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Why Faculty Did—and Did Not—Integrate Instructional Software in Their Undergraduate Classrooms

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ABSTRACT: Using a comparative case study approach, the researcher followed 13 instructors for 2 years as they attempted to integrate the Visible Human Dissector, an educational software program, into their undergraduate anatomy courses. Instructors were motivated to use the software as a supplement for limited educational resources and because of its ability to provide students with novel educational experiences. Obstacles in technology access and services as well as organizational factors prevented integration. However, personal hesitancy and lack of confidence, posited to be a major obstacle to integration in the literature, played only a minimal role in slow integration for these instructors. The greatest obstacles to changes in instruction supported by the new technology were difficulties in finding computers to run the software in traditional anatomy laboratories.

KEY WORDS: educational technology; technology integration; software implementation.

The use of educational technology at university and college campuses has grown and changed substantially in the last 15 years. Once the province of computer science departments, computers and other forms of technology are now being used for multiple functions in diverse educational settings. At many institutions instructors use web pages to organize lecture notes and homework and e-mail and electronic forums to communicate with their students. Inside the classroom, computer projection systems are replacing traditional overhead transparencies, making it possible to harness the interactive and visual capabilities of the computer for lecture and group activities. Outside of class, students work individually using computerized simulations, mathematical graphing and visualization software (Partee, 2002). We know that some uses of educational technology merely substitute a new innovation for an old one without dramatically changing instruction. In other cases, new technology has fundamentally altered how teaching

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and learning occurs at universities and colleges (Seidel & Perez, 1994).

One puzzling aspect of educational technology in both higher education and K-12 settings is why it is not used more than it is. Educational technology promises many benefits to instructors and students, but a great deal of educational technology never reaches the classroom, or is only used sporadically. Recent studies (Bates, 2003; Carneville, 2004; Green, 2001) have found wide acceptance by university and college instructors for applications such as e-mail and the web for personal and professional use, but there has been much less integration of web sites and other specialized applications into the classroom. Examining why instructors implement—or fail to implement—new educational technology for instruction is the focus of the current study.

The question of technology integration is important because higher educational institutions spend enormous amount of money and time on promoting learning technology (Bates, 2003). The amount and character of technology integration into courses has been explained as a result of access to hardware, software, and other physical resources. Yet, even after money has been poured into computer labs, smart classrooms, and technical support, some institutions still find these resources underutilized (Spodark, 2003). At the same time, other instructors "make do" in seemingly resource poor environments, either by using their own equipment or patching together lessons with whatever equipment is available (Warschauer, 2004). An examination of the motivations of instructors, the structural constraints of their workplace, the quality of available software, and other barriers to technology integration sheds light on why more integration does, or does not occur.

Background

Educational Technology Integration

Educational technology designed for instruction and learning covers a wide range of applications, lessons, activities, and games. Most forms of educational technology are used on personal computers, either in the classroom, computer laboratories, or students' homes; but educational technology also encompasses media based on machines such as palm devices and video technology. Formalized lessons such as integrated learning systems (Mills & Ragan, 2000), learning modules (Weston & Barker, 2001), and other highly structured software allow for programmed individualized learning, often at a distance. Instructional technology can also facilitate innovative instructional and learning activities in the classroom. For example, instructors in large lecture courses are increasingly using Class Communication Systems (Beatty, 2004) to assess student knowledge in real time during lectures. Other instructors use the Internet to facilitate group work through moderated discussion forums and threaded discussions (Oliver, 2000). Still others use advanced simulations, visualization software, and games to alter how instruction is delivered and how students learn (Edelson, Gordin, & Pea, 1999). These varied uses of instructional technology can support broader reform efforts to make instruction more interactive and learner-centered.

Definitions of educational technology integration generally focus on sustained and meaningful use of an application for core functions of class instruction or learning (Becker, 2000). Integration means that instructors move from initial adoption and one-time demonstrations to implementing technology as part and parcel of instruction. Full integration is also commonly understood as impacting large numbers of instructors and students through integration at an institutional level (Seidel & Perez, 1994). This definition may not, however, take into account individual faculty members who use technology meaningfully and over a sustained period of time, but who do not collaborate with their peers.

