

Designing Reference Points in Animated Classroom Stories to Support Teacher Learners' Online Discussions

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Abstract: This paper investigates how critical events or reference points in animated classroom stories can support teacher learners' online discussions about their professional practice. Research has indicated positive impact of shared artifacts or reference objects such as video records of teaching practice on the quality of teachers' conversations in both face-to-face and online discussions. Our earlier studies also show that embedding animated classroom episodes as reference objects into virtual discussion spaces can help teachers produce highly meaningful and in-depth conversations about teaching practice. Yet, all moments in a video or animation are not created equal and it is important to understand whether particular moments (reference points) included in a single reference object attract more attention than others as subjects of conversation. While this issue has been studied in the context of analyzing face-to-face conversations among teachers, we have not come across studies that examine the connection between particular reference points and the quality of online postings referring to those. This paper reports on a preliminary study that indicates promising results of how reference points can help improve the quality of teachers' online discussions. For example, teachers made more evaluative comments and proposed more alternative moves of teaching when they referred to reference points than when they did not refer to reference points. This kind of studies are important because they can help the course designer better design or select shared artifacts to facilitate and stimulate group conversations.

Introduction

Online communication tools such as chat and forum have been heavily used to sustain collaborative learning in the last 20 years, both in academic teaching (Stahl, Koschmann, & Suthers, 2006) and in professional learning (Falk & Drayton, 2009; Fishman & Davis, 2006). Obviously, communication tools themselves are not sufficient to create viable conditions that can help students learn from each other productively. Without appropriate support, learners often go off-track during their online sessions, making their discussions hardly meaningful and developed (Collison et al., 2000; Gunawardena, Lowe, & Anderson, 1997; Larson & Keiper, 2002). For example, in many non-moderated online chats and forums in which shared artifacts of the learning subject are absent, it is very difficult for members of a group to understand one another's messages, to specify their ideas, and thus to be able to develop negotiation and construction of meaning (Carroll et al., 2005; Neale, Carroll, & Rosson, 2004). Researchers of online teacher education have pointed out the important role of shared artifacts such as video records of teaching practice, as *reference objects* (Wise, Padmanabhan, & Duffy, 2009), in stimulating and facilitating learners to notice, evaluate, and reflect on critical events of classroom interactions collaboratively (Rich & Hannafin, 2009; Zhang et al., 2011). Our prior work concurs, Chieu and colleagues (2011, in review) have shown that embedding animated classroom stories into chat and forum spaces can improve teachers' online discussions about instructional practice. The presence of animations in the forum space seems to enable participants to better engage in noticing, interpreting, and evaluating important features of teaching, in proposing alternative moves of teaching, and in reflecting on their professional practice.

By reference objects we refer to the whole artifact about the learning subject that is shared and referred among members of a group during their discussion (Chieu, Aaron, & Herbst, 2013; Chieu, Kosko, & Herbst, in review). Wise, Padmanabhan, and Duffy (2009) had referred to those as reference points, but we propose to reserve this term to define another crucial concept in online interactions with continuous media artifacts: Each reference object may contain many different *points* (e.g., specific moments in a video timeline or specific locations in a picture). We believe that not all points of a reference object are equally important but rather that reference objects sometimes include key reference points that are expected to support discussion and learning. Our research aims at examining how *reference points* (e.g., critical events in a video) can help improve the quality of participants' discussions. In a preliminary study (Chieu, Aaron, & Herbst, 2013) we found a positive effect of critical events of an animated classroom story on the quality of teachers' comments when they viewed and annotated an animation individually. In this paper, we further investigate how critical events of animated classroom episodes affect the nature of teacher learners' discussions in online forums. These critical events were key in the design of the animations: As we have explained elsewhere (Herbst & Chazan, 2003; Herbst & Miyakawa, 2008) animations were designed not only to represent classroom scenarios but also to breach some instructional norms. For instance, in an American high school geometry lesson the teacher is seen asking

students to construct the proof of a claim but not providing students with statements that clearly identify the givens and the conclusion to prove, as is customary in geometry classrooms—we call this a breach of a norm of how proof tasks are assigned. Animations were designed so as to include breaches of norms since we expected this feature might prompt conversations about practice. This expectation has been met in face-to-face encounters among experienced practitioners (Herbst, Nachlieli, & Chazan, 2011). The present study explores how the quality of contributions to online discussions depended on whether contributions referred to those critical events. The study of the effectiveness of reference points thus can help validate the inclusion of breaches in the design of artifacts to support collaborative learning.

