

Studying Professional Knowledge Use in Practice  
Using Multimedia Scenarios Delivered Online

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Abstract

We describe how multimedia scenarios delivered online can be used in instruments for the study of professional knowledge. Based on our work in the study of the knowledge and rationality involved in mathematics teaching, we describe how the study of professional knowledge writ large can benefit from the capacity to represent know-how using multimedia representations of practice and alternatives to it. These instruments can be used to study what professionals notice and decide to do in practice in ways that improve upon earlier uses of written representations of professional scenarios or videorecorded episodes. In particular, storyboards and animations of nondescript cartoon characters can be used to explore professional knowledge variables systematically while the multimodal representation of human activity in context ensures the face validity of questions.

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## Studying Professional Knowledge Use in Practice Using Multimedia Scenarios Delivered Online

### Introduction

We describe the potential that rich media authoring and internet delivery have to transform research on professional knowledge. We are particularly interested in professional knowledge from professions whose practice involves relating to people and relying on knowledge that is often tacit; following Cohen (2005), we refer to those as *professions of human improvement*. Teaching mathematics is both a key example of a human improvement profession and the area where we ground our work; others human improvement professions include clinical medicine, legal counseling, ministry, and psychological therapy. With somewhat similar meaning, Grossman and associates (2009) have written about *relational practices* including counseling, ministry, and teaching. In all of those professions, some precise technical knowledge (of biology, law, scripture, subject-matter, etc.) is involved but is not sufficient; competence relies crucially on a relational know-how: Practitioners often have to come up with appropriate ways to address and relate to their clients, they have to use judgment in setting goals and matching them with means, but their actions are contingent on what their clients do. In these professions, action requires know-how whose validity rests not so much on physical laws, but on sociotechnical activity norms and professional obligations. Changes in the scale of demands for service (e.g., more human services are needed than in prior generations) and in standards for professional practice (e.g., clinicians are now expected to educate patients and involve them as agents in their recovery in addition to diagnose and treat them, teachers are expected to devolve to students responsibility for their learning and make instruction more student-centered), in professional credentialing (e.g., professional schools are increasingly expected to develop and assess professional skill rather than merely select smart people or transmit academic knowledge), and in performance standards (e.g., there are increased demands of measurement and attention to effectiveness in education, patient satisfaction in medical care, etc.) have created a practical need to identify and describe such know-how, and to improve it as part of the work of improving professional practice (Gilliam and Frede, 2012; Kominski, 2013).

From the perspective of human service professions that at some point need to distinguish some ways of doing things as knowledgeable and disseminate those ways of doing things as best practices to new generations of professionals, it seems important to ground such axiological and pedagogical work in descriptions of actual professional practice rather than on general values or orientations. It therefore seems essential to do research that unearths and describes the knowledge implicit in actual practice as a step toward the development of more prescriptive professional discourses. This is more preferable than the development of visions of best practice that are disconnected from actual practice because a grounding in actual practice can maintain the project of professional improvement within the realm of the possible, as piecemeal improvements that build on

existing structures or that adapt existing practices (Tyack, 1995). Considering this descriptive question (to identify the knowledge) as fundamental, we follow Buchmann's (1987) practice of speaking about *teaching knowledge* rather than *teacher knowledge* and generalize it to talk about *professional knowledge* rather than *professionals' knowledge*. It is likely that professionals hold at least part of that knowledge individually while other parts may be embodied in group activity structures (Cook and Brown, 1999), but at this stage it is less important to gauge the extent to which individual professionals have more or less knowledge than their peers than to consider professionals as key informants on the nature of the knowledge of their profession. While professional knowledge may be explicit or tacit, individually or group held (Cook and Brown, 1999), it is important to identify this knowledge, and describe what it is and how it functions in order to be able to design and test ways of improving it.

One way this professional knowledge can be described is in terms of the norms, obligations, and resources for professional practice. We have elaborated on these constructs in other pieces (e.g., Herbst and Chazan, 2012) in the context of our approach to the study of the practical rationality of mathematics teaching. This approach attempts to combine tacit expectations (norms) of the role professionals play in the professional situations they participate in, more explicit general demands (obligations) that characterize their professional position vis-à-vis the expectations of its stakeholders, and more personal characteristics that account for individual differences in competence and style (e.g., knowledge, skills, beliefs, etc.). Our theory accounts for professional practice as the execution of actions that for the most part satisfy the norms of situations, peppered by occasional actions that depart from such norms in ways that are justifiable by recourse to obligations. This approach permits the reconciling of considerations of individual uniqueness and free will with the social and professional pressures to conform to customary patterns of interaction.

