A Distributed Activity Perspective on Teaching in Higher Education Classrooms

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Abstract

Classrooms are the prototypical formal educational setting in higher education. In this paper, we look closely at university classes taught in a variety of different classrooms, documenting the diversity of ways that faculty members create environments for learning. We apply to our studies of teaching a distributed activity perspective, which focuses on the ways that teaching as an activity is distributed and on the ways that these distributions are mediated to facilitate learning. The teaching entities, actions, and interactions in classrooms are examined, and the mediation that spans the distribution is explored.

Introduction

We are interested in the ways that teaching can be viewed as a distributed activity. Teaching is distributed across space and time, across multiple people, across artifacts and other objects, and across media. We look in depth at these multiple distributions, and then we examine the multiple mediators that span these distributions. We examine a variety of instances of teaching and a variety of higher education classrooms within which teaching occurs.

A Distributed Activity Perspective

Many theories of human activity have focused on the individual as the unit of analysis, including the behaviorist perspective that dominated much of the first half of the twentieth century and the cognitive/constructivist perspectives that dominated the second half. Other perspectives, with their roots in the earliest theories of learning but which has been flourishing recently, focus on the physical and social contexts of the individual learner. With the rapid growth of new communication and computational media, the multiple ways that teaching and learning are distributed across multiple people, objects, time, and other dimensions has become increasingly salient. Described here is an effort to reconceptualize learning by focusing on this distribution, a "distributed activity" perspective that explores the variety of ways that human activity is distributed and then examines the kinds of mediation needed to span the distributions to allow for successful interaction. Distributed activity is not a particular kind of human activity, but instead a specific perspective on all activity. There are two aspects of activity that this perspective focuses on, distribution and mediation.

Distribution

Interaction in general, as well as the interactions that lead to the changes we call teaching and learning, is distributed in many different ways. Cole & Engeström (1993) describe how cognition is distributed in space along a dimension of spatial scale, varying from distribution "'in' the person" within a particular person's body and brain, to distribution "'in' the medium culture" among a small number of people and objects to distribution across whole societies and cultures. They also point to distribution in time,
varying along a dimension of temporal scale, with microgenetic time scales of "moment to moment lived experience", ontogeny time scales of "the life of the individual", cultural-historical time scales of "the history of human beings on earth", phylogeny time scales of "the history of life on earth, and finally the physical time scale of "the history of the physical universe."

**Mediation**

Once we focus on the full range of distribution that is present in the human activity, the question arises about how does interaction occur at all, given the variety of distributions to cross. Interaction occurs because of a variety of mediators that span the distributions. A distributed activity perspective focuses on the different kinds of mediators that are involved in learning, and the dynamic nature of their involvement in learning. As with distribution, mediation can be viewed at a range of spatial and temporal scales. There are mediators at the neuron level, mediators at the person or artifact level, mediators at the organizational or societal level. In activity, there are often multiple mediators operating at the same time that need to be coordinated. Multiple mediators are sequenced in time over the course of the activity, and that sequencing needs to be coordinated.

One advantage of the distributed activity perspective is that it helps us focus systematically on mediation in its multiple forms, and the ways in which the multiple mediators are coordinated (or not). Multiple mediators can be coordinated (interacting in ways that benefit the functioning of each mediator), uncoordinated (not interacting with each other at all), or discoordinated (interaction in a way that mutually interferes with each others’ functions), or a mixture of these possibilities. Problems with distributed activity can occur when mediators are missing altogether, or when they are present but discoordinated. Mediators may be present during the time course of activity but not at the times that they are needed for the distributed activity to occur. These are the kinds of things we will look at in our analyses of our vignettes of higher education classroom teaching described below.

**Back to the groves of academe: The idyllic wireless wall-less classroom?**

Plato taught in the groves of Academe, an olive-tree shaded site outside of Athens. Since then, many have the image of an ideal educational setting being a group of learners and teachers sitting outside under some trees, discussing deep thoughts and actively learning together. You may have daydreamed about this idyllic image, when sitting in an uncomfortable chair in a bleak overheated classroom during a boring lecture.

In the year 2000, the College of Education at the University of Illinois, Urbana-Champaign acquired several rolling carts of wireless laptop computers that could be checked out for class use. The authors of this paper were co-teaching an advanced seminar during the spring semester of 2002, and we reserved one of these carts to hold one of the seminar sessions outdoors late in the semester. Here is a picture from that session, held in a courtyard outside the Education Building.
While the session went well, we discovered during the session at least 8 reasons why classrooms are better than gathering outside in groves of trees.

1) The weather forecast contained a reasonable chance of rain that day, which would have forced us to move indoors. Instructors usually do not have to check the weather report before going to a class session.

2) The concrete benches were hard and there were no backs, reducing the comfort of seating.

