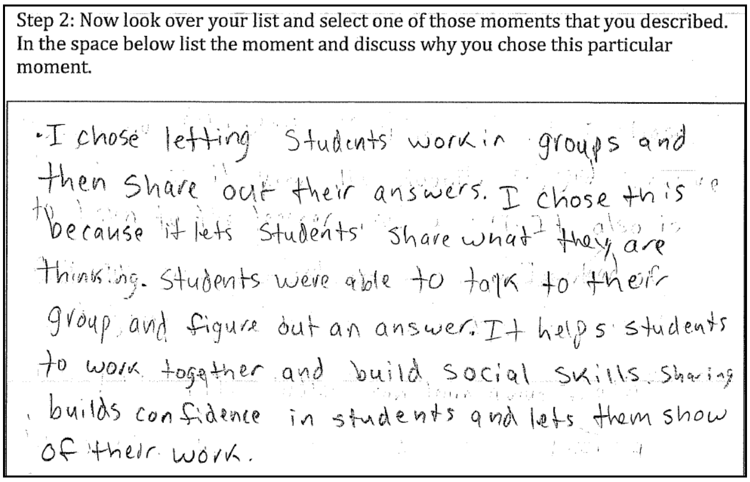
In order to examine the affordance and constraints of the animation software as a medium for facilitating PSTs' noticing, we examined feedback from both the PSTs and the MTEs. In addition, we compared the PSTs' written and animated works to more closely examine the contrast between the two formats. In the following sections we describe in detail the affordances and constraints that arose from this analysis. We also include a number of examples from both formats to further illustrate these points.

Affordances

In analysing both the PST and MTE reflections, it was clear that both groups thought the animations allowed for an accurate depiction of the pivotal moments the PSTs noticed. The PSTs found the software learning curve relatively minimal and a number of them described the process of animating as enjoyable. Further, both groups reported a greater number of affordances provided by the animation software than constraints. We describe the main affordances provided by the animations that not only represented PST noticing of a pivotal moment, but also supported MTEs' understanding of PST noticing.

Focus on specific aspects of the lesson. In comparing *what* the PSTs noticed across their written and animated responses, it was evident that the animation software shifted the PSTs' noticings to focus on specific instances. Our coding framework (Table 1) defines the different codes we used in describing what the PSTs noticed in both their written and animated responses. In coding *what* the PSTs noticed in the written format, we found that slightly more than half (58 of the 106) wrote about generalities. However, in the animated format, 99 of the 106 focused on specific aspects of the moment. We believe this shift occurred because the animations required PSTs to portray a scene with dialogue among characters, and the scripting of this dialogue led to the recreation of specific instances of note, rather than general descriptions of the moment.

The MTEs found that the level of specificity required by the creation of the animations led to a number of favourable outcomes including greater insight into the PSTs' notion of questioning and the uncovering of PSTs' mathematical conceptions. When writing about a moment, PSTs tended to describe general characteristics of note in the video. For example, one PST, Wendy wrote,


Step 2: Now look over your list and select one of those moments that you described. In the space below list the moment and discuss why you chose this particular moment.

• I chose letting students work in groups and then share out their answers. I chose this because it lets students share what they are thinking. Students were able to talk to their group and figure out an answer. It helps students to work together and build social skills. Sharing builds confidence in students and lets them show of their work.

Figure 2. Wendy's written description of her selected moment.

The written description focused on a general aspect: the use of collaborative groupings. In contrast, Wendy's animation (Figure 3) consisted of the following dialogue:

Student 1: We gave each person one and a half cookies.

Student 2:	We got one and a half cookies because we saw that each person got one cookie and there were four left over. So we divided each of the four remaining cookies in half.
Student 3:	So we glued on the whole cookies first so that everyone had one cookie. Then we took the half cookies and gave everyone a half so everybody had the same amount.
Student 1:	Cookies for everyone!

Figure 3. A screenshot from Wendy's animation.

In the animated format, we see that Wendy (necessarily) portrayed a particular instance in which the students were in a group discussing their answer with one another. The teacher is not present in Wendy's animation. Wendy's animation depicted the students working together. Wendy has animated Student 2's description of how she thought about the answer and Student 3's explanation of how they worked together to create a visual representation of the solution. The process of animating required the PSTs to build dialogue that was more specific and interactive than their written work. Therefore, the PSTs put into practice, via animation, their perceptions of the general descriptions of pedagogical strategies in their written work. This approximation of practice (Grossman et al., 2009) allowed the MTEs to follow up on the PSTs' perceptions of these instructional strategies, leading to rich classroom discussions. In addition, the level of specificity led to a greater focus on particular mathematical ideas in the moment, as described in the following section.