As a contribution to the improvement of professional practices, our account of practical rationality locates two possible levers for improvement (changes in personal resources and changes in situational structures) and it describes the process of enacting improved instruction as the enactment of justifiable breaches of norms or the adaptation to new, justifiable norms (in new professional situations).

Our use of the word *norm* tries to capture the sense to which recurrent professional practices rely on expectations for action. We use the word *norm* along with other scholars (e.g., Pepitone, 1976) where others have used *rules* (e.g., Much and Schweder, 1978; Taylor, 1993) or *routine actions* (e.g., Garfinkel, 1964). While those uses may be distinguished when considered in greater depth, for our purposes, we take them as similar and oriented to the description of socially expected patterns of action, that an observer represents in a law-like proposition. Unlike the instructions of a computer program, however, norms do not dictate action; instead, not only action follows from norms, but action also transforms norms, for example by elaborating their circumstances of use (Taylor, 1993, p. 56). Practice is irreducible to rules inasmuch as practitioners construct their existence coping with the stuff of life in ways that do not deliberately follow rules; but practice can be described *as if* it was governed by a set of norms that regulate

performance retroactively: Validating (as meeting or not meeting expectations) a range of possibly different ways of doing things; these norms are for the most part tacit, but become apparent when breached (Garfinkel, 1967; Mehan and Wood, 1975). We believe that such a notion of norm manifests itself not in the recurrence of observable behavioral regularities but in the existence of repairs to behaviors that breach expectations (see Rouse, 2007), can help account for the concomitance of, on the one hand, the original experiences lived by individual practitioners and, on the other hand, central tendencies of members of professional groups to act in ways that resemble each other. To investigate professional knowledge we consider it important to account for professional situations and their norms.

Thus our account of practical rationality, pivoting on that notion of norm, asserts a position that differs from individualist and deterministic accounts of professional action: Neither original expression of self nor blind execution of rules, professional action is constructed as agents create unique, justifiable responses to norms of situated activities. We have taken the liberty to explain what we mean by norm and why they matter in the investigation of professional knowledge because such conceptualization has important methodological consequences that take us directly to the focus of this paper in the context of this special issue. The question is, How can researchers ground empirically the notions of norms and obligations? While case study work (including ethnographic observation and interviewing) has served to develop these theoretical ideas, the empirical grounding of the theory has required us to consider what sort of instrument might allow the aggregation of data that could be used for proposing and testing conjectures about the rationality of practices. We will show how multimedia online questionnaires have supported such effort for the case of understanding tacit professional knowledge of practicing mathematics teachers.

#### Three Background Techniques: Observation of Intact Settings, Survey of Practitioners, Breaching Experiment

Three canonical techniques from social science research are in the background of our discussion. Our present conception of multimedia online questionnaires has been a way of overcoming the difficulties those techniques present in the work of accruing data to test hypotheses about norms in the practice of mathematics teaching. The first of these techniques is the observation of professional behavior aimed at detecting behavioral regularities. The second is the survey of professionals aimed at obtaining their recognition of descriptions of norms or obligations. The third is the ethnomethodological breaching experiment.

The researchers associated with the TIMSS Video Study (Stigler and Hiebert, 1999) have shown how the observation of professional behavior can lead to documenting regularities in teaching, that they labeled *teaching scripts*. Teaching scripts are “a commonly accepted and predictable way of structuring a classroom session and sequencing the instructional activities” (Stigler and Hiebert, 1999, p. 127; see also Santagata and Stigler, 2000; Santagata and Barbieri, 2005) and claimed that these teaching scripts differ across cultures. One possible way to document norms in teaching could be the observation of

such regularities in intact lessons. The observation of intact lessons seems particularly fruitful as a source for the comparison of large grain size differences among teaching across different cultures (e.g., the presence of activity types or the order among classroom segments describable after particular activity types). But to examine the phenomena we've called norms is more challenging. While the proposition of teaching scripts relies on recurrence of behavioral observations, the proposition of norms relies on the recurrence of participants' expectations of actions; as Mehan (1979) showed, classroom observations can be the source of empirical material for such work, but it calls for more detailed examination, for example the recurrent observation of a single teacher across the year. In addition to the lack of independence of the observations, the norms observed (in Mehan's case, the I-R-E recitation pattern) are still of a grain size larger than what we would want.

