A Phenomenological Defense of Computer-Simulated Frog Dissection

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Abstract
Defenders of educational frog dissection tend to emphasize the claim that computer-simulated alternatives cannot replicate the same exact experience of slicing open a frog, with all its queasy and visceral impact. Without denying that point, I argue that this is not the only educational standard against which computer-simulated dissection should be evaluated. When real-world frog dissection is analyzed as a concrete technological practice rather than an assumed ideal, the particular educational advantages distinct to real-world dissection and virtual dissection can be enumerated and compared. Building on the work of John Dewey and Don Ihde, I explore the still-expanding advantages of computer-simulated dissection, and in this proper context of comparison it becomes clear that virtual alternatives are increasingly the more educationally beneficial option.

Keywords: educational computing; simulation; progressive education; animal rights; animal advocacy; frog dissection; postphenomenology

Phenomenology has proven especially useful within the field of philosophy of technology for uncovering just how deeply the experience of this or that new technology lacks the depth of more traditional experiences, and thus how the new technology may not live up to its surrounding hype. By providing a conceptual framework for describing an individual's experience, phenomenology lends itself readily both to the task of articulating the striking richness of our everyday experience, and to that of evaluating whether a newly-offered technologically-simulated event lives up to the comparison. Hubert Dreyfus's critique of AI research is perhaps the most influential example of this line of cautioning, along with his more recent evaluation of distance learning and Don Ihde's reservations about virtual reality (Dreyfus, 1972; Dreyfus, 2001; Ihde, 2002). Albert Borgmann's multiple critiques of contemporary relationships with commonplace technologies, such as television and fast food, are also paradigmatic examples (Borgmann, 1984; Borgmann, 1992).

It is because phenomenology lends itself so readily to projects that articulate the things that technologically-mediated experiences lack that here I want to offer an explicit corrective: I develop a phenomenological account of the distinct richness that is possible for computer simulation in the classroom context. In Norm Friesen's anchor piece for this special issue of *Techné*, "Dissection and Simulation: Brilliance and Transparency, or Encumbrance and Disruption?," he presents phenomenological descriptions of the experience of both traditional classroom frog corpse dissection and a computer simulation of frog dissection. While Friesen states explicitly that he does not intend to enter the debate over which is to be preferred, my suspicion is that due to the readiness of phenomenology to point out the wilt of simulated experiences compared to those of the real world, his piece provides stronger tools to the pro-corpse-dissection side. That is, by detailing the "sensual assault" of real-world corpse dissection in contrast to the "muted" experience of computer-simulated dissection, a reader may come away from Friesen's descriptions with the impression that the depth and vividness of the experience of the dissection of a real frog corpse is so great that it presents an indispensible pedagogical opportunity (Friesen, 2012). As I show below, that impression short-changes the potential of computer-simulated dissection and it overlooks the limitations resulting from the artefacts of corpse dissection.

In what follows, I develop a phenomenological defence of computer-simulated frog dissection in the primary and secondary school classroom. I begin with a review of John Dewey's account of progressive education, the pedagogical context within which both corpse dissection and computer-simulated dissection fit. Next, I review a phenomenological account of the experience of computer interface, and I contrast that with the experience of the interface of the tools of real-world corpse dissection. Finally, computer-simulated dissection and corpse dissection are contrasted in terms of the very different kinds of educational experiences they provide. Here it is important both to consider the potential for computer-simulation to be expanded to include educational experiences unique to the virtual context, and also to consider the limitations inherent in the technological mediation of classroom corpse dissection.

With the following phenomenological reflections, I hope to challenge at least three intuitions that may underlie the thoughts of those inclined to prefer frog corpse dissection in the classroom: (1) that the vividness of the experience of corpse dissection makes it indispensible to biology instruction; (2) that the pedagogical effectiveness of computer-simulated dissection should be evaluated primarily on how well it imitates corpse dissection; and (3) that "real-world" corpse dissection presents students with any kind of unmediated access to educational content. By offering phenomenological deflations of these intuitions, and by brainstorming the ways that computer-simulated frog dissections could continue to be expanded into novel educational ground, I hope to supplement the ethical and environmental arguments that have already been developed in defence of computer-simulated animal dissection in the classroom.[1]

1. The Progressive Education Context

Much of the debate over frog dissection in the classroom occurs within the context of a general commitment to the values of "progressive education." In this perspective, schooling should create experiences that engage students' individual interests, encourage creativity, and link up lessons with the concerns of the wider community. This view can be contrasted with the "essentialist" perspective on education, as it is often referred in the field of teacher education, which advocates a focus on the most basic (or essential) knowledge and skills, such as math and writing, and recommends the use of repeated drills, standardized testing, and classic textbook work. Sometimes the history of education in the United States is cast in terms of an oscillation between essentialist and progressive values. Yet while the paradigm of education in the US set by the 2001 *No Child Left Behind* legislation certainly reflects the contemporary ascension of essentialism, progressive values are reflected in many still-common institutions, such as class trips, guidance councilors, and, relevant here, science laboratory exercises. Much of the discussion over frog corpse dissection and computer-simulated frog dissection occurs together within the context of a shared general commitment to the progressive framework; the advocates for both frog corpse dissection and computer-simulated frog dissection together appear to agree that the creation of vivid, hands-on, interactive classroom experiences is important for learning about biology.