Clearer Picture of PST content knowledge. Another affordance related to the specificity of the animated noticing was the uncovering of PST content knowledge. Because the PSTs animated a scene, subtleties in their understanding of mathematical concepts became more apparent. For example, the PSTs who animated the portion of the lesson about fair sharing revealed their definitions, understandings, and (at times) misconceptions about the topic. The following is one transcript that shows how the PST animated her definition of the terms *equal sharing* and *equal parts*.

Teacher:	Explain an equal sharing problem using cookies.
Gregory:	Dividing each of the cookies so there are none left.
Teacher:	Would you have more cookies than me?
Gregory:	No.
Teacher:	Would I have more cookies than her?
Gregory:	No, everyone would have the same amount of cookie.
Teacher:	So you are saying that everyone has the same amount of cookie and there are no parts left over?
Gregory:	Yes.
Teacher:	That is equal parts. Do you understand Gregory?
Gregory:	Yes.
Teacher:	What did you do to figure out the answer?
Gregory:	I had to divide twelve cookies among eight people. I gave each person one cookie and had four left over. So I cut them in half so that everyone would get one and a half cookies.
Teacher:	Very good Gregory, that is correct and that is equal sharing.

In the example, the PST described equal parts as, "everyone has the same amount of cookie and there are no parts left over." This process revealed information about the PSTs' understanding of "equal" because she used the characters' dialogue to define the terms within the animation. When given a classroom episode to observe and then asked to animate the most salient moment of students' mathematical thinking, the mathematics content PSTs animate can provide MTEs with a greater understanding of how PSTs attended to and interpreted the mathematics during the observation. In addition to observing the mathematics in practice, the animations allowed MTEs a better idea of the PSTs' perceptions of teacher and student interactions.

Insights into Classroom interactions. The animations provided MTEs with an understanding of how PSTs would arrange a teacher and students within a given space. The arrangement of the sprites in the scenes provided some insight into how PSTs visualize a classroom. Often, in mathematics methods courses, MTEs discuss classroom practices and describe what an effective classroom might look like. The animations provide a mechanism for PSTs to make their descriptions of mathematics teaching and make them visible. In creating animations, the PSTs have to make decisions about who will be in their scene, how the sprites will be arranged, and even about the structure of the classroom. When a MTE views the animation they are able to gain information about how the PSTs visualize classroom contexts. Related to noticing, this also provides opportunities for PSTs to represent their thoughts about how they would respond to various classroom occurrences (Jacobs et al., 2010). The way PSTs situate sprites in the animation also provides insight into what PSTs notice from a classroom episode and how they interpret the context and make plans for their own teaching contexts.

The animations afforded opportunities for MTEs to gain an understanding of who and what were the foci of PST noticing. In the animations, the PSTs made decisions about dominant roles for those involved. In some animations, the teacher is positioned as the authority in the classroom whereas in other animations the students in the classroom are driving the conversation. In the following example, the teacher works as a facilitator and the students press each other for reasoning:

Student 1:	So we need even parts.
Teacher:	When we make something even, what are we looking for?
Student 2:	Equal parts.
Student 3:	First we pass one out to each person. Then we cut them in half and pass them out.
Student 1:	We passed them out to each person then cut them and gave each person a half.
Student 3:	I know, but how do we know we are exactly right?
Student 1:	Because everyone got an equal amount of cookies.
Student 3:	We each got one whole and one half.
Student 1:	Right.

The animations clarified the emphasis because the PSTs dedicated a certain amount of time to different types of speakers. In the case of the above example, a majority of the time is dedicated to the students.

In addition to the classroom interactions, animations may provide a platform through which MTEs might examine and discuss PSTs' depictions of power roles in the classroom and positioning of particular students. For example, MTEs might ask PSTs to consider who the dominant voice is within the animation, who participated in the discussion, or where the sprites are placed in the scene. These questions further support the use of animation as an approximation of practice through which PSTs facilitate their noticing of these aspects of the classroom environment.

Approximated practice. A main affordance was that animations were closer to practice than writing. Recent attention has surrounded 'artefacts of practice' and how MTEs need to support and evaluate PSTs based on what they actually *do* (their enacted practices), not just what they profess. In this way the animation is closer to practice than their writing. The use of animation also afforded the PSTs an opportunity to think about what to do next in a given classroom situation, which was something they viewed as a challenge. As one PST noted, "[The animation] allowed me enough time to think about what I would do if I were in the actual classroom; it was a very realistic situation, which made it extremely helpful." Indeed, the use of animation provided an opportunity for PSTs to reflect on and decide how a teacher and her students would respond. However, many PSTs recognized that even though they had generous time to think about responses in the animation, they would not be afforded such a luxury in real-time contexts. As one PST noted, "I had a long time to ponder my response…but I would need more practice to do that on my feet in the real classroom."

