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Classroom Artifacts: Toward a Merging of the Physicality, Technology,

and Pedagogy of Higher Education

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Abstract

Basic research on teaching in the learning spaces on university campuses is rare, and existing literature on the use of technology in higher education tends to focus on integration without regard for the content being taught. In this paper we analyzed eight video cases of university teaching, paying special attention to classroom artifacts (technological or otherwise) and the content-specific contexts of their use. A grounded-theory framework was created which represents a first step toward describing the various artifacts and technologies in higher education classrooms and some pedagogical purposes toward which they are used. A case study is presented in further detail, which illuminates how faculty can use concrete and abstract learning artifacts to convey and construct multiple representations of expert knowledge for students.

Classroom Artifacts: Toward a Merging of the Physicality, Technology,

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In the past year there have been several key discussions highlighting the importance of considering the physical environment of learning in higher education: a feature article in *The Chronicle of Higher Education* and a special issue of the higher education journal *New Directions for Teaching and Learning*.   These discussions have largely been from one of two perspectives. One is the student perspective: surveying or speculating how students feel about learning in particular environments and the implicit messages they receive about the relative importance of education from outdated, uncomfortable, and inflexible classrooms (Bartlett, 2003). The other is a classroom design perspective: focusing on renovation and infrastructure of learning spaces (Hughes, 2002) or new construction and administrative processes thereof (Bickford, 2002; North, 2002).

Research on *teaching* in the learning spaces on university campuses is rare, however, and research on teaching in these spaces from a social-cognitive perspective of everyday enacted use is almost nonexistent. Our project is based in sociocultural and activity theory perspectives of studying practices and artifacts in the context of use (Engeström, 1987; Kuutti, 1996), combined with cognitive perspectives on the nature of expertise (e.g., Chi, Glaser, & Feltovich, 1989). In this paper we analyze video cases of university teaching to examine how faculty use concrete and abstract learning artifacts

and technologies to convey and construct multiple representations of expert knowledge for students.

Literature Review

The vast majority of existing literature on teaching in the university classroom is focused on the use of educational technology.   This research typically deals with technology integration into curriculum and technology training for instructors (e.g., Garland, 1999; Groves & Zemel, 2000), or focuses on technical specifications without regard to pedagogical concerns (e.g. Clabaugh, 1993). Much of the research on integration and skills relies solely on faculty self-report surveys (e.g. Spotts, 1999; Spotts, Bowman, & Mertz, 1997). Studies which focus on technical specifications are often derived from classroom design initiatives, wherein the potential uses of innovative and technology-enhanced classrooms are lauded by designers, without a systematic examination of how that potential is or is not realized by instructors actually teaching in those spaces (Dittoe, 2002; Stuebing, 1994). Rarely one sees anecdotal post-occupancy descriptions of such classrooms, which focus on one or two case studies of instructors who successfully integrate the newly installed technology in their teaching. Such anecdotes, however, tend to either ignore or fail to report the other instructors who teach in those same renovated or "enhanced" rooms but carry on much as before. The case study approach is taken more often in K-12 education (Cuban, Kirkpatrick, & Peck, 2001; Windshitl & Sahl, 2002), where wide scale classroom assessments of teaching practices with technology have also been conducted (e.g., Ringstaff, Yocum, & March, 1996).

Research on enacted practices and use of artifacts in education has tended to focus on one class of artifact in particular. One type of study examines the role of gestures, either in combination with display artifacts like blackboards and overhead projectors or in isolation, in formal teaching in university classrooms (Roth, 2001) and in research labs (Ochs, Gonzales, & Jacoby, 1996). Inscriptions, a category of artifacts including things like diagrams, charts, figures, etc, have been examined in both higher education and in occupational practice (see review by Roth & McGinn, 1998). Another area of research examines designed artifacts such as graphics, manipulatives, and other curricular materials as tools for scaffolding discussion and understanding. These studies examine the artifacts themselves and their affordances, as well as the practices of use and teacher and student discourse surrounding the artifacts and content in question. This strand of research has been conducted almost exclusively in K-12 mathematics education (e.g., Saxe, 2001; Sfard & McClain, 2001), however, rather than in the university setting.