A chief developer and advocate of the progressive educational perspective is the American pragmatist philosopher John Dewey (e.g., 1897; 1916; 1938). Not only did he develop the theoretical underpinnings of this perspective, he was a dedicated participant, founding the Laboratory School associated with University of Chicago which built its curricula on these ideas. Dewey often cast his claims in terms of the contrast between progressive schooling and essentialism (or "traditional education," as he called it). He insisted on the importance of assessing the individual student's experience in the classroom. This remains important, according to Dewey, not only for the progressive setting, but also for the traditional classroom, with its standardized textbooks, forward-facing desks, worksheets, and droning lectures. He says, "It is a great mistake to suppose, even tacitly, that the traditional schoolroom was not a place in which students had experiences" (Dewey, 1938, 26). For Dewey, the dull and disconnected context of traditional education *does* create an experience for students: a boring one which fails to provide lasting knowledge by failing to link teachings to students' lives outside the classroom. He contrasts traditional and progressive schooling respectively as follows:

> To imposition from above is opposed expression and cultivation of individuality; to external discipline is opposed free activity; to learning from texts and teachers, learning through experience; to acquisition of isolated skills and techniques by drill, is opposed acquisition of them as means of attaining ends which make direct and vital appeal; to preparation for a more or less remote future is opposed making the most of opportunities present in life; to static airs and materials is opposed acquaintance with a changing world (Dewey, 1938, 19-20).

According to Dewey, in order to understand exactly why it is that progressive education is important for learning, we must develop a deeper understanding of what it means to have an experience. He says, "Everything depends upon the *quality* of the experience which is had. The quality of any experience has two aspects. There is an immediate agreeableness or disagreeableness, and there is an influence upon later experiences" (Dewey, 1938, 27). A given educational experience should be relevant to the experiences of other aspects of the student's life, should lead the student to connect those parts together, and should lead to the growth of further experiences. It is important to remember that an educational experience also has the potential to remain isolated, failing to tie to one's larger life, and possibly inhibiting the growth of further experiences (say, by implying that school lessons are unrelated to real-life concerns, or by stifling creativity). As he puts it, "Every experience is a moving force. Its value can be judged only on the ground of what it moves toward and into" (Dewey, 1938, 38). The traditional approach, with its dry textbooks, abstract knowledge, and repetitive exercises, only creates experiences which "move toward and into" an attitude that classroom lessons are boring and irrelevant. He writes that with traditional education, "the subject-matter in question was learned in isolation; it was put, as it were, in a water tight compartment" (Dewey, 1938, 48). The lessons of a progressive classroom are, in contrast, learned through interactive and flexible classroom activities that maintain a connection to the larger environment. This kind of schooling, according to Dewey, creates learners that can apply their knowledge, and thus engenders citizens concerned with their communities.

Frog dissection—in both its real-world corpse and computer-simulated instantiations—clearly fits into the progressive model. Both instantiations are undeniably hands-on. And both create rich experiences for students in the classroom. Also undeniable is the fact that these two general options—corpse and simulation—create very different experiences for students. As Friesen shows clearly in his article in this volume, the experience of each of these options is quite distinct. My goal in what follows is neither to suggest that computers can adequately mimic corpse simulation, nor to assume that the closer a simulation can get to mimicking corpse dissection the greater educational value it would possess. The goal is instead to compare and contrast the educational value, in a progressive sense, of the very different experiences of frog corpse dissection and computer-simulated frog dissection.

2. A Phenomenology of Computer Interface

Philosophers of technology working from the phenomenological tradition often conceive of the relationships between users and technologies in terms of the notion of *mediation* (e.g., Verbeek, 2005; Kockelkoren, 2007; Ihde, 2009; Rosenberger, 2009).[2] Under this conception, a technology is understood to be an intermediate aspect of a user's experience, one that changes the user's abilities to perceive and/or to act on the world. Thus, in this view, a human-technology relation is non-neutral; it non-innocently alters a user's experience of the world. As a user experiences the world through the mediation of the technology, she or he interacts with the technology's *interface*, i.e., those aspects of the technology that are intended to be explicitly engaged. However, as explored below, even the technology's interface does not always maintain an explicit place within a user's awareness.[3] In this section, I consider the phenomenology of human-computer interface, and contrast this with the interface of the tools used in classroom corpse dissection.

A central relationship that a user may develop with a technology is one in which a user's experience of her or his own body is extended to include the device. Maurice Merleau-Ponty offers the example of a blind man using a cane. He writes, "The blind man's stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch, and providing a parallel to sight" (Merleau-Ponty, 1962, 143). Don Ihde uses the term *embodiment relation* to refer to this kind of human-technology interaction (Ihde, 2009, 42). In such cases, the technology itself is not the central object of the user's encounter; the technology is the means by which the user experiences an encounter with the world, a mediated encounter through which both the user and the world are transformed. In addition, whether the technology's interface itself remains conspicuous within the user's awareness depends in part on just how accustomed she or he is to the device. For one deeply accustomed to using a particular technology, the experience of the device itself may take on less significance within one's overall awareness. Ihde uses the term *transparency* to refer to the particular degree to which the technology recedes into the background of awareness as it is used (2009, 42). In this terminology, the blind man's cane transforms his perceptual abilities and also in the process it takes on a degree of transparency. That is, even as the cane enacts transformations to his perception, it fades into the background of his awareness.[4]

While a technology may be designed for a particular purpose, it always remains the case that individual users can interpret that technology differently and use it for different purposes within a different context. Ihde refers to this as the *multistability* of technology (2009, 14). An individual technology has the potential to mediate the relation between a user and the world in multiple ways. Yet at the same time, as a concrete material object, that technology cannot simply make any kind of relation to the world possible; though multiple, only certain "stable" relations to the world are enabled by a technology.