First and Second Order Barriers in K-12

Much of the empirical literature about technology integration is from the study of K-12 settings although faculty at institutions of higher education encounter some of the same challenges for technology integration as K-12 teachers. Ertmer (1999) proposed a two-tiered model with *First and Second Order Barriers* to technology integration and *First and Second Order Change* in instructional practice. First order "extrinsic" barriers are the result of poor physical infrastructure and access, lack of time, and flawed technical/professional development services while second order "intrinsic" barriers are tied to instructor characteristics such as beliefs, values, and entrenched practices. First-order barriers are commonly encountered by teachers who attempt minor ("first order") changes to instruction, such as using a computer projector instead of a traditional overhead to present the same lecture. Second-order barriers are tied to more dramatic "second order" changes in instruction as teachers fundamentally alter how their courses are taught. Ertmer found that second-order barriers are more intractable than first order barriers because they involve "challenging one's belief systems and the institutionalized routines of one's practice" (p. 48). These changes in instruction (e.g., greater use of group learning) are perceived as risky and require changing basic concepts of teaching.

Cuban, Kirkpatrick, and Peck (2001) illustrated the interplay of internal and external factors in technology implementation in their examination of highly-wired schools where technology adoption and integration lagged. A surprising finding of this in-depth case study was that investments in infrastructure and increased access to technology did not lead to increased integration. Instead, most teachers remained "occasional" or "non-users" of classroom technology (p. 813). Moreover, a majority of teachers using computers made only small changes to their instructional practices. The authors identified a number of barriers to integration that arose from the non-technological structural and practical conditions found in schools. Limited time to learn and implement new technology was considered a serious barrier as well as poorly implemented professional development and defects in the technology itself. Above all, the organization and historical context of the school environment was perceived as responsible for the lack of integration. Teachers found it impractical to integrate technology given their 50 minute as submitted class periods, inability to engage in cross-disciplinary collaboration, and lack of planning time. Zhao and Frank (2003) found similar results when examining integration at 19 public schools by using an "ecological" approach to study factors related to teacher attitudes and behavior in the broader context of school organization. Factors relating to teacher characteristics (e.g., propensity toward "exploring new technologies on own"), the practicality of technology use (e.g., "perceived compatibility of the innovation with its surroundings"), and incentives (e.g., a belief that "computers can help the teacher") all predicted computer use (p. 824).

Technology Integration in Higher Education

Fewer empirical studies have focused on technology integration in higher education than on K-12. Spodark (2003) conceptualized implementation as a combination of active organizational initiatives, vision, leadership, infrastructure, and incentives for faculty and faculty participation. Bates (2000) argued that integration hinges on faculty participation in initiatives for instructional reform incorporating technology as instructors overcome an entrenched institutional culture favoring research over teaching. Bates study of best practice institutions found that technology integration was promoted by strong plans for the use of instructional technology combining “extensive investment in technological infrastructure” as well as adequate support and training for faculty members (p. 99). In Bates’ model, investment in infrastructure and training resulted in pervasive technology use throughout the institution. Professional development at these institutions emphasized teaching and learning supported and facilitated, but not determined, by technology.

Miller, Martineau, and Clark (2000) divided barriers to technology integration into organizational and individual, a division similar to Ertmer’s (1999). Like Bates, these authors cited the lack of incentives for changing instruction in higher educational institutions as the “most critical” (p. 232) barrier to the use of educational technology. Other researchers (Rice & Miller, 2001; Spodark, 2003) also focused on the failure of many institutions to establish and implement strategic plans to increase technological use among faculty. Johnson (2000) argued that the diffusion of technology depends upon administrators properly framing top-down initiatives, establishing a favorable environment for use, and making sure faculty clearly understand how the benefits of technology use outweigh drawbacks.

Individual resistance is also identified (along with organizational barriers) by Miller et al. (2000) as a barrier to integration. These authors asserted that faculty members who do not implement technology have vague conceptions of the benefits of technology for teaching as well as an inability to formulate specific plans for implementation. Entrenched instructional practices also prevent faculty from using new technology. As instructors are asked to integrate new technology, they are also challenged to engage in more rigorous course planning and demonstrate a willingness to take risks. Faculty may not wish to change familiar instructional practices for newer and more time consuming methods that incorporate technology, especially if the benefits of the new approach are poorly defined or vaguely understood.

Method

For this study, I examined the experiences of instructors attempting to integrate an innovative software application into their courses at 10 institutions. The central question is: Why did the instructors use, or not use an innovative anatomy software in the classroom? The research examined both motivators and obstacles to use.

A comparative case study approach (Stake, 1995) examined motivation and obstacles for technology use by instructors using a new anatomy software system. The research is part of the evaluation of a 3-year National Science Foundation (NSF) funded project[1] to develop and integrate the Visible Human Dissector (VHD) software into undergraduate anatomy classrooms in Colorado.