A second technique of interest could be described in general as a self-report survey of teaching practices, used frequently in large-scale studies. For example, Smith, Desimone, and Ueno (2005) used selected items from the NAEP Teacher Questionnaire that could help understand the characteristics and frequency of teachers' practices related to teaching conceptually or procedurally. The items used to measure the extent to which teachers used conceptual teaching strategies asked teachers for the frequency of practices stated in general (e.g., "how often students... talk to the class about their mathematics work"). While this type of self-report instruments can achieve reliability and validity as measures of instructional practice, they describe practice as depending on general principles that the respondent must recognize explicitly. The extent to which practice responds to such general rules has been questioned (see Finch, 1987). In our own attempts at using this kind of instruments to measure teachers' recognition of norms for the presentation of proof problems in the teaching of high school geometry, reliability was low when the practices were smaller in grain size but described at similar level of abstraction (see Herbst, Kosko, & Dimmel, 2013).

The third technique is what ethnomethodologists called the *breaching experiment* (Garfinkel, 1967; Mehan & Wood, 1975), which uses the word *experiment* in the sense of an instance in which the phenomenon is shown (as in Francis Bacon's *crucial experiment*) rather than in the sense of random assignment of participants to conditions. Ethnomethodologists' interest in understanding the tacit order beneath routine practices is fulfilled by proposing defaults or hypotheses about ways of doing things that go without saying. These hypotheses are verified through immersing participants in instances of those practices where some of their underlying defaults are flouted, and observing how participants repair (i.e., notice, elaborate) the alteration of the normal situation. In our earlier work we had drawn inspiration from that approach to examine qualitatively the video records from teaching interventions (Herbst, 2003, 2006).

The three described techniques have been in the background as we sought to develop means to study the practical rationality of mathematics teaching. We describe these means chronologically: While we have ended with online multimedia questionnaires, we consider worthwhile to start from where the journey began.

## Thought Experiments

Heidegger notes that the skill in coping with the demands of equipment (seen broadly to include any instrument of being) becomes apparent in cases of disruption (Dreyfus, 1991). Consider the voice of the practitioner as one such instrument and imagine for a moment that we could take momentary control of the voice of a practitioner, effectively making him or her say something that, hypothetically, breached a norm, for example making the practitioner state an algebra word problem about vehicle encounters without providing any numbers. After the practitioner states the problem in that way, they regain control of their actions. We could expect a range of repairs: a rejection of the situation (e.g., I don't know what happened to me; let me give you another problem), overt recognition to the students (e.g., this problem is different than what you are used to) or subtler suggestions (e.g., how could you represent the velocities of these cars?), etc. In many ways, when some researchers started doing "first person research" (Ball, 2000), by becoming classroom teachers themselves and recording their practice (Ball, 1993; Chazan, 2000; Heaton, 2000; Lampert, 1985, 1990, 2001) they were engaging in a feasible and more ethically defensible version of that thought experiment. They went into the classroom with goals to create novel classroom dynamics and to understand from the inside (observing student reactions as well as their own, as recorded in journals) what it felt to teach in that way, thus documenting the kinds of teaching problems and opportunities that come to the surface when the norms of instruction are changed. Herbst (2003, 2006) use of *instructional experiments*, a design experiment that induced perturbations on the natural variability of teaching through curricular choices present in replacement lessons or units pursued similar goals.

Motivated by the goal in the education research community to move education research toward the gold standard of experimental research (Towne and Shavelson, 2002), we posed to ourselves the question of how could research on the norms and dispositions of teaching be done at scale (see Herbst and Chazan, 2011, for bits of history of the Thought Experiments in Mathematics Teaching project that started in 2002). We envisioned at the time that the Internet could help create and deliver vicarious experiences for teachers where they could be immersed in a breaching experiment and that their response could be tracked in ways that might help understand the practical rationality of mathematics teaching. But we had to proceed in stages to maintain our capacity to recognize the data when we saw it.