3) The concrete benches were immovable, and so could not be rearranged to fit the needs of the seminar.

4) There were no desk or table surfaces to put the laptops on, which threatened to slide off laps during the session.

5) When the sun came out from behind clouds, students had trouble reading the laptop displays.

6) The session was in a courtyard next to the entrance of the Education Building, and people entering or leaving the Building felt free to greet the seminar members or to initiate conversations.

7) There was no shared display object (no blackboard or whiteboard), and the software on the laptops did not make a virtual shared display possible, so people brought things up on their laptop displays and then turned them to show others.

8) On the day of the seminar, the university had scheduled the once-a-year trimming of the plants in the courtyard (note the clippings on the ground in the picture above), and the grounds people used loud gas-powered blowers to gather up the clippings. It soon became very hard to hear any of the other members of the class.

This is by no means a complete listing of all possible problems that can occur, but just a listing of those that were most salient during this session. By the end of this seminar
session, we wondered if Plato had to put up with gardeners and tree trimmers when his School met in the groves of Academe.

**Classroom objects as landmarks**

One advantage of holding this class session outdoors was that it highlighted aspects of the objects in conventional classrooms that are so familiar that they have become invisible. These include new technological objects such as laptop computers, wireless networks, and computer projectors, but it also includes more familiar objects like chairs, tables, blackboards, whiteboards, lighting, heating, walls and ceilings. We will call these things "classroom objects", objects that are involved in the interactions that characterize learning and teaching.

**The Big Chair: Classroom objects and implied classroom roles**

The University of Pittsburgh has a set of 26 "Nationality Rooms", with each room equipped in a style representative of classrooms in a different country. The University offers a guided tour of the rooms and also displays them on its web site [http://www.pitt.edu/~natrooms/](http://www.pitt.edu/~natrooms/). A tour of these classrooms shows the wide range of differences among the different rooms, but it also shows several features common to almost all the rooms. Almost all of these classrooms have chairs for the students and for the teacher, and in those cases with chairs for all, the chair for the teacher is "marked" as being different, in most cases by being bigger than the student chairs. The "big chair" is a marker of the special status of the teacher. Even for the Nationality classroom with a round table and otherwise identical chairs, one chair is slightly bigger than the others. A second common feature of all the classrooms is that there is a display device (usually a blackboard) on one wall of the room. This marks one end of the room as being "front", and the "big chair" is usually located at the front of the room with its back to the display device, with the student chairs usually facing this "front" direction.

A tour of the Nationality Rooms makes visible some common features of conventional classrooms, features that are so common that they are usually invisible.

**Room 37: A classroom with variability**

One of the authors (JL) was teaching in a classroom in the Education Building at the University of Illinois that had previously been renovated as a "smart classroom". This classroom had a fixed cabinet structure at the front containing the new technology, and fifteen movable rectangular tables and about thirty-two movable chairs.

He was struck by the fact that every time he arrived in the room to teach, the tables and chairs were arranged in a different configuration. No two configurations seemed to be the same. He sketched out the arrangement of the tables in the room each week before his seminar for seven weeks between March 26 and May 9, 2001 (see [http://edsserver.ucsd.edu/~jlevin/artifacts/room37-maps-2001/](http://edsserver.ucsd.edu/~jlevin/artifacts/room37-maps-2001/) ) and each of the seven arrangements were unique.
There were three main configurations: the tables arranged in parallel rows with the chairs facing the "front" of the room, the tables arranged in a closed rectangle with chairs around the outside of the rectangle, and the tables arranged in a "U" shape with the open end toward the front of the classroom. The parallel rows are best suited for a lecture format, the closed rectangle for a seminar, and the U-shape for some hybrid of these two common formats.

The author who taught the seminar (JL) rearranged the tables each week (into a rectangular format), so he was interested in knowing how the variety of different arrangements happened. That is, each Wednesday at noon, when his seminar ended, the tables were arranged into a rectangle, but by the next Wednesday at 9am, when his seminar started, the tables were arranged in a different way. He obtained a copy of the schedule for the room, and contacted all the other instructors that used the room on a regular basis. While he did not receive responses from all the other instructors, he did hear from the three instructors that used the room immediately before his seminar, and none of the three said that they rearranged the furniture. In other words, when those instructors taught in Room 37, they used whatever arrangement the tables and chairs were in when they arrived. He never did find out who (possibly multiple whos) arranged the furniture into a different form each week.

There are several things we can learn from this vignette. One is that if you provide flexibility in the arrangement of classroom objects, that flexibility is used. The second is that for some instructors and students, the arrangement of classroom objects is not important enough for them to take the time and effort to change. A third lesson is that for others, the arrangement of the classroom objects is important enough to change before or during teaching. This vignette of Room 37 does not provide evidence for the impact of the arrangement of classroom objects, either positively or negatively, on the classroom activity, since it didn't include observations of the classes being conducted using these objects. Some of the vignettes described below video-recorded classes in an attempt to get at some of these issues.