Participants

Thirteen instructors at 10 institutions participated in the study. The instructors were identified through previous contacts with anatomy education workshops held by the *Center for Human Simulation*, the developers of the Visible Human Project and the VHD software. All instructors who volunteered for the study were chosen to participate. Instructors joined the project with no requirement to use the software, but with an expressed willingness to integrate the VHD into their classrooms. All 13 volunteers participated in workshops offered by the center. In the workshops, instructors learned to use the software while providing feedback for developers on software design. Instructors were from the same general geographical area (Colorado) and ranged from full professors at large state institutions to adjunct instructors at community colleges.

Data Collection and Analysis

The researcher used a full array of qualitative data collection methods over the first two years of the project. Eighteen observations made at five institutions which allowed class visits provided detailed descriptions of use and written field notes for analysis. Structured and informal interviews with instructors were conducted at the beginning and at intervals throughout the project. A 45 minute culminating interview was conducted at the end of the project. Transcripts were made of the tape-recorded interviews. Short surveys with both closed and open-ended response options were given at five workshops to record use and perceptions of implementation obstacles. All textual data including transcripts, field notes, and open-ended survey responses were analyzed using a domain analysis (Spradley, 1979).

A wide range of topics was covered during interviews and surveys. Participants were asked how, when, and where they used the VHD

[1]National Science Foundation: DUE: CCLI: Educational Materials Development. 0127574. All requisite Human Research approvals were in place for this research.

application; if and how the application had changed instruction and learning; and what content was covered by lessons or activities incorporating the application. At the beginning of the project, instructors were asked open-ended questions about obstacles and motivation for use. Answers to open-ended questions were formalized into a list of motivators and obstacles for the culminating interview.

The Application

The Visible Human Dissector (VHD) software is an outgrowth of the Visible Human Project (originally funded by the National Library of Medicine), an ongoing 11-year effort to digitally reconstruct human anatomy from human cadavers (Center for Human Simulation, 2004; Grice, 2001). The current version of the VHD, developed for undergraduate and medical school courses in anatomy and related fields, allows the user to dissect virtually a visual representation of the visible human male[2] using the computer mouse. Other features of the applications include the ability to access lists of structures in different categories, make images larger or smaller, rotate the body or its structures, add or take away skin opacity (the ability to see internal structures in relation to external features), and see cross-sections of structures. Users can also write "scripts," or series of images produced by the instructor similar to a slide show by linking html documents to images produced by the VHD.

The VHD can be used in a variety of instructional settings. Instructors use the application to present lecture material with a computer projector or present demonstrations and ask questions about images to smaller groups with a personal or laptop computer. Students also use the application in computer labs or study anatomy with the software at home. In some cases, the VHD is used in tandem with actual cadavers as a resource or lesson guide during dissection lab.

Results

Overview

In order to answer the research questions, this study examined the use of the VHD application, motivations for its use, and obstacles

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[2]A Visible Human female is currently being prepared at the Center.

preventing either its use altogether or obstacles to possible use. Instructors' attitudes and past experience with technology were also examined to learn whether or not these played a part in decisions to use or not use the technology. *Descriptions of use* examined which instructional methods and learning activities were used with the VHD and in which settings. Categories of *motivation for use* and *obstacles for use* came from interviews and surveys with faculty. Overall, instructors were motivated to use the VHD because it filled in as a substitute for other limited educational resources such as cadavers, because of its novel capabilities as an educational tool, and because they were generally comfortable using technology. Obstacles included difficulties in finding the right equipment and accessing machines, inflexibility of curriculum and work and institutional constraints, as well as some personal hesitancy to use technology.

Use

The researcher classified instructors as *classroom*, *late classroom*, *outside classroom* or *infrequent* users of the application for purposes of analysis. The criteria for grouping *classroom* instructors included (1) use of the application during class and (2) use over multiple times during a semester or quarter. *Late classroom* instructors implemented the VHD after more than one semester of participation in the project. *Outside classroom* users employed the application as a required student activity outside of class. *Infrequent* users attended workshops, but used the application only sporadically for lecture, allowed students to use the application optionally outside of class, or did not use the application at all. Table I provides detailed information about software use by the instructors in the study.

Examination of observation, interview, and survey data found that, when compared to past accounts of course activities, all but one instructor using the VHD did not alter how lecture or lab were conducted because of the application's introduction. One instructor said he changed his instruction "substantially" to incorporate the VHD by introducing small discussion groups into his anatomy lab using the application; this change was validated through classroom observation. Other instructors said that the use of the application replaced existing Power Point demonstrations, moved independent study material from print to the computer, or allowed students to view images in a different media (e.g., moved from print to computer).