### Designing a Technique to Study the Norms of Instructional Situations

Our first approach to a virtual breaching experiment was offline, but included as a main component the notion that one could virtually immerse practitioners in an instance of a professional situation, by showing them a representation of that situation. First, we used video records of lessons where the teacher<sup>2</sup> had flouted a norm of classroom interaction

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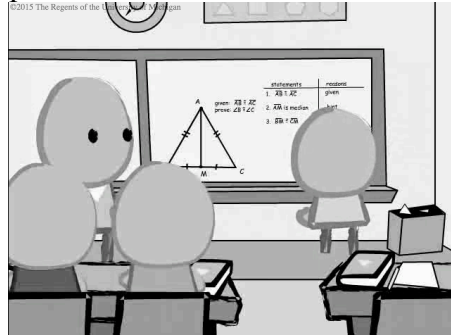
<sup>2</sup> It is worth noting that in some of the key sessions used in this work, a researcher taught the lessons that breached existing classroom norms.

(see Herbst and Chazan, 2003; Nachlieli and Herbst, 2009). We collected conversations among participating teachers about the teaching they had observed. We analyzed those conversations and enriched our understanding of how teachers might repair instruction that breached a norm (Nachlieli and Herbst, 2009) as well as to further develop the theory, observing that practitioners might see breaches of norms as justifiable (Weiss, Herbst, and Chen, 2009), which led to our proposing of the notion of obligation described above.

By the time we were collecting such video footage for use with focus groups of teachers, in the early 2000s, digital video and software to edit it had become more widespread. With these it became possible for people like us to treat video and audio footage not as a record of a single event but as a collection of expressions in a multimodal language whose parts might be combined in different ways to tell different stories and possibly prompt different conversations. Clearly the notion that film recording and editing is a language was not new (Metz, 1974), but reaching the technical capacity to play with that language ourselves was important in terms of exploring its capacity to instrument research (as opposed to merely tell a story). We could therefore think about possibilities such as, (1) if instead of having a video segment in one location of the timeline, we put it elsewhere, or replaced it with another, or (2) if an audiotrack was replaced with another, how could the viewers' responses change? It also became possible to represent instructional practice (e.g. a lesson) as a series of decisions and moves--for example by combining footage from different cases of teaching the same lesson plan into a same timeline that represented the set of possibilities afforded by a lesson. These realizations produced several artifacts and data collection trials, but the most important outcome had to do with realizing the need to push further into thinking of the need for a graphical language to create representations of professional practice. While it was thinkable that footage from different versions of a lesson could be combined to tell a story of a conceivable new version of that lesson (and hence elicit practitioners' commentary about practice), surface features (e.g., changes in clothing from one day to the next) or contextual features (e.g., the two sources of footage being from different classes) conspired against the face validity of the achieved representation. While practitioners could see the practice through its video representation, the representation itself was done in a language that visually conspired against that sense of presence. We realized the need for a more malleable visual language that could still capitalize on the multimodality and temporal nature of video.

In parallel with our collection and analysis of teacher focus group responses to video records of lessons, we secured resources to create animations of teaching scenarios that might help expand our scope of work. We were quite aware of the problems of using video to representing generality in teaching practice (Chazan and Herbst, 2011) and were looking for ways to control how much a representation of practice also constituted a representation of the social and individual context in which the practice was deployed. After some experimentation with three-dimensional characters, our hunch was that nondescript, two-dimensional, cartoon characters could help represent practice, and hence prompt practitioners to disclose the rationality of practice, without encouraging explanations that reduce human doings to the mental states of the individuals involved

(see Figure 1; also Herbst et al. 2011). We also expected that the use of the same set of non-descript cartoon characters could enable combinations of footage in the service of multiple representations of practice.



*Figure 1.* The ThExpians B character set enacting a geometry instruction scenario (© 2015, The Regents of the University of Michigan, all rights reserved, used with permission)