Theoretical Framework

Our research is grounded in ideas from CSCL and teacher education. Firstly, meaning negotiation and construction in social contexts are important conditions to sustain collaborative learning (Vygotsky, 1978; Engeström, 1999). Indeed, collaboration between facilitators and students and among students may enhance intellectual development of each individual as well as of the group (Cunningham, Duffy, & Knuth, 1993; Knuth & Cunningham, 1993). More specifically, students are engaged in active understanding and use of knowledge, and in learning from each other's work and errors, in particular, from feedback of other members on each individual's work and errors.

Secondly, communication and collaboration technologies have been crucial means to support teacher learning in groups (Fishman & Davis, 2006; Rich & Hannafin, 2009). For instance, Tapped In (Farooq et al., 2007) and The Math Forum (Renninger & Shumar, 2004) have used different communications tools such as email, chat, and forum to build highly interactive environments that can help teachers ask questions, discuss problems, share ideas and solutions with peers, receive feedback from mentors, and so on, in growing and active communities. Although those communities have been successful mainly thanks to features such as moderating, mentoring, and coaching, they can be improved by embedding shared artifacts or reference objects into members' virtual discussion spaces (Chieu, Herbst, & Weiss, 2011; Chieu, Kosko, & Herbst, in review).

Thirdly, representations of practice such as video records of classroom interactions have been widely and successfully used as reference objects to sustain face-to-face group discussions in teacher education and development (Rich & Hannafin, 2009; Sherin, Jacobs, & Philipp, 2011). Teachers are engaged in viewing and discussing video-based artifacts of teaching, with assistance of facilitators, so as to notice important features of teaching practice and to evaluate, interpret, and reflect on those features collaboratively (e.g., van Es & Sherin, 2008). Recently, a number of studies (e.g., Wise, Padmanabhan, & Duffy, 2009; Zhang et al., 2011) have also indicated the effectiveness of reference objects in online group discussions. For example, researchers of STELLAR (Derry et al., 2005) and eStep (Hmelo-Silver et al., 2005) have found a positive impact of a collaborative white-board that teachers can use to co-create reference objects, link resources to those objects, and discuss those objects, hence helping them share and develop their understanding collaboratively.

Our research extends the literature described earlier in two ways (Chieu, Aaron, & Herbst, 2013): (a) we use animations, instead of videos and other forms of representations of practice, as reference objects, and (b) we examine how reference points, in addition to reference objects, can help improve the quality of group discussions. The use of animations to support teacher learning is relatively new (Herbst & Chazan, 2006; Herbst & Miyakawa, 2008; Herbst et al., 2011; Moreno & Ortegado-Layne, 2008; Tettegah et al., 2008). Yet, the use of stylized cartoon characters can support the creation of representations of instructional practice very flexibly (Chieu, Kosko, & Herbst, in review). For example, we have been able to create a number of critical events in which teaching norms (Herbst & Chazan, 2003) are breached. Also, to the best of our knowledge, it seems that researchers in CSCL have not conducted studies about how reference points help improve the quality of group discussions systematically. In this paper, we examine how important events of animated classroom stories affect teachers' evaluation and reflection on their professional practice when they are engaged in a virtual setting for mathematics teacher learning that we describe below.

LessonSketch: An Interactive Rich-Media Environment for Teacher Learning

LessonSketch (www.lessonsketch.org) is a web-based learning environment that supports practice-based learning for mathematics teachers (Herbst, Aaron, & Chieu, in press). Both teachers and teacher educators can use Depict, an authoring tool in LessonSketch, to create cartoon-based representations of teaching in the form of slideshows. Teacher educators can use Plan, another authoring tool in LessonSketch, to build online experiences for their teacher learners. Online *experience* is a key notion in LessonSketch. It refers to a set of consecutive activities that engage teachers in viewing, examining, creating, or discussing rich-media representations of teaching (Chieu, Herbst, & Weiss, 2011). Teacher educators may use a library of more than 50 animated versions of 18 classroom stories in secondary geometry and algebra teaching, which our research group has produced, as well as any other streamed video material, to build their own online experiences. A key feature of Plan is the capacity to create advanced discussion spaces for end users. For example, Figure 1 shows a forum space in which an animation with full playback control is embedded to stimulate and facilitate users' discussion.

