Purpose, Preparation, and Power of Narratives

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Abstract: How can one convey to interested teachers and researchers nuances of the ways an instructor teaches? of the ways students learn within that instructional context? of the details of that student learning? What aspects of these issues, motivated by the need to communicate a culture of teaching and learning, contribute to a culture of research? One communicative approach involves the use of *narratives*, by which we mean documents that tell the stories of interesting incidents that occurred during class. A narrative presents what the students and instructor said and did, with commentary based upon insights articulated by the instructor and perhaps colleagues while watching a video or listening to an audio recording of the interaction (see example narratives from the Paradigms Program at http://physics.oregonstate.edu/portfolioswiki/start). We discuss the purpose, preparation, and power of such narratives.

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INTRODUCTION

How do students learn how to "think like a physicist"? What do instructors do to nurture such learning? We report here development of a series of *narratives*, documents that provide detailed accounts of such instructional conversations. A narrative presents what the students and instructor said and did during an incident of interest, with commentary based upon insights articulated by the instructor, and perhaps colleagues, while watching a video of the interaction.

These narratives are a form of story-telling, a tradition that goes back to antiquity as a way of making sense of experiences and of conveying cultural values and practices.[1] The narratives also are a form of qualitative research, one that involves "the close study of the particular".[2] In addition, they are a form of inquiry in which researchers write storied accounts of educational lives.[3] Research that interprets student and teacher talk represents the complexity of physics teaching as a cultural practice.[4] Such research offers help to instructors trying to enact a culture of learning that they may never have experienced themselves.

In writing the narratives discussed here, Emily van Zee drew upon her research in the tradition of ethnography of communication, a discipline that studies cultures through the language phenomena observed.[5] The narratives present examples of students growing into participants in the culture of "thinking like a physicist".[6] We discuss below the purpose, preparation, and power of such narratives developed in the context of upper-level physics courses for majors.

PURPOSE OF THE NARRATIVES

The narratives illustrate interactive processes that other instructors may choose to use in their courses. They also show our approach to teaching particular physics topics. The verbatim dialogue presented is not intended to be a script but rather to help interested instructors envision what engaging students in "thinking like a physicist" looks like in particular contexts. Several narratives are now available in a wiki that documents the Paradigms in Physics Program at Oregon State University. The wiki also describes the specific activities depicted and the types of activities shown (http://physics.oregonstate.edu/portfolioswiki/).

Illustrating the Use of Small Whiteboards

As students enter the classroom, each picks up a small whiteboard (about 30x40 cm), marker, and cloth to use as an eraser. A long narrative illustrates *the use of small whiteboards* to develop the formula for the electrostatic potential at a particular location due to a single point charge. The narrative begins with commentary about *establishing a friendly atmosphere*, next shows the instructor (Corinne Manogue) *using props* to introduce the topic while *asking a planned small whiteboard question*, and then presents ways that she *picked up and used students' small whiteboard responses* as the basis for *a whole group discussion*. Sometimes she helped students to clarify their comments and questions by spontaneously asking them to use their small whiteboards to present their thinking.

Students also sometimes spontaneously used small whiteboards to document increasing understandings and to contribute to the conversation. The narrative includes the instructor's reflection about why, rather than lecturing, she takes time to develop the formula for electrostatic potential in this interactive way.

Illustrating Use of Large Whiteboards

In addition to the small whiteboards for individual responses, the students use large whiteboards (about 60x90 cm) placed on the tables where they sit in small groups. A narrative illustrates ways in which a small group of students *communicated their thinking* on a large whiteboard while developing an algebraic expression for current density. The narrative also shows ways that an instructor (Elizabeth Gire) *looked over the students' writings and drawings* on the large whiteboard and then began to *engage the small group of students in clarifying their thinking*.

Illustrating a Kinesthetic Activity

A short narrative about the concept of flux, presents a series of activities that occurred on the first day of a course on static vector fields. The instructor (Elizabeth Gire) first engaged students in a *joint review of relevant prior coursework* by inviting them to state the main ideas in the previous course on symmetries and idealizations. Next she asked *a planned small-whiteboard question* to elicit the students' initial knowledge about flux. After collecting several responses and placing the small whiteboards face inward on the blackboard's chalk tray, she facilitated *a whole group discussion* based on considering the selected small whiteboard responses, one by one.