Room 162: A classroom that turned its back on technology and then re-turned
During the summer of 2002, the College of Education at the University of Illinois, Urbana-Champaign renovated the majority of its classrooms. While the planning process for this renovation was quite extensive, involving architects, media specialists, technology experts, and College administrators, two of the authors of this paper (JAL & CCC) were brought in about half way through the process when they asked what research there was on higher education classrooms and their impact on learning. We found very little empirical research to address this question. While there was a considerable body of research on pre-college classrooms and how their layout and use impacted education (Weinstein & David, 1987), there were very few empirically-based studies of higher education classrooms (Wollin & Montagne, 1981; Wong, Sommer, & Cook, 1992). There were many reports of higher education classroom renovations, some of which contained anecdotal reports of the impact of those renovations on one or two faculty (Kowalski, 2002). There were many design guidelines for higher education classrooms (Clabaugh, 1993; Knirk, 1979), but almost no systematic empirical studies.
We conducted during the spring of 2002 two focus group studies and several interviews with faculty. And we collected videotape of 8 classes in 5 different classrooms. In one of these video taped sessions, we noted the disruption caused by late arrivals to the class, because the door to this classroom (Room 162) was in the "front" of the room.

The renovation of this classroom not only introduced new technologies and improved the existing objects for learning in the room, but it also redefined the "front" of the room to be at the opposite end of the room. A computer projector and two speakers were ceiling-mounted, with the projector pointing south. A drop down projection screen was installed along the south wall. A console was constructed in the southeast corner containing a resident computer, a video tape player, and network and projection connections.
These changes were implemented over the summer, and right before classes began in the fall semester, one of the authors (JAL) visited each of the renovated classrooms to see how the planned renovations worked out in practice. He was surprised when he raised the new pull-down screen at the south end to see bare wall. A white board was planned for that wall, but somehow never got installed. So the room had two "fronts"! If the computer projector was used, the south end was the front; if the blackboard was used, the north end was the front of the room. We immediately ordered a display board to be installed at the south end of the room, but this did not get installed for several months.

At the beginning of the semester, all the chairs in this room were facing south, toward the "new" front. That did not last long, as shown in this picture:
We call this "the classroom that turned its back on technology", since all the student chairs have their backs to the new console and the ceiling-mounted projector. However, by November a blackboard was finally installed at the south end, and so as you can see in this next picture, the classroom then "re-turned" to the new technology – all the student chairs are now facing the console and the new projection screen and blackboard.
Since that time, the arrangement of chairs in this room seems to vary day-by-day, with the orientation sometimes primarily toward the south, sometimes toward the north, and sometimes ignoring either "front", as shown in this picture.

One of the lessons learned from this observational study is that classrooms are used in a wide variety of ways by different instructors, often in ways not envisioned by the designers of the classrooms. How can we systematically think about this variety of uses? Next we will introduce a new perspective on activity that might be useful for describing classroom teaching.

Vignettestes of classroom distributed teaching activity

We video recorded eight class sessions of six different classes, which met in five different classrooms during the 2001-2002 academic year. These were all classes in College of Education at the University of Illinois, Urbana-Champaign. Two classes were undergraduate courses, two were graduate classes, and one contained both undergraduate and graduate students. One of the graduate courses was small (6 students); one of the undergraduate courses was a large lecture course; the other courses were intermediate in size. One of the courses met in a relatively small seminar room; one met in a large lecture hall; one met in a computer laboratory; and the rest met in medium sized rooms with individual chairs with attached desk surfaces (like those shown in the pictures above). Four of the class sessions met in Room 162, the room described previously, before it was renovated.

Analysis of the vignettes
We will present here analyses of six episodes from three of the settings in which we collected video data. We will look at the distribution and mediation of teaching in a large lecture classroom, in a computer-lab setting, and in a medium-sized cluster-organized classroom. For each of the episodes, we coded the video according to the following framework:

- What is distributed?
- What are the mediators?
- How do the mediators interact with each other? What are the coordinations, discoordinations, and uncoordinations?

A large lecture classroom.

One of the classes we video recorded was a large lecture-oriented class, taught by a faculty member who had been repeatedly ranked as “excellent” by her students in student course and instructor evaluations. This instructor uses a variety of media in her instruction. In the class session we analyze here, she passed out a one page (double sided) handout, she used a data projector to display PowerPoint slides, and she projected video from a video tape. She wore a microphone so that her voice would be heard throughout the large lecture hall.

We analyzed three relatively short segments of her teaching during this class session. We coded each segment by answering the questions listed above, describing the distribution, mediation, and coordination in each segment.