We thus developed animations of classroom scenarios, where teacher and students were represented using nondescript cartoon characters and human actors performed the voice track (Herbst, Nachlieli, and Chazan, 2011). Not being limited to finding or recording video, we could script lessons so as to control what norms of the practice being studied would be breached. We used these with focus groups of practitioners who were experienced in teaching the content represented in the animation. As in the case of video focus groups, conversations had an open agenda where teachers discussed what they cared to discuss about the media (Nachlieli, 2011). In spite of the simplified nature of the graphics, practitioners have shown that they can talk about the practice represented as if it was a case of actual practice, for example being able to project their circumstances onto the animation (Chazan and Herbst, 2012). Both videos and animations have been effective in eliciting participant commentary about norms of instructional practice. In particular, in a study of the discourse employed by teachers discussing them, animations performed just as well as video in eliciting participants' statements about norms of professional practice, as measured by participants use of the modality resources of language; but animations were better than videos in eliciting modal statements of the normativity type (e.g., *should*; Herbst and Kosko, 2014). At the same time that we examined the data from focus groups, we also started developing the infrastructure to take this research approach to the internet—exploring whether and how the animations could elicit similar kinds of noticing and reflection when delivered online (Chieu, Herbst, and Weiss, 2011).

The notion of a *multimedia online experience* was developed to name the genre of activity that we recruited participants for—a cross between a survey and a media enhanced interview or focus group. Research participants might be individually asked to inspect a piece of media, make comments on the timeline of the media, or answer questions about the media; they might also be ushered into a chat or forum and discuss the media or the questions with other participants. An online experience thus meant to use the Internet to instrument and thus enhance the technique of using representations of practice to elicit professional knowledge. In particular it could be used to revise and



hopefully improve the virtual breaching experiment technique. It added to the notion that animations of nondescript cartoon characters could immerse viewers in a breaching experiment: It added the notion that this immersion could be done online, with many individuals having potentially the same experience. Our initial multimedia experiences have shown heavy engagement with the practice represented as evidenced in the proportion to which forum postings refer to events in the animations (Chieu and Herbst, 2013).

The initial multimedia online experiences used animations of classroom scenarios that we had scripted and directed but whose technical realization had required the work of digital artists. As a result, the authoring of a multimedia online experience was much less flexible than the authoring of a text-based survey. But in parallel we had developed *Depict*, a storyboarding tool that enabled the composition of scenarios by dragging and dropping cartoon characters on to a canvas (see Herbst and Chieu, 2011). The *Depict* tool had originally been thought as a piece of software to communicate internally about stories that needed to be animated (easing our scripting process) but we started thinking of *Depict* as a tool to author the scenarios that research participants would see and respond to: If the data was comparable to what we could get with videos and animations, storyboarding with cartoon characters brought two important affordances. On the one hand, storyboarding, unlike animating, is something researchers can do and so scenario-development can be a much more interactive process. On the other hand, the storyboards being xml files, their online delivery is much less affected by computing power and connectivity than video or animations are. In what follows we elaborate on several methodological entailments of the decision to use storyboards as the media in online experiences.

### Reproducing Data from Virtual Breaching Experiments through Multimedia Online Experiences

After piloting the notion of a multimedia online experience using animations (Chieu, Herbst, and Weiss, 2011), and realizing the need to integrate *Depict* into the fold of research tools (see Herbst et al. 2011), Herbst, Chazan, and Chieu designed and developed the online platform *LessonSketch* ([www.lessonsketch.org](http://www.lessonsketch.org)) to author and deliver multimedia online experiences. The platform combines facilities found in media authoring and archiving software, media playing and annotating software, questionnaire editing, delivering, and reporting software, and learning content management systems. Its facilities can be used not only by researchers but also by professional developers and by professionals themselves (see Herbst, Aaron, and Chieu, 2013; Herbst, Chieu, and Rougée, 2014) though in this paper we are only discussing the methods and technology developed for research on teaching knowledge elicited from practicing teachers.<sup>3</sup> While

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<sup>3</sup> *LessonSketch* is a platform that can be used for professional learning and a description of its affordances as such a platform would need to discuss its genealogy in relation to the vast literature on computer based learning environments generated over the last two decades (e.g., Grabinger and Dunlap, 1995). The present piece, however, is about the multimedia online questionnaire as a research technique and how *LessonSketch* supports its deployment.

creators of multimedia online experiences could rely on found videos or on our suite of animations as they author multimedia online experiences, *Depict* allows them to create their own scenarios very easily. *LessonSketch*'s *Plan* tool allows researchers and developers to author agendas for experiences by dragging functionalities (such as *Media Show* or *Question*) and dropping them onto a canvas that represents the sequence of screens the end user will see (see Herbst Aaron, and Chieu, 2013). Aided by *Plan*, researchers create agendas (i.e., questionnaires) that they then use to put together experiences<sup>4</sup> (i.e., administrations of a questionnaire) they share with research participants.