Because the animations served as an approximation of practice, the process provided the MTEs insight as to how the PSTs might begin to navigate the classroom. Animation provided a format to role-play teaching pedagogy. For example, the animations provided MTEs with information about the PSTs' questioning strategies. Many of the PSTs noted that the animation forced them to think about the questions they would ask in the given classroom scenario. In particular, many of the PSTs noted that they had to consider "probing questions" that were needed to deepen their own understanding of students' knowledge. Some PSTs used lower level questioning techniques that could be answered with "yes" and "no" responses, as illustrated in the following animation transcript.

Teacher:	Who knows what I mean by equal parts?
Student 1:	You divide them among everyone so that none are left.
Teacher:	So there is nothing left?
Student 1:	Yes.
Teacher:	Would I have more cookies than you?
Student 1:	No.
Teacher:	Would you have more cookies than me?
Student 1:	No.
Teacher:	Would anyone have more cookies than anyone?
Student 1:	No.
Teacher:	And that's what we mean by equal parts.

In the above example, the PSTs' script for the teacher involves a number of questions that can be answered simply with a yes or no response and does not cause the students to articulate their mathematical understanding. In contrast, some PSTs' animations involved the teacher asking questions that elicited students' understanding, such as in the following transcript from a PST animation.

Teacher:	How do you know you are right?
Adam:	Because all of us get 1½ cookies because that is all we could think of.
Teacher:	Can you explain to me the steps you took to solve the problem? All the way back to why you cut the cookies the way you did.
Adam:	Well maybe.
Teacher:	I'll wait.
Teacher:	Because I know you can. Is there a way you can explain this to someone who doesn't know anything about equal parts?
Adam:	I had 12 cookies to start with and I gave everyone 1 whole cookie.
Teacher:	Why did you give them a whole cookie?
Adam:	It was the biggest piece everyone could have.
Teacher:	Good. What do you do next?
Adam:	I had 4 cookies left and gave a ½ of a cookie to each person.
Teacher:	Very good. Why did you give a ½ piece of a cookie to each person?
Adam:	Because when I cut 4 cookies in half, that makes 8 equal pieces for each person and there is no leftovers.
Teacher:	Awesome Adam, now can you write all those specific details you just told me in your explanation?
Adam:	Of course I can Miss Brown! You are amazing and my favourite teacher!

In this example, the teacher asks the student specific questions about his mathematical thinking, such as, "Why did you give 1/2 piece of a cookie to each person?" This question does more to encourage Adam to articulate his understanding than do the questions in the previous example that could be answered with a simple yes or no. In this way, the animated medium as a tool provided insight about how PSTs might structure questions, which is important for knowing how to support the development of competent questioning.

Constraints

Although there were many affordances in using animations to capture PST noticing, there were also some constraints. While animations have promise in serving as an approximation of practice, they still do not constitute an authentic artefact of practice. MTEs can ask what PSTs *would* do in a given situation, but would need to actually observe them teaching to make claims or conclusions based on their enacted practices. The animations may give a better window into those actions than writing would, but it is still removed from authentic practice with a real classroom and real students. In addition, some of what made the animations engaging to create (using silly voices or super hero characters) may have simultaneously diverted time or attention from more substantial aspects of the work. It is hard to know if the PSTs would have spent the time they spent playing with the voices and extraneous software features in a more substantive way had those accessories not been available. Though each of these constraints may be minimized through a carefully planned use of the animation, the MTEs and PSTs mentioned specific limitations of the software itself that are addressed in the following section.

Limitations of the software. The software itself had several limitations. The program provides a fairly wide range of scenarios from which to choose, thus providing PSTs with some measure of creativity. In *GoAnimate* there were pre-designed scenes from which the PSTs could select their setting or they could create their own scenes. One constraint of the animation software was the ease of using these predesigned scenes. Often, the PSTs selected a scene with desks in rows and students at the desk. The availability of different classroom layouts was limited, so if PSTs wanted a different scene, they had to create it themselves, which required significantly more work. Knowing that certain contexts, or graphical background displays, were available while others were not, raised questions about how accurately the classroom design, more specifically—how the students are arranged--was a conscious choice of the PST and how often it was the result of ease of the technology. Further, limitations existed on the options for selected character voice tone within the animation.