Segment 1. The first segment is a 50 second portion of the class, in which the instructor is talking about changes in adolescent premarital sexual behavior over time. The segment starts with the instructor talking while displaying a slide showing a set of bullet points, and then she changes the display to a graph, which she then talks about.
A transcript and coding of this segment is in Appendix 1. This segment shows a fairly typical pattern for a large lecture class, with the instructor at the front of a room talking, gesturing, and displaying text and graphics, and with the students in fixed seats facing the instructor, listening and taking notes. Instead of the "big chair" described previously, the instructor here has a podium at the front and a microphone, both of which have both functional and symbolic aspects. Functionally, the podium gives her a place to put her notes, and also contains a computer, a VCR, and the controls for the ceiling-mounted video projector. Functionally, the microphone allows her to project her voice across the large lecture hall. Symbolically, both the podium and the microphone mark her role as the instructor.

Now let us look at the distribution/mediation coding of this segment. What is distributed in this setting? There is a handout in the hand of the instructor and a copy in front of each student. There is a display on the screen in the front of the room. And there is the instructor in the front left who is talking and gesturing. Those are the major ways in which the information being presented is distributed.

How are these distributed presentations brought together? What are the mediators of these distributions? The major mediator is the instructor, who coordinates between her talk, the handout, and the display, through coordinating talk and gestures. In her talk, she refers to the graph "we can look at a graph" and then she displays that graph. Her talk parallels some of the text on the graph that appears. She then explicitly coordinates her talk with the graph: "we can see that there has been an increase ...".

While there is considerable coordination (this is an excellent instructor), we can see some minor discoordinations as well, ways in which what is presented in one way does not coordinate with what is presented in another way. While the instructor usually uses gestures that coordinate with what she is saying and showing, she also has some "inadvertent gestures" that are not coordinated. For example, she adjusts her hair at one point with her left hand, a "gesture" with her hand that is not connected to the content of the course. This is the hand that she often gestures with during the rest of the time. She paces back and forth, and at the end of each turn, she has to reach behind her to pull the microphone cord so she doesn't trip over it, and this repeated action, done with the same hand she gestures with, is also a "inadvertent gesture", potentially confusing for the students paying attention to her intended gestures with that hand. Her pacing back and forth, more generally, is dis coordinated with her presentation of the content of the lesson. One final minor discoordination that occurs in this segment is the approximately 3 seconds of silence while she walks to the podium and switches to the next slide on the video display. Silences can be certainly used for a rhetorical effect, but this silence seems more due to the mechanics involved in changing the slides and serves as a discoordination rather than a coordination of presentations.

Finally, there are presentations that are uncoordinated, in the sense that there is no interaction at all between them, which potentially can cause problems for the learning environment. Toward the end of this segment, the beeping warning sound of a truck backing up is heard, which of course is totally unconnected to the activities going on in the class. This kind of distraction can serve as a barrier to learning, and is in fact the reason for constructing classrooms, as we learned when conducting the class described earlier outside in a patio using laptops.
Segment 2. In the next segment, later in this same class session, the instructor introduces some video she is going to present, then displays the video. The transcript and coding of this 93 second segment is shown in Appendix 2. As in the first segment, presentations are distributed around the classroom, with a handout in the hand of the instructor and in front of the students, a video display on the screen in the front of the room, and the instructor talking, walking, and gesturing at the front left of the room. The instructor and the variety of displays are mediators, and the instructor coordinates these mediators most of the time. She introduces the video, using a counting gesture with her hands to enumerate the videos she plans to show. There are two minor discoordinations in this segment. One is the approximately 7 second silence when she switches between the slide display and the video tape display. The second discoordination is the pacing in front of the room and the inadvertent gesture caused when the instructor reaches for the microphone cord when she turns back toward the podium to keep from tripping over it. Within this segment, the slide display is uncoordinated with the talk, but it was coordinated with talk in the portion of the class right before this segment.

Do all presentations in a class need to be coordinated? Not necessarily, and in most cases total coordination is impossible – for example, in this large lecture hall, there are "Exit" signs, required by fire safety regulations, which are of course uncoordinated with the presentations by instructors in the classroom. But coordinated presentations are typically the goal of instructors, and discoordinations are usually undesired. We shall see an interesting example of a discoordination in the next segment, especially the smooth way that this instructor handled that discoordination.

Segment 3. This 26 second long segment is near the end of the same class. Right in the middle of one of the instructor’s sentences, the bell rings to indicate the end of the class session. The instructor continues speaking, and when, a few seconds later, the students start gathering up their materials to leave, the instructor interrupts herself in the middle of another sentence, saying "I'm going to need another minute", and then continuing her sentence (see the transcript and coding in Appendix 3). The ringing of the bell in the middle of the instructor's talk is a discoordination, because the instructor planned her lesson to fit the time constraints of the class session. In a perfect lesson, an instructor would finish the summary right before the bell rings. This instructor handled the discoordination smoothly, and finished up her summary without disruption. Right at the end, the instructor holds up the handout paper, turns it around, and points to a spot on it to coordinate her talk with the contents of the handout.