To understand this notion, it is helpful to bring to mind examples of technologies which are often taken up for purposes quite different from that for which they were designed. I have offered the example of the magnifying glass (Rosenberger, 2009, 176). A magnifying glass is of course a tool designed for the purpose of enlarging something to see it better. However, there is another purpose for which it can be used. A magnifying glass can also be used for focusing light to start a fire (like Piggy's glasses in *Lord of the Flies*, Golding, 1955). We can even imagine a user for whom the primary relationship to the device has developed in terms of this alternate usage. Since this user is deeply accustomed to focusing light with the magnifying glass, she or he will have developed a deeply sedimented habitual relationship with the device in terms of this usage, and as it is used the magnifying glass itself may take on a high degree of transparency. As highly transparent, the user pays more conscious attention to task of focusing the beam of light than on the bodily comportments of holding and positioning the magnifying glass in hand. I have used the term *relational strategy* to refer to the particular bodily comportments, habits, and understandings that enable a user to take up a technology in terms of a particular stability (Rosenberger, 2009; Rosenberger, forthcoming). This paragraph has described some details of the general relational strategy involved in using a magnifying glass for its fire-starting stability. It would be possible to then contrast these details with those involved in taking up this technology in terms of its more traditional—i.e., magnifying—stability.[5]

Computers (in their various forms—desktop, laptop, tablet, handheld, etc.) and computer programs (e.g., software packages, websites, smartphone applications) can both be conceived in terms of user experience of interface. For example, the interface of a typical desktop computer includes a user typing a keyboard, maneuvering and clicking a mouse, and looking at a screen. In order to use a desktop computer in a smooth manner, a user must develop many specific bodily comportments and understandings which relate to the various features of the device; from a sense of the arrangement of the QUERTY keyboard, to familiarity with the positioning of one's fingers above the proper keys; from accustomedness to the feeling of the mouse under hand, to the anticipation of its corresponding movements on the screen (including a tacit understanding of the on-screen mouse's changing form: from arrow, to hand, to typing cursor, to the "standby" notice of the twirling pinwheel or hourglass). As a user becomes more and more accustomed to the relational strategies required for standard desktop computer use, these aspects of interface take on a greater and greater degree of transparency. Over time, the user is able to focus more and more on what she or he is trying to with the computer, rather than on these features of interface themselves. That is, through general computer interface training, the computer becomes embodied.[6]

A similar story can be told about the user's relation to the programs she or he runs on the computer. One can come to embody these programs in specific ways as one becomes accustomed to their use. For example, consider the experience of "logging in" to an email provider's website. For many, checking email is a commonplace activity engaged daily, if not multiple times daily. The relational strategy for interacting with the website includes, for example, an anticipation of where on the screen sign-in boxes will appear, an expectation about the placement of on-screen icons and buttons, and preconceptions about the procedures for reading and writing emails. For an everyday user, these aspects of interface with the email website may be experienced with a high degree of transparency. Through the force of well-established habits of bodily and perceptual interaction with the program's interface, the accustomed user experiences the content of her or his email with a greater significance than she or he does the means of interface itself.

The notions of embodiment, transparency, and relational strategies can be applied to the interface involved in both corpse dissection and computer-simulated dissection. As Friesen points out, the relational strategies involved in the use of computer simulations of dissection largely reduce to those described above regarding desktop computer use generally. Despite the possibility of on-screen representations of scalpels, magnifying glasses, and pins, a user's approach to computer-simulated dissection occurs in terms of bodily relations to mouse clicks, keystrokes, and screen watching. In striking contrast, real-world corpse dissection involves grasping scalpels, rendering incisions into flesh, pushing pins through appendages, encountering the smells of formaldehyde, and such.

Independent of the biology lessons of dissection (addressed in the next section), questions can first be raised about the educational value of the interface of each mode of dissection itself. Following Dewey, we can consider what further experiences will connect up with the experiences of the interface of corpse dissection and computer-simulated dissection. That is, we can ask how training regarding each of these forms of dissection—corpse and simulation—is educationally valuable to students in itself. In the case of computer-simulated dissection interface, the value of the interface training is straightforward: using a computer program about dissection involves learning about how to use the computer generally. Instruction regarding this kind of interface may be more or less important depending on the individual student's knowledge of computers. This relation also opens the possibility of integrating the dissection simulation with other lessons about computer interface, such as typing instruction.

In the case of the tools of real-world corpse dissection such as blades and pins, it is less clear into what further experiences of primary and secondary school instruction these experiences of interface may "flow," as Dewey would say. Put another way, it is unclear what educational value in itself is possessed by, say, pressing a pin through a dead frog's wrist. However, it is impossible not to acknowledge that such an experience would be as memorably discomforting as Friesen's paper underlines. The use of these tools adds a visceral dimension—e.g., the feeling in one's hand of the scalpel as it is pulled though the frog's resisting skin—to an experience of content (i.e., entrails) that is already fraught with uneasiness and abjection. With that acknowledged, I agree with Estrid Sørensen's observation in her contribution to this volume that Friesen's article overlooks the level of disgust that students still experience through dissection simulated on the computer (2012).