While limited options provided a cap on the time PSTs spent on contextual factors of their animation, such limitations also serve as a constraint. First, we wonder whether the PSTs might not have been able to position sprites in the way they noticed or would have preferred. Second, we were limited in the analysis of the animation for specific focus such as positioning, teacher voice and wait time. Thus, the animation could be viewed as more of a rehearsal of pedagogical practices rather than as an authentic experience.

Figure 4. A commonly used predesigned classroom scene provided by GoAnimate (above) and one of the few instances of a PST designed scene (below).

A second, software-related constraint was the time involved to incorporate manipulatives or other visual supports into the animations. The choice of classroom resources available in the animations was narrow. The animation software did permit the creation of different manipulatives, however, this took a considerable amount of time to include, as compared to not including anything tangible. Further, some PSTs were unable to figure out how to include these representations. For example, one PST stated, "…I showed the student explaining how his group showed the problem. However, the animation did not include the students' physical work, which would have made it better. Their work along with their explanation is important." Another PST remarked, "My animation for the most part, depicts what I remember from the video as my chosen piece. However, I had problems figuring out how to show the final amount of cookies and how they were divided in the animation." As a result of comments such as these, questions remain about the extent to which the tools the animated students were using accurately represented the tools that students would use when in a real classroom context.

Loss of generalities. In addition to constraints related to the software itself, MTEs also noted the inability for PSTs to communicate more broadly what they noticed when animating. In the written reflections PSTs could broadly describe aspects of the classroom such as the teacher's effective use of questions to refocus student thinking without telling them the answer, however there was no means of making similar generalizations in the animations. As a result, the use of animation limited the MTEs' ability to discern *how* the PSTs were noticing. How the PSTs noticed referred to whether their responses described, evaluated, interpreted, or reflected upon their selected moment. The written responses allowed the MTEs to determine how the PSTs noticed because the PSTs could generally describe and discuss the moment from their perspective. In contrast, because the animations served as an approximation of practice in which the students and teacher in the animation were enacting a particular moment, the ability to determine how the PSTs noticed was lost. Take for example Hannah's written description of what she noticed.

> When the teacher facilitated a discussion with her class on what the word "equal" means, I thought this was pivotal because without her knowing that her students have that knowledge they may not be able to perform the task. It was important that the students realize "equal" means each person gets the same amount of cookies as everyone else with none left over and it was important the students were able to say that. She defined the word in the context of this specific problem.

Hannah's written response explains why she focused on the teacher's facilitation of a class discussion. Hannah's written work was coded as attending to the teacher (who), focused on general teaching strategies (what), and taking an interpretive approach to noticing (how). Her written response does not provide a lot of specifics related to the exchange, but allowed her MTE to understand why she found the discussion important. In contrast, her animation, necessarily, provided a very specific interaction among the children.

Teacher:	Ok class, when we cut something in half what are we looking for? What do we need?
Student 1:	Equal Parts.
Teacher:	We're going to look at the idea of having equal parts. When I say equal parts, what do I mean?
Student 2:	It means dividing the cookies to all eight people with nothing left.
Teacher:	So would I have more cookies than you, or you have more cookies than me?
Student 3:	No. No one has more than anyone.
Teacher:	Yes, that's what we mean when we say equal parts.

If we are to consider the animation apart from the written response, it is no longer clear why Hannah chose this particular exchange. Hannah's animated response was still focused on the teacher (who). However *what* Hannah noticed shifted from an attention to the general pedagogical strategy of defining a word central to the task's context to a focus on the particular meaning of equal parts. The MTE may have thought Hannah chose this moment because of the focus on equal parts or because she thought the teacher asked particularly meaningful questions. Without the written response, the MTE would not be privy to Hannah's attention to the teacher ensuring everyone has a shared understanding of equal in order to engage in the task. Therefore, although we see a form of Hannah's approximation of practice in the animation, the animation alone may not allow insight into the reasoning behind that practice.

The difficulty in communicating generalities in the animations suggests that coupling such activity with written reflections might further the MTEs' understanding of the PSTs' noticing and support future learning.

Discussion and Implications

In summary, the specificity of the animations helped the PSTs to focus on particular aspects of practical teaching such as classroom layouts, questioning skills, and making decisions about what to do next in a given situation. In particular, the use of animation allowed PSTs to attend to teacher and student responses in creating dialogue for their scenarios. Indeed, the impetus of using animation was to encourage PSTs to make a decision about how a teacher and his/her students would respond. This process required PSTs to think about the exact language each would use. In relation to noticing, PSTs had to attend to what was said, make interpretations about the dialogue, and then decide how both the teacher and students would respond. For example, if PSTs animated a scene about a fifth grade class and fractional understanding, the PSTs would have to think through what a fifth grade student might say.