The narrative then illustrates ways the instructor *used a hulu hoop to represent "a little piece of area*" and *gave some students meter sticks* to hold at different angles to represent a vector field. By moving the hoop to spaces without students holding meter sticks, to spaces with students holding meter sticks sticking through the hoop, and then to spaces with students holding the ends of meter sticks placed within the plane of the hoop, she created a vivid visual representation that for a flux in a vector field to occur, the tail of the vector needs to be on the area's surface.

Illustrating a Wrap-Up Discussion

During a 'compare and contrast' wrap-up discussion, the instructor guides students in developing new understandings by *examining similarities and differences i*n what the small groups report. The main idea emerges during the *wrap-up discussion* rather than during the small group activity itself. Two narratives of *wrap-up discussions*[6] illustrate the process in which the instructor (Corinne Manogue) helped students gain a deeper understanding of the relations between geometric and algebraic representations of eigenvectors.

Illustrating *Name the Experiment* Activity

Students typically have a vague understanding of the meaning of the various partial derivatives involved in expressions of thermodynamic quantities. Two 'Name the Experiment' narratives illustrate ways that the instructor (David Roundy) engaged students in *designing thought experiments* to measure a variety of thermodynamic partial derivatives. In the first 'Name the Experiment' activity, the derivatives involved temperature, volume, pressure, internal energy, and entropy, with entropy fixed (as well as length and tension for situations involving strings or rubber bands). The second 'Name the Experiment' activity involved partial derivatives in which the entropy was changing. Both activities engaged students in *thinking about what was being held constant* for a particular partial derivative and *how that might be achieved experimentally*.

As the students presented their solutions during the wrap-up discussion, they were learning to "think like a physicist" by *envisioning experimental ways of defining the mathematical entities* involved in complex thermodynamic expressions. The fifth small group of students, for example, had worked on the partial derivative of volume with respect to temperature at constant pressure, $(\partial V/\partial T)_p$. On their whiteboard they had drawn a picture of a cylinder with a piston with a thermometer inside the cylinder. An arrow pointing down, above the piston, was labeled constant pressure.

Student 7: We did "d V d T" holding pressure constant so we just have a piston system, and I guess it's frictionless when the piston goes up and down. There's a constant pressure on the outside of it and then a thermometer on the inside suspended somehow. We're gonna make all the measurements, and then add a heating element under it to make it hotter, and then measure the new volume to see the relationship.

Roundy: And how are you going to keep the pressure constant?

Student 8: We'll pretend this is a vacuum, and we'll put weights on there. (laughter)

Roundy: It doesn't need to be a vacuum, but if you want to do any pressure that's under an atmosphere, you either need to pull up on it…

The narrative then summarizes a conversation in which David and Corinne discussed student ideas and what an instructor needs to know to facilitate such an activity.

PREPARATION OF THE NARRATIVES

A good way to begin a complex endeavor is to start simply. For example, Emily van Zee's first experience in documenting and interpreting what people say and do occurred during interviews with introductory physics students discussing electric circuits.[7] During interviews, one has the considerable advantage of a quiet room, a single speaker, a well-defined task, and a focus on interpreting what the speaker may be thinking and understanding. The narratives include an example of such a research interview, in which a junior physics major talked with Elizabeth Gire about the use of operators in quantum mechanics. Preparing narratives about teaching a course is a more complex process, involving recording classes, selecting incidents, transcribing, reflecting with the instructor, and writing.

Recording the Class Session

We use a digital camera on a tripod, with a student assistant to swivel the camera toward speakers and to zoom in and out as needed. We also place other cameras and mikes near small groups to capture multiple examples of student/student interactions during activities and whole group discussions.

Keeping track of recorded data can become a complicated process, particularly if one chooses to document every class session. We download and label each file with date, course, and camera (e.g. 110426Ph423Main), make an archival DVD for each session, and place a working copy on a password protected server available to the entire research team.

Selecting an Incident of Interest

Emily collaborates with the instructors to identify sessions and incidents that they think portray the interactive processes that other physics instructors might be most interested in adopting. We have focused primarily on documenting various types of instructional conversations, with attention to examples of interesting student thinking.

Transcribing the Incident

A helpful way to start transcribing is to make a quick pass through the entire session, placing a time stamp at transition points and a short summary of what happened during each segment of the session. Then transcribe in detail the particular incident of interest. For long utterances, Emily chooses to format talk with a conceptual unit on each line rather than ongoing paragraphs. She notes some pauses, gestures, and actions but prefers a relatively clean transcript to ease reading by the instructor and others. In transcribing, we use Inqscribe (http://www.inqscribe.com/).