Of course the lessons learned through the experience of interface are not only those which reduce to interface training itself; lessons learned through interface training exist in relation to the experience of the content of the dissection exercise. A. David Kline makes this point while defending corpse dissection, stating, "There is certain knowledge that they [students] can get best by cutting open the abdomen of a creature and seeing the mesentery. By exercising knowledge *how*, they attain knowledge *that*" (1995, 194). That is, mastering the otherwise irrelevant interface of corpse dissection is part of a process that, according to Kline, is the best way for students to learn the anatomy lessons at issue. I agree that the experience of interface is valuable most of all for its relation to lesson content. However, I suggest that pro-corpse dissection views like Kline's assume that the lessons learnable through the evisceration of a corpse are the only ones that should be considered in this debate. In the next section, I show this to be their crucial mistake.

3. Lesson Content Mediated by Computer Simulations and Laboratory Corpses

While it may be differences in interface that jump first to mind when contrasting computer-simulated dissection and real-world corpse dissection—the mouse clicking vs. the scalpel wielding—these two educational practices also mediate student experience very differently. That is, it is not only the interaction with tools that is different; these two practices make possible very different learning experiences of lesson content. They enable very different access to the subject matter itself. The things that can be revealed to students about biology through the experience of cutting open a frog corpse are very different from what can be revealed through the experience of interacting with a computer simulation.

To explore these differences it is important to consider two contexts of technological mediation:

(1) We must consider not only attempts to imitate corpse dissection through computer simulation, but also the potential for simulation to go beyond the limitations of real-world frog corpse dissection. I suggest that the potential for computer-simulated dissection has not yet been exhausted, and that the pedagogical value of corpse dissection may even be surpassed by what

simulations could deliver. As shorthand, I use the term *expanded simulation* here to refer to simulations designed not only to imitate real-world corpse dissection, but to also reach beyond the constraints of those practices in order to exploit the unique pedagogical opportunities afforded by the virtual environment.

(2) We must also consider the ways in which real-world frog corpse dissection itself—while of course involving actual, non-simulated frogs—nonetheless in practice also crucially involves artifacts of laboratory environment, procedure, and "sample" preparation. Recognition of the technological mediation of the practices of frog corpse dissection highlights the limitations of this form of biology education.

I explore these two contexts, expanded simulation and the artifacts of corpse dissection, in the following two subsections.

3a. Expanded Simulation

While increasing in popularity, computer-simulated frog dissection remains novel compared to the long-established classroom practices of real-world frog corpse dissection. Innovations continue to be made with regard to computer-simulated dissection, and such developments are furthered by the continuing advancement of computing capabilities generally. Thus, it is important not only to contrast the pedagogical value of traditional corpse dissection with that of the particular simulations that happen to be available today, but to also consider simulation's expanding potential. My contention here is that computer-simulated dissection has the potential to offer distinct pedagogical advantages that go beyond the charge of simply imitating corpse dissection, far enough, even, that the issue of imitation may be rendered moot. The question becomes: in what novel and pedagogically relevant ways can simulations mediate student experience of the subject matter?

Here I would like to consider three ways in which contemporary frog dissection simulation software could be expanded: (1) dissection simulations could be expanded to include an integrated and interactive environmental context; (2) they could be expanded to incorporate animal motion, including the dynamics of systems within the body; (3) they could be expanded to incorporate a variety of dissection options, including advanced abilities to make mistakes and to explore multiple examples.

(1) *Environmental Contextuality*. Computer simulations of frog dissection could be expanded to include interactive resources regarding the natural habitats of these animals. Information from the volumes of books and video documentary on frogs and their relationships to their environment could be integrated into the simulation itself.

For example, it is possible to imagine a simulation which begins with a video of an actual frog in its habitat, complete with information about predators and prey, ponds and lily pads. The video could zoom inward to a close-up view of the frog and then the video-frog could transform into a simulated frog whose interior could be explored through virtual dissection. The frog's internal organs could be investigated through the simulated dissection, and then afterward the view could pull back and return to the video of the frog in its environment. (An example of a dissection program that includes substantial interactive education about frog habitation is *Digital Frog 2.5*.[7]) Unlike the frog corpse, the simulated frog in such expanded simulations could be returned to its habitat—its virtual habitat—after it has been investigated.

The point is that the virtual context need neither include nor reduce to the context of classroom laboratory corpse dissection; there are other contexts made possible by computer simulation. There need not necessarily even be any simulation of real-world laboratory devices such as the pins which secure the frog corpse to the wax-lined tray, the scalpel, or the magnifying glass. The simulated dissection could include a simulated context of the frog's natural environment, rather than a context that reduces to an imitation of laboratory practices concerned exclusively with how a dead and isolated frog can be dismembered. Where real-world frog corpse dissection is limited to the context of a classroom lab table, an expanded simulation instead has the potential to include education about the relationships between an individual, its bodily processes, and its natural surroundings.

(2) *Interior Dynamics*. Many have recognized that computer-simulated dissections present a distinct advantage over corpse dissection, namely, that simulations can enable students to explore their subjects in motion. Since in the case of corpse dissection the frog under examination is necessarily dead, neither its bodily motion nor the dynamics of its internal systems can be explored. Simulations, on the other hand, are not encumbered by this limitation, and many cutting-edge simulation programs explore the educational possibilities enabled by this divergence. It is possible to imagine expanded simulations that take even fuller advantage of this potential.