According to Smith and Stein (2011), anticipating student thinking is an essential component of orchestrating productive classroom discourse. Aside from the animated mediums, PSTs often have opportunities to reflect on lessons, write reflections, and develop lesson plans. The animation supports these processes and provides a closer approximation of practice that necessitates conceptualization and articulation of what the teacher and students might say. Therefore, the animation encourages teacher noticing as defined by Jacobs and colleagues' (2010). This type of noticing involves making decisions about how to respond. With the animation, the PSTs must decide how sprites will react to each other and then animate the teaching moves that coincide with their understanding. In addition, the animations also allowed the MTEs to see the ways in which the PSTs positioned students and construed interactions in the classroom.

Similar to results of Amador and Weiland (2015), learning from noticing often requires the support of a more experienced other. The use of animation provides a window into PSTs' approximation of practice. Results of this study, however, suggest that without further probing and analysis of PSTs' decisions and their reflections on such decisions, animations alone may not give full insight into the context and content of their approximations of practice. The descrepency between PSTs' envisioned and animated practice may be due in part to the time required for PSTs to manipulate the software to include desired details. Further research on the use of animation to represent PST noticing as an approximation of practice to support learning of best practice is necessary to ensure MTEs support and maximize the learning of such opportunities.

In examining both the PST and MTEs' perspectives on the use of animation, it was clear there was much agreement in terms of both the affordances and constraints. Both the PSTs' and MTEs' reflections revealed that overall they thought the animations allowed the PSTs to accurately recreate their selected, pivotal moment. In addition, both groups thought the PSTs found the assignment engaging and enjoyed the freedom to recreate their moment in the way they saw fit. The MTEs also noted that the software provided essential information about what the PSTs notice and consider salient from a given classroom episode. In terms of limitations to the animation software, the PSTs' most frequent complaint was the lack of control over the classroom scene layout and/or characters' voice inflection and movement. Several of the PSTs noted that these limitations could lead to a less accurate portrayal of the classroom environment. The other primary constraint, also noted by MTEs, was the inability to include visual representations of student work. Several of the PSTs noted that the representations they were discussing were key to understanding the classroom discussions.

Similar to research findings for the use of video to support teacher learning (Estapa, Pinnow, Chval, in press; Santagata, Zannoni, & Stigler, 2007; Star et al. 2011, van Es & Star, 2005) animations also provide a space for PSTs to rehearse pedagogical practices. The written medium, guided by video, allowed PSTs to chart noticing they saw, both prompted and non-prompted. However, when animating the selected moment they drew on or from their own experiences and knowledge. Misconceptions of 'what' and 'how' this looks could be revealed in the animation prior to the PSTs entering the classroom. Further, the written work generated from video often included fewer details than the animation or was less specific. This resulted in written accounts that were more about broader aspects (i.e. classroom management or lesson concepts) as compared with the animation that often focused on student mathematical thinking. The written and animated mediums represented different levels of aggregation of ideas. It is important for MTEs to gain an understanding of how PSTs conceptualize the larger ideas to which the written medium affords this opportunity to a greater extent than the animated medium. However, when further analysis of PST noticing is desired at a more specific grain size findings from this study suggest animation is a tool to allow PST such noticing.

There are many possibilities for the use of animation in teacher education moving forward. For many MTEs, animations may provide a step towards exposing a clearer vantage point of the mathematical and pedagogical content knowledge of their PSTs, while illuminating what they notice (Jacobs et al., 2010). Animations might serve as one medium through which PSTs can work with MTEs in deconstructing practice. Through such work animations might allow PSTs to conduct rehearsals instead of or in addition to having in class rehearsals with their fellow PSTs. Further, MTEs could have PSTs participate in a noticing, animation, and reflection process on experiences from class, video segments, or instances in the field to support learning of best practice. Such practices could also assist MTEs with constraints of access and permission to video and share footage of elementary students in the actual classroom setting.

The future is similarly open regarding the use of animations to facilitate PSTs' noticing. Noticing, as is the case with many aspects of teaching, is enhanced with practice, experience, and support (Philipp, 2014). Therefore, providing opportunities for PSTs to engage in this practice through animated simulations presents a number of new opportunities for MTEs. Animations can potentially transform the ways in which we support PSTs' noticing. In spite of the software limitations and constraints the future potential for animations as a form of practice-based teacher education represents a ground breaking new direction for the field.

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