Table I
VHD Use by Instructor

Institution	Instructor position	Predominant use(s)	User group
Large State University 1	2 (team) Assistant professor instructor	Student use for independent study, no lecture	Outside
Large State University 2	Laboratory instructor	Optional student use outside classroom, use with teacher's assistants	Infrequent
Small State University 1	Assistant professor	None	Infrequent
Small State University 2	Full professor	None	Infrequent
	Visiting professor	Individual use required in class	Outside
Private University 1	Associate professor	Lecture	Classroom
Inner-city Community College 1	Instructor	Lecture, assessment, group discussion	Classroom
	Instructor	Lecture, group discussion	Late Classroom
Urban Community College 2	Instructor	None, but planned	Late classroom
Rural Community College	Instructor	Lecture, assessment	Classroom
Suburban Community College 1	Instructor	None, but planned	Late classroom
Suburban Community College 2	Instructor	Optional student use	Infrequent

Motivators: Resources and Tools

An important quality of the VHD as an instructional resource is its ability to stand in or supplement the use of human and animal cadavers. As background it should be noted that anatomy education is fundamentally linked to the availability of cadavers. Even where human cadavers are available (usually at larger institutions), they are expensive and access to them is often highly limited. Smaller institutions generally use animal cadavers or rely on models and images.

Motivation for using the VHD came from perceived benefits related to *limited access to instructional resources* (e.g., cadavers) and the use of the VHD as an *innovative cognitive tool*—a resource that was perceived as allowing instructors and students to manipulate images in novel ways. While few instructors (or even the designers of the VHD) would advocate entirely replacing cadavers with a computer simulation, instructors found the VHD filled an obvious need. For those institutions with human cadavers, the application allowed students access to simulated cadavers free of time restrictions. For four classroom users at community colleges (where no human cadavers were used), access to 3-dimensional human imagery was paramount in their decisions to implement the VHD. Two instructors used the application for assessment purposes, quizzing students on visual representations of human anatomical structures or leading discussions about anatomical systems with small groups gathered around a laptop. Previously, this type of assessment was only possible with cadavers, illustrations, or models. Instructors perceived the use of the VHD for assessment as streamlining practical testing while allowing for more complex testing of anatomical systems versus simpler isolated structures.

All instructors in the study also said that the VHD had advantages over other resources as a cognitive tool, providing a means for students to learn anatomy in a qualitatively different manner than was provided by other resources. Unlike a book, it provided a three-dimensional representation; and unlike other anatomical software packages it presented a representation of a real human and not schematic drawings. For institutions without human cadavers, the VHD allowed a virtual representation of a human (versus an animal), which instructors found superior to models and flat images. Instructors also praised the VHD's ability to isolate and link anatomical systems and show relationships between structures, qualities they found difficult if not impossible with other media.

Motivators: Personal Attitudes of Instructors

All but one of the instructors stated that they were comfortable with technology in general and with other forms of educational technology. In the *classroom* group, two instructors identifying themselves as "technophiles" used other educational technology such as web pages and Power Point in their classrooms. Both also used non-educational technological innovations such as palm pilots and subscribed to or read computer related publications. One instructor in the classroom user group did not consider himself an "early adopter," but had used educational technology in his course before. All but one of those in the *outside classroom* and *infrequent user* groups had used other technology (e.g., Power Point) before in their courses and said they felt comfortable with using technology for personal uses.

Obstacles: Equipment and Accessibility

With several exceptions, each of the institutions in the study had excellent or adequate computer resources for running the VHD application as determined by (1) the presence of computers less than 3 years old and (2) access to centrally located computer laboratories. At an inner city community college, the computer laboratory devoted to the VHD contained older machines (5 years old) housed in a crowded room; these computers were replaced after 2 years into the study. At the same institution, the computer projection system broke down half way through the second semester of the study. Two other institutions did not have computer projection systems.

For some instructors, the ability to use the VHD was partly determined by services provided by information technology (IT) organizations responsible for installing the application in computer labs. Instructors at smaller institutions (community colleges and the private college) did not perceive this as a problem since they knew the IT staff and generally could count on quick responses to service requests. Installation became difficult at three larger state institutions with instructors at one state institution waiting for over a year until the application was installed and another waiting 4 months. Engaging the IT organizations at the larger state universities required a series of phone calls, waits for call-backs, and few or no face-to-face contacts with personnel. Moreover, larger institutions were much more hesitant to install potentially untested software on machines on their campuses.