While investigations of instructors' use of learning and teaching artifacts are rare, we do not want to give the impression that scholarship on teaching in higher education does not exist. On the contrary, much scholarly effort has been devoted to the idea of defining "good teaching" at the university level. These writings have proven useful to many faculty and instructors seeking to obtain suggestions for improved teaching. From a research perspective, however, there are some critical problems with this body of work. Basic research on university teaching is rare, for a number of reasons which we will discuss throughout this paper. Instead, the vast majority of published work tends to focus on recommendations and "tips" culled from anecdotes and received knowledge about university teaching (Ericksen, 1984; Hativa, 2000). Within these prescriptive rather than

research-based writings, many of the themes highlight intangible factors like "engagement," "active learning," "high expectations," (Chickering, Gamson, & Barsi, 1987) or other principles, instead of concrete teaching practices in the classroom. Many of these works also deal with teaching factors not bound to the classroom such as availability and student-teacher contact (Chickering, et al., 1987).

These aspects have more to do with *being* a teacher than the act of classroom teaching, per se, and while these principles are admirable in not limiting the notion of teaching to only those actions occurring within the classroom walls, the extent to which these recommendations can translate into observable phenomenon has yet to be shown. Some basic research on university instruction has been conducted, but what little research there is tends to focus on students' experience of formats such as lectures, study groups, and problem-based learning (e.g., Pascarella & Terezinni, 1991). The teaching method or phenomenon in question is usually treated as context and takes a back seat to student learning outcomes.

One of the likely reasons for the dearth of basic research on university teaching is its relative lack of prescriptive power. Research on K-12 teaching is designed to inform the practice of K-12 teachers, as well as teacher training, educational policy, and curriculum development. University instructors are presumed to be experts in their given field, however, so it is thus assumed that they must know how to teach their area of expertise. Given this assumption of teaching competence and the lesser importance of teaching compared to research efforts in obtaining tenure and status at many institutions (Boyer Commission, 2001), it is not surprising that research on university teaching lags behind research on teaching in other settings. Our motivation, however, was not based

on a perceived need for evaluative research or prescriptive outcomes. Rather, we took a phenomenological approach to the study of teaching in higher education. From this perspective, assumptions of expertise are valuable, in that they suggest a theoretical framework for investigation.

Approaches to studying expertise vary widely depending on the focus of investigation. Studies of expert *thinking* take an exclusively cognitive focus, illuminating the ways experts organize and access their knowledge in fundamentally different ways. This body of research reveals that expert knowledge, as exemplified in the areas of physics and chess, is characterized by multiple representations, fluid retrieval, and organization around "big ideas" rather than surface features (Chi, Feltovich, & Glaser, 1981; deGroot, 1965; Ericsson & Staszewski, 1989). Studies of expert *practice*, however, take a very different approach. These investigations largely come out of sociocultural perspectives and focus on qualitative descriptions of action and participation; skilled use of tools and artifacts; reflections on activity and discourse; and attempts to locate expert practice within history, culture, and community (Greenfield, 2000; Hutchins, 1995; Keller & Keller, 1993; Lave & Wenger, 1991; Schön, 1983). It is difficult to reconcile these two disparate means of studying expertise. We will argue in this paper for a hybrid approach; that is, examining the ways in which enacted practices of skilled teaching leverage myriad classroom artifacts to construct and convey multiple representations for students of domain-specific expert knowing and doing.

Methods

Participants

Seven instructors and their students in the College of Education at the University of Illinois at Urbana-Champaign participated in this study. All participants were volunteers who agreed to have their teaching video taped, and human subjects consent was obtained from all instructors and their students on the day of taping. All instructors in this study are colleagues of the principal investigators (the first and second authors) in the College of Education. Due in part to difficulty obtaining participants for the study, and also a desire to create a more egalitarian relationship between investigators and participants, the principal investigators are also included as instructors; their teaching and their classes comprise part of the data set. Thus the distribution of data is as follows: two investigators and five volunteer instructors, for a total of eight teaching cases (the first author was taped twice in different teaching situations). The participation of colleagues and selves in this study poses some interesting issues for investigator subjectivity in research, something which we will address in the discussion of our results.