We have used the facilities of *LessonSketch* to create and deliver multimedia online experiences to hundreds of participants, so far mostly for instrument development. The data collected has shown to be usable in the sense that in addition to responses to close-ended items it does produce commentary of quality comparable with that of the participants' discourse in our animation and video based focus group. These multimedia online questionnaires are thus a new generation of virtual breaching experiments.

### Some Issues of Instrument and Research Design

#### Instrument Design

By using storyboards in multimedia online experiences we have not had to depend on finding video records of a teacher breaching a norm of an instructional situation or on developing a high end animation. To research teaching knowledge one can deliberately choose specific instructional situations and, within those situations, chose specific norms to study via designing scenarios that breach that norm. The design of those scenarios still requires some unique skill (i.e., the capacity to represent practice using dialogue, inscriptions, and observable behavior), but it seems that both technically and technologically we are much closer to being able to investigate practitioners' recognition of specific norms. As we do that, we have come to realize that the design space has some texture that we need to be aware of.

It is important that scenarios do not depict the moment alone when a breach happens unless such moment is one that practitioners would unproblematically recognize as separable from the stream of experience. Rather, if a storyboard includes both moments when norms are flouted and moments when norms are complied with, researchers can include contrast questions: As Dimmel and Herbst (2014) have shown, in an instrument that explored semiotic register norms concerning what teachers expect from students, the scenarios were long enough that in addition to asking general descriptive questions, participants were asked to comment on the appropriateness of two different segments of the scenario—one where the breach was included and one where there was no breach.

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<sup>4</sup> An experience consists of one or more agendas and a set of parameters including the dates when the experience is available, the means of access, prerequisite experiences, etc. In *LessonSketch*, the *Experience Manager* tool allows the configuration and delivery of experiences.

An insight from ethnomethodology is that participants in a situation are mutually accountable. This insight we have used originally in our research to expect that participants will repair breaches as part of the process of talking about the scenario. But it also applies to the scenarios themselves. Namely, teacher and students help each other make sense of the situation in which they are. Authentic representation of scenarios where one norm has been breached, especially to the extent that the scenario continues beyond the breach, would then call for representing what happened after, and this would expectably include some element of accountability (e.g., if the teacher breached a norm in how she presented a problem, they themselves might repair it for the students or the students might repair it with a question or comment). Clearly, the creation of a scenario requires many more decisions than that of breaching a norm. It is quite possible that a scenario might have, in addition to the breach called for by the research interest, other breaches that just help the story be compelling. To the extent that an instrument will provide analytic leverage on the problem of whether and how a norm operates in a situation, it is thus important to include not only items that breach a norm but also items that represent a balanced array of consequences of that breach, including breaches that are repaired in the scenario and breaches that are treated as unproblematic in the scenario.

The norms that are breached may apply to strategic or tactical actions. By strategic we mean actions that are done to pursue an objective after which the whole situation has been deployed. Tactical actions instead are actions that are done to handle a circumstance that presented itself once the situation has been deployed. The distinction between strategic and tactical not only gives language to describe how participants might account for breaches of norms, but also because it helps design how to study the norms for how the teacher might respond to students' work. We have seen through our work that creating items that probe strategic norms is somewhat easier than creating items that probe tactical norms. For example in creating items that probe norms about how a teacher responds to the ways in which students solve equation tasks, several contingencies needed to be considered in making the scenarios: (1) that the teacher would respond normatively to students' normative answers, (2) that the teacher would flout the norm (i.e., repair) when responding to students' normative answers, (3) that the teacher would not repair a student's breach of the norm, and (4) that the teacher would repair a student's breach of the norm. In here the tactical norm of interest is the one breached in (3) but the other alternatives help provide contrasts so that participants' reactions to (3) could be pondered (see Chazan and Lueke, 2009).

### Research Design

The classic breaching experiment and our first generation of virtual breaching experiments (using videos or animations with face to face groups of teachers) were experiments in Bacon's sense—a demonstration of what the phenomenon looks like. While important for the purpose of revealing the existence of norms for professional action, their limited number could hardly serve to assess the strength of norms, let alone individual differences in norm recognition. The second generation of virtual breaching experiments (online experiences including storyboarded scenarios that breached norms) could potentially have many individuals participate in the same experience and thus allow us to quantify the extent to which individual professionals recognized the norm. In this

context two things have become possible: To develop instruments that purport to measure the extent to which professionals recognize a norm and to use experimental design to reveal the existence of a norm.