Another obstacle to implementation was the lack of computer resources in anatomy laboratories. One possible use of the application was as an adjunct to dissection or other activities in anatomy labs, with students using the VHD as a reference to orient themselves to cadavers, animals, or models.[3] However, most anatomy laboratories visited during the study looked as if they had changed little in the last 25 years, with either human or animal cadavers used for dissection

[3] One medical school not involved in the current study was in fact using the application in this way.

and specimens of bones and organs in cabinets. Several institutions had one or two older computers in the anatomy lab that would not run the application, but were used for making notes. Instructors faced substantial difficulties finding computers to run the application in anatomy laboratories; many departmental budgets were devoted to buying cadavers (or other materials) and had little left for technology. At several institutions, instructors attempted to go through informal channels to borrow or receive donated hand-me-down computers for this purpose. One instructor abandoned this quest after a long and unsuccessful effort to upgrade donated laptops. Others said they had few or no organizational channels for buying computers for this purpose.

Obstacles: Inflexibility of Curriculum

Instructors perceived large classes with highly structured course and laboratory plans as an obstacle to integration. At three universities, the same course had been taught for many years by a series of different instructors. Because of the perceived inflexibility of course content and schedules, these instructors found changing courses to incorporate new instructional methods and technology difficult and sometimes impossible. At the two large state universities and at a smaller state university this was identified as a significant obstacle to integration into the classroom. This was especially critical in attempts to bring the VHD into the human cadaver lab. As one instructor said "access to cadavers is so limited, there's no time to use the computer in lab." Conversely, one commonality among classroom users said to motivate use was a lack of rigid curricular constraints; all said they were relatively free of tight oversight on what could be taught and how, and had designed their own courses as opposed to teaching existing courses.

Obstacles: Work and Institutional Constraints

The obstacle of limited time for learning and preparing lessons using the application was common for almost all instructors using the VHD; all but two instructors said they had difficulty finding the extra time needed to learn the application and write scripts or lessons for lecture or laboratory presentation. Limited time was a formidable obstacle for instructors attempting to write scripts. The production of longer scripts was a time intensive effort sometimes taking three to four times as long as the resulting lecture presentation. Instructors found this effort daunting, and two said they avoided using the application in the classroom because of this perceived extra work. Two instructors in the classroom group who used the application frequently said that work on the VHD took the place of preparation of materials in other areas (e.g., Power Point presentations) and thus did not add much time to their workload.

Obstacles: Personal Attitudes of Instructors

In the present study, only one instructor said outright that she had difficulty implementing the new technology because of a "lack of confidence." In other cases, instructors in the *infrequent use* group tended to cite a mixture of outside obstacles and internal reasons for not using the technology. One instructor said that her failure to learn the application and implement it in her course was due to a combination of "procrastination" and a lack of time. Two other instructors attributed their lack of use to overly busy schedules combined with a general lack of motivation to change their instruction.

Discussion

Why did the instructors in this study use, and not use the VHD? The policy models for increased technology integration laid out by Bates (2000), Spodark (2003) and Miller et al. (2000) emphasize that integration is encouraged by infrastructure investment, institutional initiatives (e.g., professional development), the development of a campus culture that emphasizes leadership, and a critical mass of users and faculty participation. Changes to institutional contexts of work and structural incentives are also recommended by these authors. In the current study, instructors cited some of the same factors in their decisions to integrate the VHD; in other cases the motivations and obstacles for technology use were somewhat different than the model presented in the literature.

Dramatic awards such as recognition, added pay, or credit toward promotion/tenure for technology integration and altered instructional practices would be welcomed by almost all instructors in the study; but 10 of 13 instructors said that fairly minor incentives such as course buyouts would help immensely in motivating use. These incentives were not in place at any of the institutions, so are not listed as motivators for use. All but one instructor said their institutions already viewed technology integration "as a good thing," but said changes to policies rewarding the significant amounts of work needed to implement new technology were not in place. At universities, spending significant amount of time working on technology integration with the VHD did not fit easily into schedules; and instructors at larger state institutions and some of the community colleges where workload was high attempted to have assistants, visiting faculty, or students develop lesson material for the application. Institutions could help encourage technology integration for the faculty in this study by allowing instructors to spend time working on lessons incorporating technology (or other changes to instruction) through the provision of course buyouts, providing money for paying assistants to develop lesson material, or counting time for materials development as teaching service.