Data collection

After instructors had agreed to participate in the study, we gave them the option of choosing which date to be recorded. One of the principal investigators attended the instructors' classes, administered human subjects consent forms to students, and then sat in the back, taped the entire class (at least an hour in all cases), and took field notes (principal investigators taped each other's classes). During videotaping, the camera was primarily focused on the instructor, but with a deep and wide-angle view, so as to capture as much of the whole classroom as possible.

The data set we used for this paper comprises eight video cases of teaching in the College of Education. Despite disciplinary similarity, the class formats across the data set are quite diverse, ranging from fairly large lectures (approximately 200 students), to medium-sized lecture-discussions (25-30 students), to small seminars (4-8 students). Teaching methods included instructor lecture, guided whole class discussion, hands-on laboratory training, diffuse small group collaboration, and student presentations. Some instructors taught in renovated, high-tech classrooms, while others taught in more traditional spaces. The range of content being taught in the classes included: conflict resolution methods for classroom management, educational technology interface design, methods of online learning, Gardener's theory of multiple intelligences, and adolescent sexuality. Students ranged from undergraduates through doctoral candidates.

Data analysis

Our methods for data analysis were entirely qualitative. We followed the principles of Interaction Analysis (Jordan & Henderson, 1995) to organize and prepare our video data corpus for more detailed analysis. First we created detailed content logs of each class session, describing instructor and student actions and paying careful attention to the various types of artifacts present in the environment and employed by the instructor and students during class time. Interaction analysis suggests annotating video and creating an organizational framework that includes the following: (1) the structure of the event; (2) the temporal organization of the event; (3) the spatial organization of the activity; (4) participation structures; (5) problems and problems solving; and (6) artifacts and documents. In attending to artifacts in particular, we created an emergent

framework of the different types of artifacts we observed and the functions they served in the learning environment. We tracked different types of representations in the data corpus and how they were employed by instructors, creating a descriptive model using a grounded theory approach (Glaser & Strauss, 1967). This method involves an ongoing conversation between the data and an emerging theoretical and/or practical framework. As in much qualitative research, the emergent model used to classify data in this study is a type of results; consequently, our artifact framework and our descriptive model will be described in the next section.

The final step for this analysis was to select case studies representing variance in the descriptive model as well as having practical significance. We chose one case to analyze for this paper: an exemplary case demonstrating the coordination of multiple representations using multiple display artifacts. This case was then analyzed further through even more detailed annotation, transcription, and case-specific model building. It should be pointed out that since this work is ongoing, the framework resulting from the analysis presented here is by no means static or comprehensive, but is rather meant to illustrate the kind of analysis possible when considering the content of instruction as well as the physical environment and the technologies employed.

<div align="center">Results</div>

Artifact Framework

This study sought to create a relatively comprehensive taxonomy of classroom artifacts—a framework which includes inscriptions, gestures, and tools, but also broadens the notion of artifacts to consider objects such as furniture, specific electronic

technologies, and more subtle ambient features of the learning environment like sound and temperature. The aim in this study was not only to classify teaching artifacts, but also to investigate their relationships to pedagogical goals in higher education. Through analysis of eight video cases of university teaching and learning, a taxonomy was created which encompasses six types of artifacts, organized according to their relationships to meaning and knowledge in the classroom: concrete carriers, concrete conveyors, inscriptions, texts, virtual artifacts, and ambient artifacts. Each category will be described in turn.

Concrete carriers are physical objects in the classroom environment which cannot convey or display explicit meanings or knowledge directly, but may carry meanings based on their condition, size, and placement within physical space. The concrete carrier category is primarily comprised of furniture such as the wide variety of tables, cabinets, chairs, and desks found in classrooms. Furniture carries strong meanings about the nature of authority, expected modes of participation, and even normalcy of users' age and body type. For example, small tablet-armchair desks oriented toward the front of a classroom indicate expectations of focus on the instructor, little student-student discussion, and thin and flexible student bodies. Seats bolted to the floor in a lecture hall carry the expectation of minimal student movement and an unswerving focus on the front of the room. It is important to point out that the arrangement and nature of concrete carrier artifacts do not determine classroom activity, but these characteristics impact user expectations and afford greater ease of use for some functions over others (Ching & Ching, 2001).