A variety of pedagogical opportunities are afforded by the fact that the object of study in a simulated dissection need not retain the features of an inert corpse. Some of the frog's most interesting features as a species—its hop, its tongue—could be better explored if they could be observed in action. In simulation, students could potentially be exposed not only to what individual organs look like and to the organs' particular spatial configuration, but also to the roles of these organs in the dynamic functioning of larger systems: circulatory, respiratory, digestive, nervous, etc. It is possible to imagine a simulation in which the dynamics of, say, the respiratory system are tracked throughout a simulated frog's body. One option for interface would be to shrink the size of the students' perspective and to take them along an interactive 3D tour within vessels or along nerves. Students could track air into the lungs and then follow further as the oxygen is introduced to the blood and delivered throughout the frog's body. In such expanded simulations, students may have the freedom to choose which systems they follow, which systems are visible at a particular time, what malfunctions occur if nodes are interrupted, or how close inwardly they wish to zoom (including, potentially, exploration at the cellular level). For example, as takes place in the *V-Frog* simulation, the frog's simulated heart can be witnessed not as an inert bean-like mass, but as a beating simulated organ.[8]

The temporal dynamics of the simulation are also a feature potentially subject to customization in computer-simulated dissection. Where real-world corpse dissection will require a separate dissection event—a separate corpse—for each stage of a frog's life cycle that students and educators may wish to explore, simulations could instead potentially include speeded-up views of frog maturation, both in terms of exterior bodily morphology and the development of internal systems. The example of frogs is of course especially interesting in this regard, with their tadpole and leg-sprouting stages. Indeed, even speeded-up perspectives on frog evolution through history are possible.

Building on the suggestion above that expanded simulations can integrate learning about an organism's environment with learning about its internal bodily structures, we can imagine a version of a simulation in which a narrative begins, for example, with a video of a frog consuming a fly and then shifts to a simulation in which students interactively explore the dynamics of the digestion process. The frog's environment is also deeply relevant to its reproductive processes, with fertilization of course occurring externally.

The dynamics of the frog's internal systems can be potentially represented in multiple ways, a point raised in Ihde's response in this volume (2012). That is, it need not be the case that simulations only do their best to provide a view of what it would look like were a frog to be cut open yet remain alive and functioning. As Ihde notes, an alternative visual template could involve views made possible by contemporary imaging technologies, such as fMRI. It might be possible to integrate education about contemporary imaging into the lessons on internal bodily structures.

(3) *Subject Variability*. Simulation also has the potential to be expanded to provide individual students with the experience of multiple frog subjects. In real-world corpse dissection, if a student is to be exposed to, say, frogs of different sizes, then multiple frog corpses are required for dissection. A useful moment of classroom dissection can be when different students dissecting different corpses come to recognize that the specimens maintain individual differences. There is no reason that an expanded simulation cannot include the experience of multiple objects of study.

Expanded simulations could allow students to encounter frogs of different sizes and different levels of maturation. Individual simulated frogs could spend time in the different areas of their simulated environment, perched by the side of a pond, for example, or swimming if still tadpoles. A simulated frog found under the mud at the bottom of a pond during wintertime in the simulation could be shown to have internal processes that reflect its stage of hibernation. Students could potentially encounter a variety of virtual stomach contents upon exploring different individual simulated frogs.

An issue raised in the consideration of these potentials for simulation is the seemingly unlimited pliability and customizability so often identified as a constitutive feature of virtual objects. Questions arise here in terms of how useful an infinitely moldable object would be for pedagogy. A version of this concern arises, for example, in Friesen's paper when he identifies the reversible quality of the particular simulation he investigates. He writes, "with the online dissection, there ultimately seems to be no chance of making an error with the incision or with any other part of the dissection activity overall" (Friesen, 2012). This surely cannot be an inherent limitation, but one specific to the individual simulation with which he has tinkered. For expanded simulations, these kinds of limitations can be addressed straightforwardly: just as in real-world corpse dissection, instructors are important. There is no reason why reversibility—or any other pliable feature—*must* be part of the student experience of computer-simulated dissection. For example, a toggle could be added to a simulation to enable instructors to choose an irreversibility setting. If an instructor finds it pedagogically valuable to evaluate the choices students make through the course of the simulated dissection, tools for doing so could be developed. If irreparable mistakes are deemed important by the instructor, then limits can be placed on students' abilities to correct mistakes in a simulation. That is, simply because simulations in theory can be substantially malleable, it need not be the case that this malleability be placed totally under the command of students rather than teachers.

To be clear, the suggestions outlined here do not represent fantasies possible only in some distant future, but instead simply an extension of directions already being explored by dissection simulation developers. The point is that compared to the practices of real-world corpse dissection in the classroom, set as they are in long-entrenched traditions and expectations, computer-simulated dissection is instead only just beginning to discover its potential. It is a potential tied to our capacity to imagine novel and effective pedagogical strategies, and also to the advancement of computing generally.