One of the characteristics of this expert teacher is her skill at coordinating the multiple presentations of the content of the course. One benefit of multiple presentation formats is that it reaches more students, given the individual differences in the effectiveness of different presentation formats across the large number of students in a course like this one. Another benefit is that it encourages the learners to acquire multiple coordinated representations, an element of expertise in a domain. This instructor coordinates multiple presentations in a relatively seamless manner – the relatively few discoordinations and uncoordinations serve to highlight the much more frequent coordinations in her teaching.
A laboratory demonstration.
Another of the classes we video-recorded was a demonstration of a computer-animation application (Flash) in a computer lab. The instructor in this class was introducing his students to the key concepts behind creating a computer-generated animation. We will look at two segments in this class session, one in which there was considerable discoordination in the presentation and a second in which there was largely coordination.

Segment 4. In this segment, the instructor is describing how animations are created as a series of separate frames that are rapidly presented to the viewer to create the illusion of motion. In this 22 second segment, the computer he was planning to use to show the animation did not have the proper software installed, and another person is working to install that software while the instructor proceeds with the lesson. He shows the animation by dynamic gestures, moving his hand in front of himself while facing the students, who are seated at computers facing the video screen that the instructor is standing in front of. But the display on the video screen is a display of the computer that the other person is using to install the needed software. A transcript and coding of this segment is found in Appendix 4.

Figure n+1: An instructor in front of a computer laboratory classroom.

In this segment, the instructor starts to convey the concept of animation, by moving his hands to indicate the movement of the animation that he is unable to show on the video display. There are 40 frames in the animation he is describing of a circle moving from the right of the screen to the left of the screen and back to the right. The instructor indicates the starting point with his left hand, then moves his right hand to indicate the location of the circle at frame 20, saying "So it goes from 1 to 20...". Then he mistakenly continues moving his hand, saying "and then...". Then he stops, and says "Actually, wait, it goes from 1 to 20 then back to 40 to get the back and forth and back and forth."
While moving his right hand to the starting point while saying "1", to the left stopping when he says "20" and then back to the starting point when he says "40". He repeats this dynamic gesture three more times during this short segment.

The distribution of presentations in this segment includes the projected computer display, the instructor standing in front of the display talking and gesturing, and the computer monitor in front of each student in the computer lab. The instructor coordinates his talk and his gestures. There's a discoordination between what the instructor says and gestures initially and what he then repeatedly says and gestures afterwards. This discoordination is marked by the instructor with an explicit apology "I'm sorry". The computer display in the front of the room and the displays on each student's computer are uncoordinated with the instructor's talk and gestures.

**Segment 5.** The discoordinations that dominate segment 4 contrast with the more coordinated presentations of segment 5, the same instructor making the same point, but this time with a functioning computer display. The transcript and coding of this segment is in Appendix 5.

![Figure n+2: An instructor in front of a computer laboratory classroom with a functioning display.](image)

During this segment, the projected display behind the instructor shows a small circle moving left and right and a larger square moving up and down across a large stationary circle. The instructor's talk and dynamic gestures are coordinated relatively tightly in time with the movement of the small circle in the animation being displayed. The exceptions to this tight coordination are when the instructor turns away from the screen but continues moving his hand, and then either leads or lags the horizontal movement of the small. The movement of the square up and down is coordinated with the horizontal movement of the small circle, but is uncoordinated with the talk and gestures of the instructor. That is, the movement of the square is perceptually more
salient than the small circle, since it is brighter and larger, but it is not the focus of the instructor's talk and gestures.

In this setting, we see several good examples of powerful uses of dynamic gestures, especially when coordinated with a dynamic display of the activity. But this coordination adds a constraint on time of movement that was not present in the previous segment when the display was uncoordinated with the gesture. This pair of segments 4 and 5 shows some of the underlying processes and constraints involved in creating multiple coordinated presentations.

A medium-sized classroom organized into multiple small groups.
In a medium-sized classroom, the focus a class taught by one of the authors (CC) was on examining educational software. This class met in Room 162, the room described earlier, but before its renovation. After a general whole group introduction, the class was divided into multiple groups with three students in each group, and each group was given a wireless laptop and a handout with URLs of educational software to examine. In the segment we will analyze here, the students were in the process of examining software, the instructor asked the whole class a question, students answered by raising hands, and then the groups went back to the examination of software again. The transcript and coding of this 22 second segment is in Appendix 6.

Figure n+3: Two groups of students responding to a question from the instructor.