Concrete conveyors are physical objects in the classroom whose function is to explicitly display representations of knowledge. This category includes instructional technology artifacts such as computers and computer projectors, projection screens, document cameras, television monitors, and VCRs, as well as more traditional display artifacts such as overhead projectors, blackboards, whiteboards, and paper handouts. Conveyor artifacts only display representations of knowledge; they are not themselves representations of knowledge. The exclusive use of some conveyors over others, however, may imply meaning about the nature of knowledge or scholarly activity in a given domain. We have collected large scale survey data from undergraduates at the same university to investigate how they think about instructors' use of various display artifacts, high-tech or otherwise; however, analysis and reporting of this student data is beyond the scope of this paper.

The next two categories of instructional artifacts move away from the focus thus far on sizeable, three-dimensional items such as furniture or computers. *Inscriptions* are defined as written or printed objects which are particularly meaningful for a group of people, require specialized understanding to interpret in significant ways, represent and crystallize knowledge or information, and focus or organize activity (Roth & McGinn, 1998). Examples of inscriptions in university teaching include graphs, charts, tables, equations, schematics, timelines, and many others. Inscriptions are often displayed via another class of artifacts, concrete conveyors; for example, an equation written on the blackboard, a graph projected onto a screen via PowerPoint, etc. Inscriptions are usually a visual representation of information which can be taken in by the viewer all at once; a given inscription typically inhabits a single page, a single screen, or other single display

space. Examining the inscription in greater detail may require focusing in on a sub-part of the representation, such as one column in a table or a single point on a graph, but the overall visual space remains the same.

Unlike inscriptions, *texts* are more lengthy and may occupy multiple display spaces (pages, screens, etc). While inscriptions may usually be taken in visually all at once, texts typically unfold in linear time. Whether reading or viewing, there is almost always a beginning, a middle, and an end. Texts may also be open to multiple interpretations. Examples of texts in university teaching include obvious artifacts like books, articles, and outlines, but also less obvious items like videos, films, simulations, transcripts, and primary source documents. Texts may be displayed via concrete conveyors, for example showing a video with a VCR and television screen or displaying copies of legal documents on the overhead projector, or they may exist on their own, as in a course where everyone reads and brings the same book to class.

The next category, *virtual artifacts*, might seem somewhat out of place in a study which focuses exclusively on face-to-face classroom environments, rather than distance or asynchronous learning. We found, however, that virtual artifacts are not exclusively an on-line phenomenon; the use of gestures in the classroom often results in their creation or co-construction. Previous work on gestures and body language in university teaching has examined how instructors use gestures to direct students' attention to particular parts of a complex inscription (Roth, 2001), or how scientists physically inhabit the realm of theory by acting out the movement of subatomic particles with their bodies (Ochs, et al., 1996). In our data, instructors also often used gestures to create "artifacts in the air," which they would then ask students to attend to and interact with, as if these virtual

artifacts were physically present and visible rather than imagined. For example, in discussing a traditional model of intelligence, the first author drew a normal curve in the air with her index finger and then used both hands to box off the area greater than two standard deviations above the mean, indicating the "gifted" part of the distribution. In another case, an instructor referred back to the outline which had been on the blackboard earlier in class but had since been erased; he walked over to the board, continued talking, and used his hands to point to various parts of the now-missing outline as if it were still displayed.