3b. The Artifacts of Corpse Dissection

An intuition that may be at work beneath arguments in favor of corpse dissection is that computer simulations are inherently artificial and as such must always be only inferior copies of comparable real-world educational tools. According to this line of thinking, while simulations may be getting better and better at approximating real frogs, they will always have a long way to go. Thus, real-world frog corpse dissection should not be substituted with something inherently lacking; when it comes to child education, there is no substitute for exposing students to real-world objects.

There are two assumptions behind this line of thinking with which I disagree. The first is that simulations should only be evaluated on how well they work as substitutes, stand-ins, or approximations of corpse dissection. A simulation can aim to do more than simply mimic real-world corpse dissection as best as possible. I have instead argued above that the value of simulation lies in its own distinct pedagogical advantages.

The second assumption is that frog dissection simply presents a student with "the real thing." This is an exaggeration. That is, while it is certainly true that in real-world frog corpse dissection students are exposed to actual rather than virtual objects, it is simply not the case that corpse dissection represents any kind of unmediated encounter with the subject matter of the frog body. Classroom frog corpse dissection is indeed deeply technologically-mediated, and those transformations to a student's experience of the subject matter are non-innocent—both pedagogically and morally.

As has been emphasized throughout the paper, a central feature of real-world corpse dissection is that it involves not an encounter with just any frog, but necessarily only a frog's dead body. Friesen's phenomenological analysis brings many of the aspects of this essential feature of real-world frog corpse dissection to attention, including student experiences of abjection, the smell of formaldehyde, eventual desensitization, etc. I suggest that this feature of real-world corpse dissection renders it unable to even potentially provide the kinds of pedagogical advantages that are possible for expanded simulations. Consider again the three points of potential expansion outlined in the previous subsection: the frog's interaction with its environmental context; the dynamics of interior systems; and subject variability without multiplying subjects. It is not only the case that simulations can be expanded to address these educational issues; it is also correspondingly the case that corpse dissection, as such, cannot.

Take, for example, the issue of environmental context. It is certainly possible to supplement frog corpse dissection with instruction regarding the habitat of frogs, though not with the same potential as simulation for the integration of media. Even still, it remains the case that this particular frog, the one whose corpse the student is about to mutilate, is one whose relation to the environment has been necessarily altered as part of a technologically-mediated process. It has been extracted from its environment already (or raised in an artificial one), has died of non-natural causes, has been treated with chemicals, and has been packaged and shipped. These technologically-mediated features are not irrelevant to the lessons learned by students. One of Dewey's central insights is that the context of the classroom is itself significant to the learning experience. These artifacts of the corpse dissection procedure—the packing and shipping, the chemical treatments, the pins and wax trays—are parts of the student experience. For example, Friesen provides the example of the encounter with the jar of formaldehyde stuffed full with frog corpses as an aspect of the lab dissection context that students commonly find striking (2012). Reading that section of his paper I was reminded of my own experience of dissecting a frog in high school. While it may very well be the case that those forgotten incisions contribute to my current knowledge of anatomy, I do instead distinctly recall the experience of seeing that flat and vacuumed-sealed bag the size of a desktop full of overlapping frog bodies.

Ethical arguments for and against corpse dissection in the classroom have not been the focus of this paper, but there is one ethical argument that should be addressed here for its relevance to the progressive educational context inhabited by both real-world and computer-simulated frog dissection. It is often argued that the practices of classroom frog corpse dissection have the lamentable side effect of engendering in students a disrespect for life; in this view, through corpse dissection students are taught by implication that an animal's life is not even worth one afternoon lesson that could have been learned otherwise.[9] I suggest that conceiving of computer-simulated dissection and corpse dissection as two forms of technological mediation draws out this issue explicitly.

As technologically-mediated practices, computer-simulated dissection and real-world corpse dissection have been shown above to each involve certain forms of interface, to enable certain pedagogical possibilities, and also to each be limited in certain respects. This backdrop of technological mediation is part of the structure of interconnected classroom experiences that Dewey highlights, that "moving force" as he calls it, which travels into other experiences, for better or for worse. In the case of expanded simulation, we have seen the virtual frog to move into further experiences such as the interaction with the dynamic systems of internal organs, the training of computer interface skills, and the context of the organism's habitat. Contrarily, we have seen real-world frog corpse dissection to move into experiences such as the visceral feeling of slicing flesh, the training of the skills of using of scalpels and pins, and the context of the preparation of the animal's dead body. It is the last of these, the student's encounter with the frog *as* a corpse—extracted from its natural environment, killed, prepared, and shipped—that introduces lessons about how students should regard animal life. As Dewey puts it, "Perhaps the greatest of all pedagogical fallacies is the notion that a person learns only the particular thing he is studying at the time" (1938, 48).

4. Conclusion

Through this phenomenological analysis, I hope to have shown that the context for comparing corpse dissection and computer-simulated dissection should not reduce to questions about how well a computer program can imitate classroom laboratory procedure. As Friesen demonstrates in his piece, the experiences of corpse dissection and computer-simulated dissection are very different. Building on this insight, I have explored the distinct advantages that computer-simulated dissection could provide to students, and have also considered limitations distinct to corpse dissection. These advantages of computer-simulated dissection include simulation's expanding abilities to provide original educational opportunities for exploring dynamic and variable subjects in relation to their environments, and for integrating these lessons into computer interface instruction generally. These limitations of corpse dissection include the inherently inert objects of study abstracted from their environments, and the arbitrary training of the dissection interface.