In this classroom, the spatial distribution of teaching is the most obvious of the three classroom settings we have explored in this paper. While there is still an instructor, and the picture above shows a focus of attention on her, during most of the class, attention of each student was focused within his/her small group of three as they examined and discussed three different educational software web sites. There were distributed groups of students, each with their own independent laptop computer display, operating semi-autonomously within this one room. The talk of the other groups was uncoordinated with the talk within each group; the sounds created by the web pages of other groups
also was uncoordinated, and served as "background noise" for each group. The question from the instructor "How many groups are on your second web site?" served to temporarily coordinate the activity of all the groups, but that coordination ceased once the question was answered (marked by the instructor saying "Good."). Later in this class session, the groups came back together into a whole group, but during this segment, there were multiple uncoordinated group operating in the room, with the activity and presentations coordinated within each group of three students. For the nearby group, for instance, the three students are talking about their display, the middle student types on the keyboard, and the student furthest away from the camera points to the laptop screen to make a particular point about the educational website being examined. So, there is mediated activity within each group, largely uncoordinated with the other groups until coordination is created by the instructor by her question and then released by her response to the students’ hand raising answers.

Discussion

Distributed teaching in classrooms
From the analyses presented above, it is clear that teaching is distributed, even in conventional classrooms. Once we see the ways that teaching is distributed, over people, over media, over objects, over space, over time, the issue is then how does teaching occur, given these distributions? How are these distributions bridged? What are the mediators of this distributed learning?

The cases studies described here begin to describe the distribution of teaching in these higher education classrooms and to specify the kinds of mediators that are involved in bridging these distributions.

Multiple coordinated representations.
What is expertise? This is obviously an important question in studies of teaching and learning, as the goal is typically to help learners achieve expertise in some domain. There have been a number of studies of what makes experts different from novices (Chi, Feltovich, & Glaser, 1981; Larkin, McDermott, Simon, & Simon, 1980; Levin, Stuve, & Jacobson, 1999). One characteristic of experts is that they typically have multiple representations of the domain of expertise, and they have the metaknowledge that allows them to coordinate those representations, choosing one that is more likely to be appropriate at a given time and switching from one representation to another when needed. Novices, on the other hand, have only a few representations, and those representations are usually uncoordinated or discoordinated. So expertise in a domain can be described at the application of multiple coordinated representation of that domain.

Multiple coordinated mediation.
Now expertise is typically distributed rather than solely embedded in an individual. How can we extend this concept of individual expertise to a broader notion of distributed expertise? As we have seen above, it takes mediation to span the various ways in which expertise is distributed. Typically there are multiple mediators, and for a distributed expert system, these multiple mediators are coordinated, instead of being uncoordinated or discoordinated.
**An expert teaching distributed activity system.**
As we have seen in the vignettes described previously in this paper, learning typically takes place within a distributed activity system. What characterizes an expert learning/teaching system? One characteristic is the multiple coordinated mediation among the various distributed components of the distributed system. We have seen in the vignettes here ways in which expert teaching is characterized by the use of multiple coordinated media of presentation, and in which problems in teaching are created by uncoordinated or discoordinated uses of media.

**Summary**
With a set of studies of higher education classrooms and their uses, we have uncovered some of the ways in which learning is distributed and mediated. We have analyzed in detail six segments of teaching and learning in three very different higher education classroom settings. We presented a description of a distributed learning perspective we are developing to account for teaching and learning through multiple coordinated presentations and multiple coordinated mediators of learning.
References


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Appendix 1: Transcript and coding of segment 1 of a large lecture-oriented class

[00:00:00.00] [START 10:17:12AM APR 11 2002]

[00:00:05.05] I: ...attitudes about premarital sex and that this is in line with what individuals are reporting about their sexual behavior and this is true of adults but it is also true of adolescents

[00:00:17.15] I: and we can look at a graph [walks over to podium to switch the display]

[00:00:20.21] [video display changes to a graph "Historical Changes in ..." with about a 3 second silence while she changes the display and adjusts the hair over her left ear]

[00:00:22.15] I: so, in surveys dating back to 1968, of the percentage of 18 year olds who report that they've had sexual intercourse, we can see that there has been an increase and that line is stable into the early nineties for males and increases just slightly for females into the early nineties

[00:00:43.24] I: but I want to note that there's been attitudes and changes in society’s view and adolescents' views of premarital sex ...

[00:00:48.03] [gestures with her left hand during the last part of the talk above]

[00:00:50.21] [END 50.21 seconds]

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What is distributed?
* video projector display in front of room, instructor in front, handout in the hand of the instructor and in front of each students

What are the mediators?
* instructor (major mediator), displays, handouts

How do the mediators interact with each other? What are the coordinations, discoordinations, uncoordinations?