The final category, *ambient artifacts* is one we struggled with in the development of this framework. Sound, temperature, lighting, and other ambient features seem more relevant to discussions of architecture or human factors than teaching and learning, necessarily. Further, the conditions of many of these items are out of the instructors' control. This particular category was a case, however, in which our fellow participants were truly collaborators in this study. Before we began videotaping, we conducted focus groups with colleagues in the College of Education. The purpose of these focus groups was to inform the College's classroom renovation project, and instructors were given the opportunity to voice their opinions about how classroom conditions should be altered. The focus groups were facilitated and recorded by the first and second authors. Analysis of the focus group data is beyond the scope of this paper; however, we were amazed that characteristics of sound, temperature, and lighting featured so prominently in the discussion. Ambient features seem to be an artifact of learning environments which remains unnoticed until something goes wrong—a noisy class next door or glare from the windows rendering the projection screen unreadable—yet focus group participants

believed these aberrant occurrences to have a strong negative impact on the quality of
teaching and learning. The importance of these artifacts to instructors was clear, hence
their inclusion as the last category in our framework.

Case Study

We now turn to the exemplary case study we selected for further analysis, which
demonstrates how an instructor can leverage multiple technologies and other artifacts for
learning in order to construct and display multiple representations of domain-specific
expert knowing and doing. The instructor we selected is an assistant professor, her class
was a large undergraduate lecture, and on the day we visited, the topic concerned
research on early adolescent sexuality. (The case study is a colleague/participant, not one
of the authors.) Despite being only an hour long, her lecture managed to convey how
developmental research experts in the field of education form a comprehensive
understanding of adolescent sexuality issues by integrating information about policy,
legislation, educational curriculum, sociological and behavioral trends, psychological
identity, personal narrative, and program evaluation.   The professor employed multiple
display artifacts and multiple representational artifacts in her teaching. Table 1 on the
following page shows a chronological outline (an *inscription*, incidentally) of the various
topics covered in her lecture and the artifacts leveraged to convey each one.

<insert Table 1 here>

One of the main reasons this case stands out is that the instructor created an
authentic picture of expert knowledge in this field for her students. She not only drew
together multiple information sources about adolescent sexuality (the aforementioned

issues of policy, behavior, social trends, etc.), but she also displayed inscriptions and texts that are consistent with the types of artifacts encountered by professionals in this field, and helped her students to interpret them. In addition to PowerPoint outlines of information, she included excerpts of actual legislation in discussing educational policy, statistical tables and charts when describing results from large-scale survey data, and narrative individual case histories to illustrate psychological dimensions of sexual identity and their relation to self esteem.   Students thus received not only a descriptive treatment of the topic area, but more importantly, an active experience in expert practice (or as close as one can get in a large lecture, anyway).

Existing literature on teaching in higher education might prescribe several different approaches to examining this case study. Authors advocating "good practice" might focus on those instances when our instructor engaged students in active discussion: students suggested possible societal factors impacting the historical change in adolescent sexual behavior as shown by the timeline; students posed questions about why adolescent males reported higher levels of sexual activity than females on the bar chart; and students responded sympathetically to the narratives and the video subjects' obviously low self esteem. Researchers concerned with technology integration into the college classroom might tally up the number of electronic technologies used—the computer/projector and the VCR—and assess our instructor's facility with the technologies she employed. These approaches, however, seem somewhat narrow, and neither captures the complexity of what our instructor managed to accomplish in her class. Furthermore, these approaches do not address the content being taught and examine technology use and instructors' engagement of students in this context. University instructors are, after all,

first and foremost content experts; to neglect this fact in examining their teaching is to miss a significant part of the big picture.

Discussion & Implications

This study is in an early stage, and it is difficult to draw conclusions from an emergent and still evolving framework derived from eight videos and one in-depth case study. Nevertheless, our study speaks to the existing literature in the field of higher education, particularly studies of instructional technology. We can argue based on our initial findings that an exclusive focus on technology artifacts (concrete conveyors) and their constituent software applications is insufficient to capture the complexity of teaching practices. Studies of technology integration in the college classroom should address not only what is being used, but also the pedagogical and content purposes for which it is used. Although it may be problematic to include less tangible artifacts such as inscriptions and texts in the same framework with instructional technology, such considerations are necessary to get a more complete understanding.