To be clear, I do not take the above analysis to have proven there to be no distinct advantages to corpse dissection. However, it has shown the inadequacy of any argument claiming that corpse dissection is superior to computer-simulated dissection simply because it retains features that computer simulations cannot imitate well. The distinct advantages of corpse dissection must be weighed against the distinct and continually advancing advantages of computer-simulated dissection. In this proper context of comparison, I suggest that corpse dissection increasingly appears lacking.

The phenomenological arguments in defense of computer-simulated dissection in this paper are intended to supplement the ethical and environmental arguments against frog corpse dissection in primary and secondary school classrooms, and of course these points also apply more broadly to any animal dissection in primary and secondary school. When added to arguments regarding the ethical treatment of animals and the environmental impact of these practices—arguments which are by themselves persuasive to many—the case against favoring computer-simulated dissection in the classroom is left on increasingly thin and withering ground.

References

Akpan, J. P. (2001). "Issues Associated with Inserting Computer Simulations Into Biology Instruction: A Review of the Literature." *Electronic Journal of Science Education*. 5(3).

Allchin, D. (2005). "'Hands-Off Dissection?' What Do We Seek In Alternatives to Examining Real Organisms?" *The American Biology Teacher*. 67(6): 369-374.

Borgmann, A. (1984). *Technology and the Character of Contemporary Life*. Chicago: University of Chicago Press.

Borgmann, A. (1992). *Crossing the Postmodern Divide*. Chicago: Chicago University Press.

Borgmann, A. (1999). *Holding On To Reality*. Chicago: University of Chicago Press.

Dewey, J. (1897). "My Pedagogic Creed." *The School Journal*. LIV(3): 77-80.

Dewey, J. (1916). *Democracy and Education: An Introduction to the Philosophy of Education*. New York: Free Press.

Dewey, J. (1938). *Experience and Education*. New York: Collier Books.

De Villiers, R., and M. Monk. (2005). "The First Cut is the Deepest: Reflections On the State of Animal Dissection in Biology Education." *Journal of Curriculum Studies*. 37(5): 583-600.

Dreyfus, H. (1972). *What Computers Can't Do*. New York: MIT Press.

Dreyfus, H. (2001). *On the Internet*. London: Routledge.

Fallman, D. (2007). "Persuade Into What? Why Human-Computer Interaction Needs a Philosophy of Technology." In Y. de Kort et al. (eds.), *Persuasive 2007, LNCS 4744*. Berlin: Springer-Verlag. pp. 295-306.

Fleishmann, K. R. (2003). "Frog and Cyberfrog Are Friends: Dissection Simulation and Animal Advocacy." *Society & Animals*. 11(2): 123-143.

Friesen, N. (2012). "Dissection and Simulation: Brilliance and Transparency, or Encumbrance and Disruption?" *Techné: Research in Philosophy and Technology*. 15(3): this volume.

Golding, W. (1955). *The Lord of the Flies*. New York: Coward-McCann.

Heidegger, M. (1953). *Being and Time*, trans. J. Stambaugh, 1996. Albany: SUNY Press.

Hickman, L. (2008). "Postphenomenology and Pragmatism: Closer Than You Might Think?" *Techné: Research in Philosophy and Technology*. 12(2).

Hug, B. (2008). "Re-Examining the Practice of Dissection: What Does It Teach?" *Journal of Curriculum Studies*. 40(1): 91-105.

Ihde, D. (2002). *Bodies in Technology*. Minneapolis: University of Minnesota Press.

Ihde, D. (2009). *Postphenomenology and Technoscience: The Peking University Lectures*. Albany: SUNY Press.

Ihde, D. (2012). "Dissection and Simulation: A Postphenomenological Critique." *Techné: Research in Philosophy and Technology*. 15(3): this volume.

Keiser, T. D., and R. W. Hamm. (1991). "Dissection—The Case For." *The Science Teacher*. 51(1): 13.

Kline, D. A. (1995). "We Should Allow Dissection of Animals." *Journal of Agricultural and Environmental Ethics*. 8(2): 190-197.

Kockelkoren, P. (ed.). (2007). *Mediated Vision*. Rotterdam: Veenman Publishers and ArtEZ Press.

Medrazo, G. M. (2002). "The Debate Over Dissection: Dissecting a Classroom Dilemma." *Science Educator*. 11(1): 41-45.

Merleau-Ponty, M. (1962). *Phenomenology of Perception*, trans, C. Smith. London: Routledge.

Mitcham, C. (2007). "From Phenomenology to Pragmatism: Using Technology as an Instrument." In E. Selinger (ed.), *Postphenomenology: A Critical Companion to Ihde*. Albany: SUNY Press, pp. 21-33.

Oakley, J. (2009). "Under the Knife: Animal Dissection as a Contested School Science Activity." *Journal for Activist Science & Technology Education*. 1(2): 59-67.

Orlans, F. B. (1991). "Dissection—The Case Against." *The Science Teacher*. 58(1): 12.

Riis, S. (2010). "A Sense of Postphenomenology." *SATS: Northern European Journal of Philosophy*. 11(1): 107-115.

Rosenberger, R. (2009). "The Sudden Experience of the Computer." *AI & Society*. 24: 173-180.