Reflecting Together about the Incident

The narratives present a combination of verbatim dialogue from class and commentary. The source of the commentary has been debriefing sessions in which the instructor has watched the video with Emily and sometimes others. Emily types into the relevant place on the transcript while the instructor talks about what has just been said and done (as do others if present).

We do not follow a particular script; the instructor watches the video and decides when to pause it, then simply talks about what is happening at that moment, the philosophical underpinnings for the statements being made and actions taken or not taken, the likely issues students are facing, similarities and differences between what this class of students seems to be experiencing with the topic and those evident in other years - whatever occurs to the instructor as remarkable about this moment. Because Emily sometimes cannot keep up typing what is being said, she requests pauses so she can catch up; these seem to provide impromptu opportunities for the instructor, and others if present, to reflect and often deepen the subsequent comments. Sometimes the instructor has added comments to the transcript while watching the video alone.

Writing the Narrative

The introduction to a narrative summarizes what has happened in the course and session up to the moment the dialogue being presented starts. Also important is summarizing the physics issues being addressed. Writing the main body of the narratives is challenging. Emily starts with the verbatim transcript of the incident of interest interspersed with the verbatim comments by the instructor and others during the debriefing sessions. Her goal is to keep the flow of the narrative manageable for the reader while presenting the class dialogue, with commentary closely aligned to what the instructor, and others if present, have articulated. In creating the narrative commentary, she typically uses as much as possible of the instructor's own words in reflecting on the dialogue.

POWER OF THE NARRATIVES

Creation of these narratives has affected us as instructors, users, and authors in a variety of ways. In reflecting on the debriefings, Corinne Manogue noted:

> I think the process of being interviewed for a narrative is very valuable to me, the kinds of questions that you have asked me have taught

> me a way of being reflective about my teaching that I didn't previously know and they've taught me things to be reflective about that I wouldn't have known to focus on. I think that learning those things has actively changed my classroom practice.

She described our process in the debriefing sessions:

> In the early times when you interviewed me, my memory of them is that you would refer to an incident in class which you found interesting as you were watching and you would ask me why I did what I had done, whether it was planned, and what my interpretation was of both my own actions and how the students responded.

She noted that these debriefing sessions had helped her become more aware of changes she had been making based on past experiences as well as prompting awareness of the nature of student-student and student-teacher interactions, a new noticing of who was asking the questions and who was answering them.

David Roundy commented on the usefulness of talking with other instructors about what students were learning and how and why they were learning it and why it mattered. The debriefing sessions also helped him in preparing a paper for publication about the *Name the Experiment* activities. He thought that access to the narrative would help a reader of the paper to actually try using the activities.

When Mary Bridget Kustusch joined the research group as a post doc, she read some of the narratives to get ready to teach the Paradigms in Physics courses. She noted that the narratives had been helpful in preparing to teach content she had never taught before:

> The narratives were very helpful in giving me that sense, what are the goals of this particular way of doing things, what are the issues the students might have with this way of doing things, how might I address those issues when I've never done it this way before.

She also appreciated the increased understandings she gained from the narratives when teaching new topics:

> I myself didn't have a geometric understanding of eigenvalues and eigenvectors and if I were asked to teach this geometric understanding without having the perspective of the narratives it would have been much more challenging and I think I wouldn't have done it as well.

She found that reading through the narratives helped her to take the information from the other activities on the wiki and use the information in a productive way.

As an undergraduate, Novela Auparay experienced the courses first as a student and then as a research assistant. While recording a course on Central Forces, she was impressed by Mary Bridget's use of small white board questions and the interactions these inspired. Creating a narrative about this has given her many different perspectives as a future teacher, helping her to think about how she would plan such a class.

Writing the narratives also has been powerful for Emily van Zee, who has become more aware of the nuances of various physics concepts and what it means to "think like a physicist" in teaching her own courses.

CONCLUSION

The process of cultural change is complex. For us an exciting development has been the interest of an undergraduate, now an emerging researcher, in writing narratives to share approaches to teaching and learning that she had valued as a student. For us her work signals the promise of narratives in fostering cultural change in both instructional and research contexts.

ACKNOWLEDGMENTS

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