The next steps for our study with our existing data are to explore a variety of instructional practices in as much depth as our current case study. The case study reported here was exemplary of our expert, multiple-representation model. However we also have cases which look different and afford investigation into other important questions. What happens, for example when something goes wrong with the instructional technology, as it often does? How does an instructor then cope with a lesson which does not go according to plan? Another question is how our model can be informed by instructional formats which are not as teacher-centered as our case study. How might

representational activity thus be distributed across multiple participants—teachers and students?

Other long-term goals of this study are to collect more video cases and to collect and analyze more complimentary data. Mentioned earlier in the paper are our existing focus group data and student survey data, which will be analyzed and reported elsewhere. We would also like to tie our observations of teaching practice to post-interviews with our faculty participants and ask them to describe their goals for the recorded lesson, how they feel about the various artifacts in their classroom space, etc. This direction is in line with research suggestions regarding the need to connect faculty's espoused beliefs about the value of educational technology with their actual practices, rather than relying exclusively on self-report surveys (RER, 2002). In addition to participant interviews, we want to collect more video teaching cases from departments across campus. This variety will help us address disciplinary differences in teaching strategies and the relative value of particular artifacts and learning spaces within and across domains.

This issue of studying teaching from multiple domains brings up an issue of researcher subjectivity, however.   The first and second authors are both faculty in the field of education; therefore, we are qualified to attend to the representations of expert cognition and practice that College of Education instructors in our data set were able to achieve in their classes. We bring our own professional vision and background knowledge to examining the intersection of course content and classroom artifacts. This would definitely not be the case in our future study of teaching in engineering, biochemistry, Portuguese, dance, or many other fields. Interviews with instructors outside our areas of expertise, in which they can reflect on their own thinking about the

content area and its relation to their pedagogical choices regarding artifacts for learning, are thus that much more crucial.

And speaking of researcher subjectivity, there is of course the obvious fact that by studying teaching in higher education, we are effectively studying ourselves. In this project in particular, we were *literally* studying ourselves and five of our colleagues, but even in a large future sample without the authors as participants, we would still be studying what we do. Putting college teaching under a microscope seems to imply that there is something wrong with it in its current state; this implication is unsettling for researchers and participants alike. Particularly for professionals in the field of education, research on teaching in other contexts often means evaluation. In fact, it took a great deal of reassurance and explanation for some of our colleagues to understand that we were not interested in evaluating their teaching or somehow ranking them against one another. Once they understood that our approach was phenomenological, and that we ourselves were also participating, they were more willing to let us enter their classrooms. It is our hope that by demonstrating the importance of this kind of research, we will be able to open the doors of the university classroom (both literally and metaphorically) and shift it from a private space of unstudied and undocumented activity to an open forum for marveling at the impressive achievements at the intersection of teaching artifacts and expert cognition found therein.

Acknowledgments

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Table

Table 1.

Case study: Chronological progression of multiple representations in class

Topic	Display Artifact	Representation (Artifact)
Recent change in sex-ed policies	PowerPoint	Timeline (Inscription)
Types of sex-ed programs	PowerPoint	Outline (Text)
Sex-ed legislation	Paper Handout	Legislation excerpt with definition of "Abstinence Only" (Text)
"Comprehensive" vs. other sex-ed	Paper Handout	Comparative table (Inscription)
Sex-ed community survey	PowerPoint	Table with statistical results (Inscription)
Adolescent sexual behavior (Historical)	PowerPoint	Line graph showing changes 1960s-1990s (Inscription)
Adolescent sexual behavior (Modern)	PowerPoint	Bar graph displaying 1995 national survey results (Inscription)
Outcomes of early sexual activity	PowerPoint	Outline (Text)
Factors that influence contraceptive use	PowerPoint	Outline (Text)
Dimensions of sexual identity	PowerPoint	Outline (Text)
Narratives of early sexual activity	VCR/Big Screen	Video (Text)
Interpretation of narratives	Instructor	Repeatedly gestures to screen after video is over (Virtual Artifact)
Disruptive sound	*Bell*	*Loud ringing (Ambient)*
Evaluation of sex-ed programs	PowerPoint	Outline (Text)