On the first matter, to develop instruments that measure the extent to which professionals recognize a norm, the basic observation is tied to the second point made above: When participants respond to a scenario that breaches a norm, we'd like to ascertain that their responses are reactions to the breach of the norm rather than to idiosyncrasies of the scenario itself. Having multiple items that can be valid cases of breach of the same norm but different amongst themselves in regard to their storylines (e.g., the action taken to breach the norm is different, contextual details are different, specific aspects of the mathematics are different) can be useful to develop a composite norm recognition score. Herbst et al. (2013) show an example of this sort of instrument.

On the second matter, to test whether a hypothesized norm is indeed the norm, one could randomly assign participants to one of two conditions. One condition includes scenarios that represent the situation but where there is a breach of the norm being examined. The other condition includes scenarios that match most of the storyline of the former but where the norm is not breached. In both cases, responses can be examined for the presence or absence of repairs as well as for the ratings of appropriateness; participant scores per item can be aggregated, and one can test for the difference of means. Dimmel and Herbst (2014) used that design to explore semiotic norms in the doing of proofs in high school geometry. In that case, the virtual breaching experiments are indeed experiments in the sense of social science research.

### Other Uses of Online Multimedia Questionnaires

The discussion above describes how we have developed the notion of a multimedia online questionnaire to bring to scale virtual breaching experiments. In doing so, the stimulus has been represented through storyboards where the research participants read speech balloons. And the participants' responses have been restricted completely to participants' language choices in response to open ended questions and to their ratings in appropriateness questions. As we think about how multimedia online questionnaires can be enhanced, one way they could do this is by better reproducing the conditions of a virtual breaching experiment.

The research instrument can better situate the participant in the context of instruction by involving them in a more immersive environment. Animated videos with voice over could be better than storyboards with speech balloons if the respondent has means to register their embodied response as they traverse the scenario. Some of those means are already deployed in the LessonSketch platform, where participants can place virtual colored pins along the timeline of a video possibly to identify a moment when they had a particular feeling or idea about what they saw. They can also make comments on the timeline. Chieu and Herbst (2013; see also Chieu, Aaron, and Herbst, 2013) analyzed forum participants' comments on the actions in an animation and discovered significant

differences in the quality<sup>5</sup> of those comments when they were about a moment when there had been a breach of a norm compared to when they were about moments when there had not been a breach of a norm. But making written comments on the timeline of a video is only a minimal way of capturing the respondent's appraisal. Other ways of collecting data are possible with current computing facilities. For example, the software could ask for permission to record the participant's embodied experience by turning on the computer camera and microphone. While connectivity issues may still make the identification of the moments in the video that triggered the reaction we can expect these issues will be resolved with time. There is however a need to develop systematic ways of reading orientational meanings and appraisals from body images and tone of voice and to relate such semiotics to the notions of breach and repair described above.

Also, multimedia online questionnaires include a much larger set of possible instruments beyond virtual breaching experiments and that can be deployed with capabilities such as those of the LessonSketch platform. A slight variation of the virtual breaching experiment in which respondents are shown one representation of practice and asked to comment on it, is a comparison problem inspired on the practice of optometrists who ask patients to compare how they see with two purportedly different lenses. We have used this metaphor to design an instrument (described by Herbst, Kosko, and Dimmel, 2013) in which participants are asked about what they would think more appropriate as a way of presenting a problem: They are given two versions, one that complies with the norm and another one that breaches the norm, and a scale to indicate the extent to which they consider one or the other more appropriate. In general participants could be given a stem scenario represented through a media artifact such as a storyboard, then asked to consider two possible ways of continuing the scenario, both of them represented in the same graphic language as the stem, and a scale to rate the extent to which they would consider one or the other most appropriate.

A second variation is a decision problem. Again one can think of a stem scenario that presents the situation using a media artifact and stops at a moment when the practitioner needs to make a choice for what to do. The respondent could be asked to consider a number of possibilities each of which is represented with multimedia, for example using the same graphic language as the stem, and to either choose one of them that they would consider most appropriate to do or rank them in order of preference for them personally. Kosko and Herbst (2012) describe an instrument designed to gauge the extent to which practitioners choose an action consistent with a norm when a norm is at stake and how such data can be analyzed using multinomial regression.

