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Science teachers and the dissection debate: Perspectives on animal dissection and alternatives

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This study investigated Ontario science and biology teachers' practices and attitudes toward animal dissection and dissection alternatives. The data was collected through a mixed methods approach involving online surveys (n=153) and subsequent telephone interviews (n=9) with secondary school science and biology teachers. The findings indicate that teachers identify strengths and drawbacks to both dissection and alternatives, but the majority continue to strongly favour traditional dissection and see it as vital to biology education. Further, although teachers expressed concerns with dissection, their concerns were overshadowed by an overall dissatisfaction with alternatives. It is argued that teachers need to engage more deeply with the ethical questions that underlie dissection and consider how its learning outcomes can be achieved through humane science education practices. It is also argued that science teacher education programs should include ethical discussions about the controversies of dissection and provide training to familiarize pre-service teachers with alternatives.

Keywords: animal dissection, dissection alternatives, secondary school science education, teacher practices, ethics

Introduction

Animal dissection is a controversial pedagogical practice. In educational contexts it raises ethical and environmental concerns regarding the killing of animals, the ignoring of animal welfare standards, the weakening of respect for life, and the "turn-off" factor for some students (Balcombe, 2000; Bishop & Nolen, 2001; Hug, 2008; Jukes & Chiuia, 2003; Marr, 2001; Oakley, 2009; Sapontzis, 1995). The "dissection debate," with ethics at its core, often centres around the validity of killing animals—an estimated 10-12 million animals per year in North America (Rosenberger, 1998)—for a school science activity.

The burgeoning industry of dissection alternatives presents an additional challenge to dissection. Given that there are ways students can learn about anatomy and physiology without using animals that have been killed, should schools not pursue these alternatives exclusively? Virtual dissection simulations, 3D models, plastinated specimens, videos, slides, charts, and online presentations offer ways for teachers to avoid the ethical controversies associated with dissection without compromising student learning. Research based in middle and high school contexts indicates that outcomes pertaining to learning anatomy and physiology can be met with virtual alternatives and that student knowledge gain can be equivalent, and sometimes superior, to a traditional dissection (e.g., Kopec, 2002; Lalley, Piotrowski, Battaglia, Brophy, & Chugh,

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2010; Maloney, 2005; Montgomery, 2008; Youngblut, 2001). Given evidence that alternatives can and do work, why do teachers continue to dissect?

This study aimed to understand, from teachers' perspectives, whether and why they use dissection and what perspectives they hold toward alternatives. Bringing teachers into this discussion is important as their voices have largely been underrepresented in existing research. As King, Ross, Stephens, and Rowan (2004) write, "The use of animals in dissection activities in high school biology education is believed to be widespread … but currently, there are few data regarding its prevalence, or its role as an educative resource, from the biology teachers' perspective" (p. 475). Similarly, Hart, Wood, and Hart (2008) note that: "Although the subject [of dissection] has been a lively focus of articles among animal welfare organizations and philosophers, educators have had much less involvement in addressing this question than one might expect" (p. 49). This study aimed to investigate the choices teachers make about this controversial practice, their attitudes toward dissection and alternatives, and how they respond to the ethics of the dissection debate.

Classroom Practices: A Review of the Literature

Research suggests the majority of biology teachers in North America continue to dissect. According to three American reports, between 75-79% of biology teachers use dissection in their classes. One study of middle and high-school biology teachers found that 79% of respondents (N=494) reported dissecting in their current teaching practices (King et al., 2004); similarly, an examination of science teachers' practices in Massachusetts (N=667) revealed that 78.1% of respondents had offered dissection at least once in the last five years (Almy, Goldsmith, & Patronek, 2001). A third study, based on responses from members of the National Biology Teachers Association (N=215), found that 75% of respondents reported intending to use animal dissection in their science classes (Cockerham, 2001). These studies are based on American samples, which reflects the reality that dissection is practiced most frequently in North America. Indeed, dissection is not a global phenomenon: it is no longer practiced in primary and secondary schools in The Netherlands, Switzerland, Argentina, Slovak Republic, and Israel, and is rare in schools in Sweden, Germany, and England (Balcombe, 2001; Waltzman, 1999).