We have applied a design-based research approach (Brown, 1992; Collins, 1992) for the design, development, and evaluation of LessonSketch. That iterative and self-correcting process has helped us identify and validate a number of operational design principles and improve the tools as well as the user interface of LessonSketch (Chieu, Herbst, & Weiss, 2011; Chieu, Kosko, & Herbst, in review). The advanced forum tool presented in Figure 1 is the result of that process after several iterations. In those earlier studies, we have examined the effectiveness of reference objects and validated a key design principle: embedding shared artifacts (i.e., animated classroom episodes) directly into discussion space to support users' exchange of ideas and development of understanding. In the next sections, we report on another study to provide more evidence for that design principle. In this study, however, we emphasize the role of reference points.

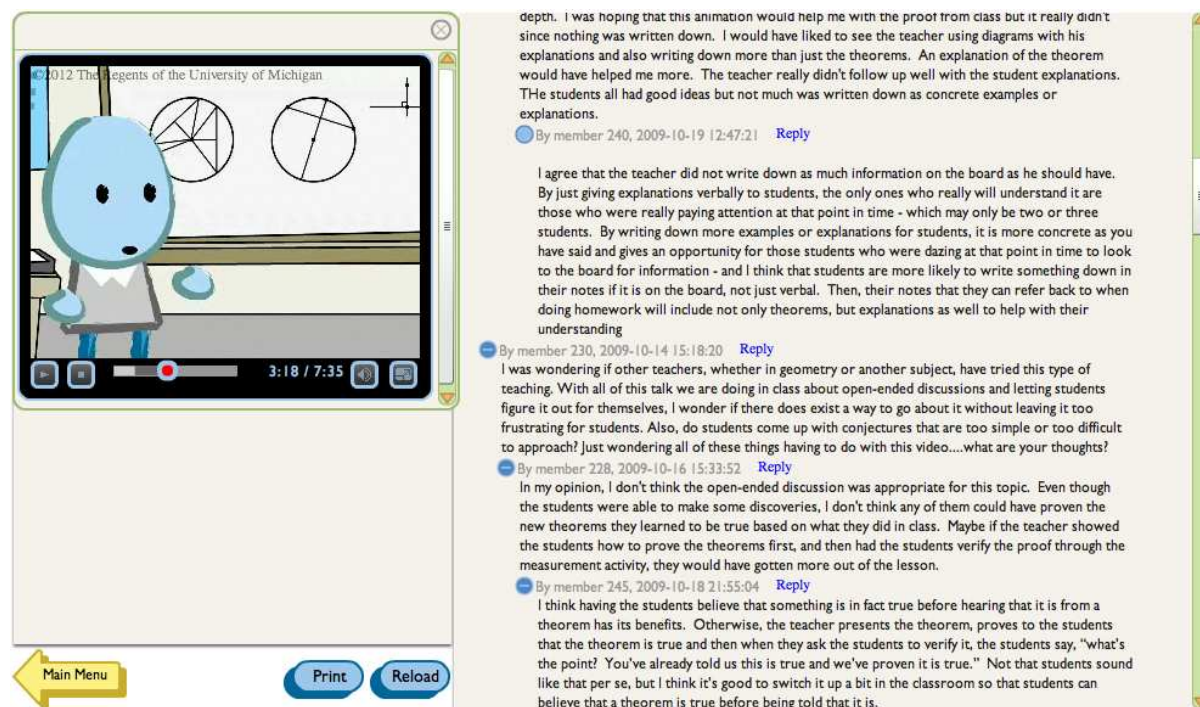


Figure 1. Advanced discussion space in which a version of “Chords and Distances” is embedded (users’ name is replaced with a system-generated id, in order to protect users’ identity).

Method

Research Questions

We use a method reported in earlier studies (Chieu et al., 2011, in review) to examine the correlations between whether and how users refer to embedded artifacts and what the qualities of their postings are. We use *Reference* (how a posting referred to the embedded animation) as an independent variable and *Evaluation* (whether a posting contains evaluative comments), *Reflection* (whether a posting contains a reflective comment), and *Alternativity* (whether a posting proposes alternative moves of teaching presented in shared artifacts) as three dependent variables. Verifying the presence of those dependent variables in users’ comments is crucial in collaborative and professional learning (Rich & Hannafin, 2009; Schön, 1983; Zhang et al., 2011).



Settings, Participants, and Procedure

We created eight online experiences for a one-semester class on geometry instruction in teacher education at a university in the East of the United States. Eleven pre-service teachers and ten beginning teachers (16 females and 5 males) enrolled in the blended course, making 21 participants in total (see Moore-Russo & Viglietti, 2011). In each experience, users first watched and commented on versions of animations individually, and then discussed those animations with peers in a non-moderated, asynchronous forum (see an example in Figure 1).