Rosenberger, R. (2011). "A Phenomenology of Image Use in Science: Multistability and the Debate over Martian

Gully Deposits." *Techné: Research in Philosophy and Technology*. 15(2): 156-169.
Rosenberger, R. (forthcoming). "The Importance of Generalized Bodily Habits for a Future World of Ubiquitous Computing." *AI & Society*.
Sørensen, E. (2012). "Comment on Norm Friesen's: 'Dissection and Simulation: Brilliance and Transparency, or Encumbrance and Disruption?'" *Techné: Research in Philosophy and Technology*. 15(3): this volume.
Steinert, S. (2010). "Interfaces: Crosslinking Humans and Their Machines." *International Journal of Applied Research on Information Technology and Computing*. 1(1): 130-140.
Sapontzis, S. F. (1995). "We Should Not Allow the Dissection of Animals." *Journal of Agricultural and Environmental Ethics*. 8(2): 181-189.
Suchman, L. (2007). *Human-Machine Reconfigurations: Plans and Situated Actions, 2nd edition*. New York: Cambridge.
Tripathi, A. K. (2010a). "Application of Information & Communication Technology in Education." Research report posted at: http://www.childresearch.net/RESOURCE/RESEARCH/2010/TRIPATHI2.HTM
Tripathi, A. K. (2010b). "Ethics and Aesthetics of Technology." *AI & Society*. 25: 5-9.
Winograd, T., and F. Flores. (1986). *Understanding Computers and Cognition*. Norwood: Ablex Publishing Corporation.
Verbeek, P.-P. (2005). *What Things Do: Technology, Agency, and Design*. State College: Penn State University Press.

Notes

1. For more on the debate over frog dissection in the classroom, see (e.g., Keiser and Hamm, 1991; Orlans, 1991; Kline, 1995; Sapontzis, 1995; Akpan, 2001; Medrazo, 2002; Fleishmann, 2003; Allchin, 2005; De Villiers and Monk, 2005; Hug, 2008; Oakley, 2009).

2. More specifically, the perspective I work from in this paper is called "postphenomenology." Postphenomenology refers to a contemporary school of thought which builds on the work of Don Ihde, and which addresses issues regarding the bodily and perceptual experience of technology through a perspective which combines thinking from the philosophical traditions of phenomenology and American pragmatism. For more on postphenomenology, see (e.g., Verbeek, 2005; Ihde, 2009; Rosenberger, 2009; Riis, 2010; Rosenberger, 2011; the 2008, 31(1) issue of *Human Studies*; and the 2011, 16(2-3) issue of *Foundations of Science*. For critical assessments of the relationship between postphenomenology and American pragmatism, see (Mitcham, 2007; Hickman, 2008).

3. For more on the notion of interface, see (Steinert, 2010).

4. Another clear inspiration is the work of Martin Heidegger, especially his account of tool use in *Being and Time* (1953). I hesitate to utilize Heidegger's work here, however, since I do not want to commit this analysis to the larger account of ontology and the critique of the history of philosophy within which his account of tool use is intimately embedded.

5. Like the notion of multistability itself, the notion of "relational strategies" represents an analytic tool to be deployed contextually. For example, we could consider a transistor radio in terms of its multistability, brainstorming various uses for the device and considering various meanings it could potentially maintain for different users within different contexts. But we could then also change the entire context of this analysis by opening up the radio, pulling out an individual transistor, and then considering its own potential stable relations. The situatedness of the person conducting the analysis is thus at issue in these sorts of investigations.

The notion of relational strategies—referring to the bodily and conceptual approach that enables a particular stable relation—is also wrapped up within the pragmatic contextuality of the analyst. If we were to brainstorm multiple possible stabilities for the transistor radio, then we could consider what sorts of general comportments and understandings would be required for one to take up the device in terms of each stability. If we were to next pull open the transistor radio, tear out an individual transistor, and brainstorm multiple stabilities possible for it, then we could again consider the relational strategies that would be required for one to take up each of those stabilities. Likewise, in the case of computer interface we could consider the relational strategy associated with our approach to the computer as a whole, or we could consider the relational strategy of our approach to only the computer mouse, or keyboard, or screen, etc. This depends on the context of investigation.

6. For further phenomenological accounts of computer use, see (e.g., Winograd and Flores, 1986; Borgmann, 1999; Dreyfus, 2001; Suchman, 2007; Fallman, 2007; Tripathi, 2010a; Tripathi, 2010b).

7. For more on the *Digital Frog 2.5* computer-simulated dissection, see:
www.digitalfrog.com

8. For more on the *V-Frog* computer-simulated dissection, see:
www.tactustech.com

9. For examples of the argument that corpse dissection teaches disrespect for life, see (e.g., Orlans, 1991; Sapontzis, 1995; Oakley, 2009).

Douglass Allchin argues the opposite: that it is in fact simulations that teach disrespect for life by presenting animal bodies as easily and cleanly dismantled, thus objectifying them. He writes, "A proper aim is discovery, not destruction. One should separate and clarify: Trace pathways, find boundaries, encounter connections—quite impossible if things are pre-cut and disappear as preformed units in a single mouse-click" (Allchin, 2005, 370). While initially persuasive, it is exactly this kind of argument that does not hold up in the face of what expanded simulations could deliver. Like Kline above, Allchin's arguments assume that the goal of simulation must be to reproduce the experience of corpse dissection. I have shown that on the contrary the proper comparison is instead between corpse dissection's limitations and advantages and computer simulation's own distinct limitations and its still-expanding advantages.