A third variation is a branching instrument, inspired by "choose your own adventure" books (see Vicary and Fraley, 2007). Participants may be presented a stem scenario through a media artifact and the scenario may stop at a moment when the story might

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<sup>5</sup> This quality was assessed in terms of the presence of reflective comments and the consideration of alternative teaching actions, which were in turn found using a coding scheme derived from ideas in Systemic Functional Linguistics (see also Chieu, Kosko, and Herbst, 2015; Halliday and Matthiessen, 2004).

branch depending on a decision. The participant may be invited to consider the options and make a decision. Once the decision is made, the story may continue (for example following up on the decision made and possibly showing what might be deemed consequences of the decision made). The story might stop again and the participant be asked to make another decision, and so on. For example, an earlier decision about the problems a teacher could pose to students might be followed up with information about how students responded to the problem that the teacher posed, but then the participant could be asked about how they might respond to what the student happened to do. The extent to which normative actions chosen in later questions depend on choices made in earlier questions could then be examined statistically.

All of those possible problems are variations of the original virtual breaching experiment where the participant is only expected to comment or choose actions that have been represented for them. But with the affordances of authoring and collaboration tools available, respondents can do more, both individually and collaboratively. One example of that can be described using the *Depict* tool (Herbst and Chieu, 2011). Unlike other storyboarding tools, *Depict* requires very short time investment in character design and customization<sup>6</sup> and thus it permits a rapid representation of a storyline that has multiple frames. Researchers can therefore create questionnaires that ask open-ended questions such as “what would you do next?” but whose response needs to be in the form of a depiction that shows it, particularly quoting exactly what the participant would say. Clearly, in fields like mathematics teaching where a lot of professional knowledge is embodied in ways of doing the work but not precisely codified into declarative knowledge, it can be more compelling for practitioners and more reliable for researchers to have practitioners show rather than tell that knowledge.

With the inclusion of voice and image recording capabilities, *LessonSketch* can also be used to collect a more embodied form of survey response to capture something closer to actual performance. Participants can be given a scenario in the form of an animation or storyboard and told that the representation will stop at a moment when they will be expected to play the part of the teacher (e.g., as soon as a student finishes putting her work on the board). The software can record the time it takes the participant to offer her contribution as well as the contribution itself which can then be examined using a variety of lenses (particularly as a speech act in classroom language). This could, of course, be thought as a turn-taking simulation where over time research participants enact the role of a teacher across a lesson while researchers play (or program) student roles. In this sense technology can mediate (and make available online) activities like medicine’s standardized patient (Barrows, 1993; see Chieu & Herbst, 2011, for a description of a simulation environment).

We are aware that the encounters with representations of practice that we have been describing are only simulations of real teaching practice in schools, and not yet particularly immersive simulations. Thus, the responses that we are studying are

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<sup>6</sup> We describe *Depict*’s character set as *lean* in the sense that the graphics available to customize characters are sufficiently few to facilitate the author’s focus on designing practices rather than characters.

responses to the virtual experience that the representations can evoke. The steps we have taken improve upon some of the limitations of other research techniques. But, by no means do our efforts eliminate the need to consider that the representations we use (insofar as they are treatments) and the empirical material they call forth from participants (insofar as it affords opportunities for observation and study) are still subject to valuable critique with respect to construct and external validity (Shadish, Cook, & Campbell, 2002, p. 38).

### Conclusion

We have illustrated how multimedia online experiences can be used to canvass professional knowledge. We have pointed the reader to pieces where concrete examples of such instruments have been used to collect data on professional knowledge. While the examples that we know pertain to the area of mathematics teaching where we do our research, the possibilities of the genre are open for researchers interested in professional knowledge across professions of human improvement. In areas where language choices, manner, tactics and strategy, and decisions under conflicting demands are needed, there is a need to situate research in particular practices. Yet to be able to go beyond case studies, it is important to reproduce the particular practices for large numbers of research participants. Multimedia online questionnaires offer one approximation to solve that problem and nondescript cartoon characters offer one language for representing the practices of human improvement professionals without defaulting to the very specific characteristics of social and individual context. We expect that scenarios of professional practice and experiences that require clients to comment on or respond to those scenarios can help researchers understand issues about the knowledge of professional practice-- often embedded in the temporality and multimodality of practice.

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