Coordinations:
* Instructor's coordination of her talk with the display at the front of the room

Discoordinations:
* inadvertent gesture of straightening hair
* instructor's pacing in front of the room
* inadvertent gesture of moving the microphone wire
Appendix 2: Transcript and coding of segment 2 of a large lecture-oriented class

[10:30:00.00] [START APR 11 2002 10:30:00 AM]

[10:30:00.15] I: The bulk of research has been on sexually transmitted diseases, pregnancy

[10:30:05.15] I: there is much less on emotional outcomes associated with sexual activity.

[10:30:13.00] I: What has been done is very troubling, particularly among young adolescents

[10:30:20.00] I: ... and I'm going to show a clip now, before we continue to talk about challenges to building a positive sexual identity ...

[10:30:20.15] [I switches computer display to next slide]

[10:30:23.23] [I's hand sweep gesture]

[10:30:28.12] I: ok ...

[10:30:36.03] [I puts down the paper she has been holding and turns off computer-projected text]

[10:30:38.00] I: these are various interviews ... I think there's four total

[10:30:42.10] [I counting on hand]
I: these are from two different

[10:30:47.10] [I counting on hand]
I: PBS documentaries -

[10:30:50.25] [I counting]
I: one shown on Frontline - and have adolescents talking in a variety of ways about their experiences and feeling around sexual activity.

[10:30:59.24] I: The first interview are with three girls who've been involved with a program at their school pledging their virginity ... until they're married ... ok

[10:31:11.13] [lights dim]
[10:31:14.14] [video appears]

[10:31:11.01] [a video clip begins to show]

[10:31:33.07] [END 1 min., 33.07 secs.]

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What is distributed?
Presentations distributed around room, with the instructor at the front bottom, the display at the front middle & top, the handouts in the hands of the instructor and the students

What are the mediators?
instructor mediates using the different presentations (talk, computer projection, video, handouts), with talk, gesture, and timing, coordinating (mostly) those different mediators.

How do the mediators interact with each other? What are the coordinations, discoordinations, uncoordinations?

Coordinations:
1) counting gesture when enumerating in talk
2) preview talk about video

Discoordinations:
1) the delays when she switched from computer display to video display (putting down the paper she’s holding, bending down to switch the projecter at the console and start the video playback
2) her reaching for the microphone cord at the end of her pacing away from the podium to pull it with her as she paces back toward the podium (an inadvertent gesture)

Uncoordinations:
1) showing Display 2 with no talk about it (within this segment), but instead talk about the upcoming videos

Appendix 3: Transcript and coding of segment 3 of a large lecture-oriented class

[00:00:00.00] [START 10:51:34AM Apr 11 2002]

[00:00:00.28] I: this additional support going from 100 million to 133 million so if anything we're continuing in this trend of abstinence-only. DEAN, the program that is provided to most adolescents

[00:00:11.11] [bell rings]
[00:00:12.14] I: is also getting additional money that is going to be for more restrictive abstinence-only programs.
Prior to this, as long as you didn't put out,

[00:00:20.00] I: I'm going to need another minute,

[00:00:21.16] I: as long as you didn't present contradictory information, you didn't have to emphasize all eight elements.

[00:00:25.21] [Instructor turns paper handout she's holding over and points to a place on the paper, holding it up for the students to see.]

[00:00:26.18] [END 26.18 seconds]

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What is distributed?
* display in front upper center of room
* Instructor pacing across the front center of the room
* the handout, carried and pointed to by the instructor, but also in the hands of each of the students

What are the mediators?
* the instructor's talk
* the instructor's gestures
* the handout, the display

How do the mediators interact with each other? What are the coordinations, discoordinations, uncoordinations?

Coordinations of mediators:
Instructor coordinating her talk, her gestures, and the paper handout

Discoordinations of mediators:
The bell ringing in the middle of the I's talk, and the resulting actions by the students to gather up their stuff and leave

The action of pulling the mike wire at the end of each turn in the I's pacing creates an inadvertent gesture

Uncoordinations of mediators:
computer display is uncoordinated with the talk and gestures during this segment

Appendix 4: Transcript and coding of segment 4 of a laboratory demonstration

[00:00:00.00] [START 2:00:40PM MAR 11 2002]

[00:00:00.16] I: So it goes from 1 to 20
[I moves hands to indicate movement of animation]

[00:00:03.08] I: and then

[00:00:05.07] I: actually, wait, it goes from 1 to 20 then back to 40 to get the back and forth and back and forth.

[00:00:09.22] I: Otherwise it would go like that and stop and suddenly TELEPORT back to 1.

[synchronization of I's hands with I's saying of the numbers]

[00:00:14.18] I: So I'm sorry.