Data Collection and Analysis

We analyzed discussion logs of the stories “Chords and Distances” in Experience 3 and “The Square” in Experience 5 (watch those stories at www.lessonsketch.org). As mentioned previously, for each animated classroom episode we created a number of moments (i.e., reference points) in which one or more instructional norms are breached (see more details about how we created the animations in Herbst & Chazan, 2003). For example, Table 1 shows the main reference points of The Square.

Table 1: Critical events of The Square in which one or more instructional norms are breached.

Interval	Critical Event(s)	Breached Norm(s)
0:23 – 0:39	The teacher asks "what do you think happens with the angle bisectors of a quadrilateral?"	The teacher should pose a specific problem, which the provided one is not.
0:39 – 0:46	The teacher asks students to make conjecture and prove them.	The teacher should provide the givens and "prove" or the teacher should ask students to make conjectures only.
1:22 – 1:35	The teacher lets Alpha draw the diagram.	The teacher should provide the diagram (in doing proofs and in explorations).
1:41 – 1:46	The teacher criticizes Alpha's idea.	The teacher should encourage students who share their ideas.
1:50 – 2:01	The teacher asks the class to do a task based on Alpha's idea.	The teacher should provide the givens and prove. The teacher should choose the task that students work on.
2:05 – 2:11	The teacher repeats Alpha's words "cut the square in half."	Statements to be proven should be made using the diagrammatic register.
2:18 – 2:21	The teacher repeats Beta's words "the diagonals are also the angle bisectors."	Statements to be proven should be made using the diagrammatic register.
2:43 – 2:46	The teacher calls Gamma to the board.	The teacher should only invite a student to the board if s/he knows what the student is going to present.
2:50 – 3:17	The teacher lets Gamma generalize the square to the rectangle.	The teacher should keep the class on the task they were working on (the square).
3:27 – 3:32	The teacher repeats Gamma's point: "diagonals and angle bisectors are not the same thing."	Statements to be proven should be made using the diagrammatic register.
4:00 – 4:10	The teacher makes a strange inscription (in a  the ang. bis ) and asks students how would they prove something like that.	A proof problem should be stated in parsed form (Given-Prove) and using the diagrammatic register.
4:14 – 4:38	The teacher doesn't call Lambda to the board. The teacher doesn't remove one diagonal that Lambda requests.	Proofs are to be written in statements and reasons (the teacher is keeping Lambda away from any writing environment). Diagrams are supposed to have only the elements needed to do the proof.
4:50 – 4:56	The teacher doesn't enforce the diagrammatic register when Lambda uses conceptual language (isosceles triangle).	Statements in proofs are written using the diagrammatic register.
4:56 – 5:01	The teacher asks "Lambda, what are you trying to prove?"	The teacher should provide the givens and prove.
5:12 – 5:19	The teacher misunderstands what Lambda is talking about.	The teacher should enforce the students' use of the diagrammatic register when doing proofs.
5:29 – 5:45	The teacher reluctantly removes a diagonal according to Lambda's request.	The diagram should include only the elements needed for the proof.
5:56 – 6:02	The teacher doesn't correct Lambda's statements about "those triangles" and that "If you can prove congruent for one side you could prove it for the other."	Proof statements should be written in the diagrammatic register.
6:36 – 6:56	The teacher provides the givens and "prove" too late.	The teacher should provide the givens and "prove" at the beginning of the task.
6:56 – 7:10	The teacher asks for the proof of the statement after Lambda has spoken through it.	The teacher should have asked Lambda to write the proof in statement and reasons form earlier.

We consider that each forum post contains a single contribution to the discussion. So, we took the forum post as the unit of analysis. We used elements of Systemic Functional Linguistics (SFL; Halliday &

Matthiessen, 2004; Martin & Rose, 2007) to code forum posts. SFL provides the basis for an operational and valid approach with which researchers can analyze the content, context, and construction of a discourse. An important number of educational researchers have recently adopted SFL for content analysis (Schleppegrell, 2012). In our own work, SFL helped us identify, for instance, where and how users made evaluations of events in or reflections on an embedded animation (Chieu, Kosko, & Herbst, in review).