In Ertmer's (1999) analysis, first and second order barriers to change corresponded with (either) small or more dramatic changes to instructional practices. For the instructors using the VHD, substantial first order barriers of poor or missing equipment and slow IT services were present for five instructors. In most of these cases, instructors managed to surmount these first-order obstacles and implement some form of integration. However, it was almost impossible to make second-order changes to instruction by using the VHD as an adjunct to dissection or other activities in the anatomy laboratory because of first-order external obstacles related to funding, bureaucracy, and a lack of precedent for using computers in anatomy laboratories. These structural obstacles to technology use may be common for instructors at many colleges and universities. It is a situation markedly different than a model that posits a fundamental personal reluctance among instructors to change instructional practices because of fear or lack of confidence.

This situation is analogous to difficulties placing computers in public school K-12 classrooms. Becker (2000) found that teachers faced significant challenges overcoming centralized laboratory models of computer usage, but that meaningful computer use increased when more than five computers were placed in the classroom. Solutions to this problem lie in the ability to make resources more portable, multi-use, and decentralized, a policy that retains roughly the same level of investment but shifts resources away from traditional computer laboratories. Instructors said that even small diversions in resources (e.g., donation of used computers) could have tipped the balance toward laboratory use, but no organizational avenues existed for recognizing and facilitating unanticipated technology implementation.

Bates (2000) and Ertmer's (1999) calls for dramatic changes to professional development did not resonate with the instructors in this study. Ertmer suggested that a vital role of institutions was to provide models for technology integration and encourage collaboration among colleagues. Bates called for fundamental changes at universities to emphasize innovative teaching as well as the encouragement of role models and suggested making professional development in technology instruction a required activity, linked to computer purchasing as it is at Virginia Tech (p. 100).

The instructors in the current study operated in highly autonomous environments and, with some exceptions, did not collaborate in the classroom with peers. Almost half of the institutions had active technology and/or teaching initiatives designed to help instructors integrate technology in their courses and provide professional development for changing instruction; but none of the instructors had interacted with specialists or had taken advantage of related professional development efforts. In general, instructors only interacted with institutional IT initiatives when accessing infrastructure and equipment. This seeming indifference of instructors toward campus initiatives could partly be due to the provision of training by the developers of the VHD (making many campus professional development services unnecessary) or to poor program implementation on the part of schools. However, most instructors felt that even if they had not attended the professional development workshops offered by the CHS, the institution would not have much to offer them in way of extra help, training, or incentives. Moreover, at the larger state institutions, IT specialists and others linked to educational technology initiatives were perceived more of an obstacle than help.

Instructors who infrequently used the VHD or who used the application with their students only minimally reported resistance to using the application based on a general fear of technology or deep-seated resistance to change. These fears were complicit in decisions to hold off on integration efforts, but they must be viewed in tandem with how instructors conceptualized the potential benefits of using the application and the severity of obstacles in the environment. For some instructors in the study, the immediacy of the VHD's benefit as a human dissection simulation and as a way to enable novel instructional and learning activities motivated them to overcome any external barriers.

In other cases, a disposition to procrastinate or a general lack of confidence was coupled with real obstacles such as a lack of computer projection equipment or difficulties with IT services. In only one case was any suggestion of "technophobia" involved in integration; all but one instructor in the *infrequent use* group said they were comfortable with both educational and other technology. While some might make the case that some instructors lacked the will or were clinging to entrenched practices when they failed to implement true second-order instructional change, this would ignore the immense difficulty of such an undertaking.

Conclusion

Because of the small number of instructors involved in the study and the case-study nature of the data it is not possible to offer prescriptive recommendations or highly reliable generalizations about technology integration. The present study does, however, provide a sense of how first- and second-order barriers to technology integration work at universities and colleges with one specific application and how findings support or contradict existing literature. Examining the distribution of these obstacles in the population of faculty and instructors at universities and colleges would involve a large-scale survey.

The current study examined how instructors at 10 institutions integrated new anatomy software into their courses. Instructors were motivated to use the application because of its perceived benefit as a cognitive tool for students and as a supplement for limited instructional resources in anatomy classrooms and laboratories. They were prevented from using the VHD to its fullest capability because of obstacles in technology access and services, as well as organizational factors in the institution. While personal hesitancy and lack of confidence played some role in slow integration, the greatest obstacle to implementing a substantially changed method of instruction was the fundamental difficulty in finding resources to install computers to run the software in anatomy laboratories.

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