[00:00:15.07] I: It goes from 1 to key frame 20 and then to key frame 40.
I: 1 20 40 1 20 40

[somewhat loose synchronization of I's hands with I's speaking of numbers]

[00:00:22.26] [END 22.26 seconds]

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What is distributed?
* Projected display in front of room
* Instructor in front of room, between display and students (partially blocking the display)
* Student computer displays in front of each student, seated at a computer in a computer laboratory

What are the mediators?
* the instructor's gestures and talk

How do the mediators interact with each other? What are the coordinations, discoordinations, uncoordinations?

Coordinations:
* Instructor coordinates (mostly) his talk and his gestures

Discoordinations:
* the instructor's initial gesture and talk with the revised gesture and talk

Uncoordinations:
* Computer display uncoordinated with Instructor's talk and gestures
* Display on each student computer uncoordinated with instructor's talk and gestures
Appendix 5: Transcript and coding of segment 5 of a laboratory demonstration with display

[00:00:00.00] [BEGIN 1:56:01.00 Mar 11 2002]

[[00:00:01.24] I: Now, the way Flash works is, it works in a timeline, ok, like, in terms of frames.

[00:00:11.11] I: So, think in terms of PowerPoint, the frames are slides, the frames of animation.

[00:00:16.10] I: This animation has, I think, forty frames.

[00:00:20.00] I: OK, going to 20 back to 40

[[00:00:24.0] I: it just loops, ok,

[00:00:26.25] I: 1
[00:00:26.25] [I points to left edge of purple circle]

[00:00:26.25] [brown circle is at left edge of purple circle]

[I moves left hand from left edge to right edge of purple circle]

[brown circle moves from left edge to right edge of purple circle]

[00:00:28.14] I: 20
[00:00:28.14] [I points to right edge of purple circle]
[00:00:28.14] [brown circle is at right edge of purple circle]

[I moves left hand from right edge to left edge of purple circle (partly ahead of the movement of the brown circle)]

[brown circle moves from right edge to left edge of purple circle]

[00:00:30.05] I: 40
[00:00:30.05] [points to left edge of purple circle]
[00:00:30.05] [brown circle is at left edge of purple circle]

[00:00:31.14] [END  31.14 secs.]

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What is distributed?
* the projected animation
* the instructor's talk
* the instructor's animated gestures
What are the mediators?
* the instructor’s talk and dynamic pointing
* the animated projected image

How do the mediators interact with each other? What are the coordinations, discoordinations, uncoordinations?

Coordinations:
* the pointing, the talk, and the animated image

Discoordinations:
* the mismatch (leading and lagging) between the instructor's dynamic pointing and the moving projected image

Uncoordinations:
* the red square moving up and down is uncoordinated with the instructor's pointing and talk

Appendix 6: Transcript and coding of segment 6 of a medium-sized group-organized class.

[00:00:00.00] [START 4:18 PM APR. 17 2002]

[many students and the instructor talking all at the same time]

[00:00:03.09] [in nearer group, all three staring at the screen, the middle person typing on the laptop keyboard]

[00:00:01.23] [in farther group, talking - farthest person puts her hand over her face]

[00:00:08.27] [the farthest person in the nearer group points to a place on the laptop screen, talking, until interrupted by the instructor]

[00:00:09.29] I: How many groups are on your second web site?

[00:00:10.28] [students in both groups look off to the left of the screen, where the instructor is standing]

[00:00:13.23] [one student in the farther group holds up her hand; another waves her hand]

[00:00:13.23] [all three in the nearer group hold their hands up]

[00:00:15.08] I: Good.

[00:00:17.24] [students resume talking]
[00:00:18.02] [The nearer group and the farther group both go back to looking at their group's laptop computer screens]

[00:00:22.01] [END 22.01 seconds]

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What is distributed?
* the groups of students working independently
* laptops
* shared instructions for the evaluation task

What are the mediators?
* the laptops
* the students’ talk and gestures (pointing to the screen, for instance)
* the instructor's question
* the students' hand raising

How do the mediators interact with each other? What are the coordinations, discoordinations, uncoordinations?

Coordinations:
* the instructor’s query about how far each group is
* the hand-raising by the students

Discoordinations:

Uncoordinations:
* the talk from other groups
* the sounds of the other laptops

Taxonomy of mediation; grammar of mediation

Look at the Ching, et al. 7 types of artifacts

Bruce & Levin taxonomy (inquiry, communication, construction, expression)

Logic of interaction: types of interaction; types of mediation; capturing the dynamics of classroom interaction;

Similarities & differences
Grouping and dividing

Threads of discourse; multiple; starting new ones; terminating old ones
Landmarks in the classroom (landmark artifacts, landmark events, landmark in the talk, …)

What are the dimensions that the landmarks mark?

What are the goals and actions of the teacher and students, and how do they interact?

figure 8 interaction