We reused the coding schemes of an earlier study (Chieu, Kosko, & Herbst, in review), which were validated by two independent coders, to assign values for *Reference*, *Evaluation*, *Reflection*, and *Alternativity*. Kappa statistics for all codes, which are greater than .45, suggest a moderate inter-rater reliability. For *Reference*, we distinguished three values, as follows: We assigned the value C when teachers made one or more references to critical events of the embedded animation (see examples in Table 1), the value S when teachers referred to one or more specific events of the animation but those events are not critical (e.g., teachers referred to a specific time code that is not presented in Table 1), and the value G otherwise (e.g., teachers referred to the animation in general). Table 2 shows an example of a reference to the critical event “The teacher doesn’t remove one diagonal that Lambda requests” at the interval 4:14-4:38 (see Table 1).

For *Evaluation*, we used markers of *affect* (indications of how teachers felt, e.g., like or dislike), *judgment* (indications of how teachers assessed characters of animations, e.g., nice or rude), and *appreciation* (indications of how teachers assessed actions in animations, e.g., engaging or boring), all of those founded on an SFL-based appraisal theory (Martin & White, 2005), to identify where teachers made evaluative comments on teaching practice. These codes helped us decide whether a post contained *Evaluation* (coded 1) or not (coded 0). The post presented in Table 2 contains *Evaluation*, because of the presence of an affect marker (like) and an appreciation marker (the teacher’s action of not changing the diagram confused some students).

Table 2: Analysis of a forum post in the discussion of The Square (we underlined pieces of the post and added codes in brackets and in capital letters right after those pieces of text).

I like [EVALUATION] your comment because [REFLECTION] I also wondered why the teacher never really made sure that the whole class understood the proof with one diagonal. At first the teacher did not even change the diagram while the student was explaining their proof [C REFERENCE]. This seemed to have confused some of the other students [EVALUATION] because [REFLECTION] the one student was talking about one diagonal and the drawing had two. I agree that the teacher should have had the students discuss why they were using one diagonal instead of two more [ALTERNATIVITY]. It may have also been useful if the teacher wrote down the steps of the proof that the one student was saying [ALTERNATIVITY]. It may have made it easier for the other students to follow.

For *Reflection*, we considered the presence of markers of manner and causal-conditional enhancements in comments on instructional practice as evidence of logical reasoning or thinking about thinking, and therefore evidence of reflection (coded by 1, otherwise by 0). Causal-conditional enhancement (e.g., if then, provided that, because) qualifies clauses through variations of logical connections. Manner enhancement (e.g., by means of, and thus) modifies clauses through comparisons or means. The post shown in Table 2 contains *Reflection* due to the presence of two markers of causal-conditional enhancement.

For *Alternativity*, we looked at participants’ proposal of teaching moves that should or could or would have been taken as alternative actions in the animation (coded by 1, otherwise by 0). We counted when participants used modals (e.g., should, could, would) in reporting actions, or potential mood (e.g., students would prefer another problem), or subjunctive mood (e.g., if the teacher had given another problem), or negative mood (e.g., the teacher did not provide a diagram to the students). We coded the previous post as 1 for *Alternativity* because of the use of modals (should) and subjunctive mood (if the teacher wrote down the steps of the proof).

An earlier study (Chieu, Kosko, & Herbst, in review) had shown that the use of different animated classroom episodes did not seem to affect the quality of teachers’ conversations over the semester. That is, the dependent variables of interest (*Alternativity*, *Reflection*) did not seem to depend on which animation was being discussed or when in the semester the discussion occurred. Thus, we aggregated the codes of all posts of the two discussions and used logistic regression models to examine the correlations between *Reference*, as an independent variable, and *Evaluation*, *Reflection*, and *Alternativity*, as three dependent variables.

Results and Discussions

Overall, we coded 89 forum postings of the two discussions. There were 36 postings referring to critical events, 11 postings referring to specific but not critical events, and 42 postings not referring to critical or specific events. Table 3 shows the difference between when participants made reference to critical events and when they did not make reference to critical events (i.e., they referred to specific or general events that are not critical). Results in Table 3 can be interpreted, for the case of evaluation, as follows: A post that did not contain reference

to critical events had a 60.3% probability of including evaluation. Yet, if a post did contain reference to critical events, then the chance of including evaluation improved to 94.4% ($p < 0.01$, effect size or odds ratio = 11.2). In other words, the odds of a post including evaluation if it contained reference to critical events was 11.2 times higher than the odds of a post including evaluation if it did not contain reference to critical events ($p < 0.01$). The other dependent variables also show similar trends.

Table 3 indicates evidence for a positive impact of reference points on the quality of teachers' discussions. In an earlier study (Chieu, Kosko, & Herbst, in review), however, we had found similar results of the impact of referring to specific (not necessarily critical) events in the embedded animation on the quality of participants' conversations. Results of the analysis of the two discussions described earlier (see Table 4) also reconfirm this claim. This could mean that making reference to specific events itself may be sufficient to improve the quality of teachers' discussions. The number of specific but not critical events was too low in these two discussions to warrant a comparison. Thus, we leave that for a future study. We note, however, that when participants made references to specific events they referred to critical events (77%) more frequently than non-critical events (23%), and the difference was statistically significant (two-tailed p -value < 0.05).

Table 3: Difference between referring to critical events and not referring to critical events.

Dependent Variables	Probability of a Post Containing the Dependent Variable When the Post Did Not Refer to Critical Events	Probability of a Post Containing the Dependent Variable When the Post Did Refer to Critical Events	P Value	Effect Size
<i>Evaluation</i>	60.3%	94.4%	$p < 0.01$	11.2
<i>Reflection</i>	60.3%	80.5%	$p < 0.05$	2.7
<i>Alternativity</i>	56.7%	86.1%	$p < 0.01$	4.8

Table 4: Difference between referring to critical or specific events and referring to general events.

Dependent Variables	Probability of a Post Containing the Dependent Variable When the Post Did Refer to General Events	Probability of a Post Containing the Dependent Variable When the Post Did Refer to Specific or Critical Events	P Value	Effect Size
<i>Evaluation</i>	52.5%	93.6%	$p < 0.01$	13.3
<i>Reflection</i>	54.7%	80.8%	$p = 0.01$	3.5
<i>Alternativity</i>	52.5%	82.9%	$p < 0.01$	4.4

Concluding Remarks

Reference objects such as video records of practice, animations, and pictures have played an important role in supporting collaborative learning. It would be even more crucial in online contexts in which it is very difficult to help group members stay focused and productive throughout a discussion session (Collison et al., 2000; Larson & Keiper, 2002; Gunawardena, Lowe, & Anderson, 1997). Obviously, not all reference objects have the same impact on the quality of group conversations. The course designer would still need to devise shared artifacts that are meaningful and useful to a group of learners. Sometimes the course designer would have to cut and select, for example, short and generative clips of long and unedited video records of practice for use in educational settings (van Es & Sherin, 2008; Zhang et al., 2011). We believe that there are important elements of a single reference object that could be subject of interest in learning sciences in general and in CSSL research in particular. Thus, we have introduced and examined another important construct: *Reference points*, as critical elements of a single reference object (Chieu, Aaron, & Herbst, 2013).

In this paper, we take critical events or moments, in which instructional norms are breached, of animated classroom episodes as reference points. We show preliminary evidence for a positive impact of critical events on the quality of teachers' conversations. For example, teachers made more evaluative or reflective comments and proposed more alternative moves of teaching when they referred to critical events than when they did not refer to critical events, which may help them produce highly meaningful and in-depth exchanges of ideas, and thus learn from one another about professional knowledge and skills. This finding would be beneficial for the course designer in the process of creating or editing shared artifacts for group discussions. In the future, it would be important to categorize reference points further (e.g., to identify different kinds of breaches) and to investigate the effectiveness of each category to inform of instructional design better. It may also help the moderator or facilitator of groups of learners better organize and sustain discussion and collaboration; for instance, during a discussion session s/he may frequently invite students to look at and talk about critical events, and sometimes ask them questions such as "What do you think of this event?" "What would you do if you were the teacher?" "Why would you do that?" so as to engage them in evaluating and

reflecting on their professional practice. Studying whether this type of intervention by the moderator or facilitator could improve the quality of group discussions further would be valuable as well.

By including in a video recording moments in which teaching norms are breached, designers can create reference points. There may have other ways to do so for the same reference object or for different kinds of reference objects, depending on the course designer's goals for the discussion session. For example, for animations or video records of practice one may include and emphasize moments in which student thinking is predominant as critical events if s/he wants teachers to develop the ability to notice and interpret student thinking. For the kind of picture media such as an image of student work, reference points could be specific locations in the image in which the student made an error or had an interesting idea.

Finally, cartoon-based artifacts such as animations and image sequences seem to have advantage over other types of media in representing practice, especially when considering the flexibility to create and edit reference points for use in educational settings. For example, it is much easier to produce animated videos that include moments in which teaching norms are breached than to find those breaches in video-recorded lessons.

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