Research regarding teachers' use of dissection alternatives is sparse, making it difficult to gain a clear picture of the popularity of alternatives. The limited research to date suggests teachers mainly use alternatives as supplements, rather than substitutes, to conventional dissection. This is demonstrated in King et al.'s study (2004), where teachers reported using charts, videos, 3D models, CD-ROMs, and other computer-based resources, but only 31.4% agreed that alternatives were as good as dissection for teaching anatomy and/or physiology. Similar findings were noted by Almy et al. (2001), who found that teachers were split on the validity of computer simulation as a pedagogical tool, even though 78.1% of the teachers in the study who offered dissection also reported offering alternatives.

Many variables can influence a teacher's decision to use alternatives, either in lieu of traditional dissection or in conjunction with it. In considering the factors that increase teachers' likelihood of using a virtual dissection alternative, Cockerham (2001) found that a teacher's positive attitude toward virtual dissection, their previous experience using a virtual dissection, and their intention to use a real animal dissection were all positively related to their likelihood of using a virtual dissection. Other variables that may influence a teacher's decision to use alternatives include their access to them, perceptions of their effectiveness, willingness to explore new modes of learning, attitudes toward animals and technology, preparedness to teach biological science, and available resources, budgets, time, and supports (Hart et al., 2008). With limited

research in this area, more data is needed to understand why teachers continue to dissect and what im-pres-sions they hold of alternatives.

Research Participants and Design

This research was part of a larger doctoral study on animal dissection (Oakley, 2011). The results reported in this paper were obtained through a two-phase data collection process conducted over a four-month period in 2010, involving surveys and interviews with teachers who were teaching, or had previously taught, senior level (Grades 9-12) science and biology courses in Ontario, Canada. The participants were recruited through the Science Teachers' Association of Ontario and invitational emails sent to school boards and teachers in the province. In total, n=153 teachers (98 female and 55 male) participated in the study. Their teaching experience ranged from 1 to 37 years, although the majority (59.7%) reported they had been teaching science and/or biology between 1-10 years in Ontario.

In the first phase of the research, participants completed a 30-question online survey (Oakley, 2011) investigating their use of, and attitudes toward, dissection and dissection alternatives. The majority of the survey questions (26 in total) were closed-ended, featuring checklists and Likert scales, along with open-ended comments fields so that respondents could elaborate upon their answers. The remaining four questions were open-ended. The numerical data reported in this paper were taken from an analysis of survey questions asking teachers whether they used dissection (and why), whether they used alternatives and what types of alternatives they used (and why), and the benefits and concerns they associated with each instructional method. The narrative data—including the descriptions of each theme and supporting quotations—were selected from comments shared in the open-ended questions and comments fields on the survey, as well as select passages from the transcripts of nine interviews conducted in the second phase of data collection.

Nine teacher interviews were conducted following the closure of the survey. The interviews were facilitated by a question at the end of survey that asked participants if they would be willing to participate in a follow-up discussion about their experiences; of the 153 teachers who completed the survey, 64 volunteered to be interviewed. Twelve individuals were selected for the interviews based on gender diversity (6 males and 6 females were selected), diversity in years of teaching, and diversity in responses on their surveys pertaining to dissection practices and use of dissection alternatives. The goal of the interviews was to obtain more depth of information regarding individual teachers' perspectives, but due to the time commitments associated with conducting, transcribing, and analyzing interview data, conducting more than this number did not seem feasible. Of the 12 individuals selected, 9 (4 female, 5 male) agreed to be interviewed. All interviews were conducted following a semi-structured interview guide; the average length of the recorded interviews was 25 minutes.

Following the data collection via the surveys and interviews, all data were analyzed separately and in tandem. I analyzed the survey data using descriptive statistical analysis techniques (calculating percentages and counting the number of times themes were mentioned), and used line-by-line content analysis techniques to determine the salient themes in the interview transcripts. The two sets of data were then analyzed together. In this paper, I draw from the combined pool of closed- and open-ended survey data (phase 1) and interview data (phase 2) to provide a picture of teachers' practices and perspectives concerning animal dissection and use of dissection alternatives.

Results

Teacher Practices and Perspectives: Dissection

It was clear that the majority of teacher participants found unparalleled value in traditional dissection, as 87.5% either agreed or strongly agreed with the statement, "Real animal dissection is important to the teaching of biology," and more than half (56.3%) agreed or strongly agreed that "there are no substitutes for real animal dissection." Further, the majority of participants—94.1% (144 of 153 teachers)—reported conducting dissections in their classes. While the survey focused exclusively on secondary school dissections, some teachers indicated that they also conducted dissections in other grades and courses, including Grades 2, 4, 7, and 8, and in non-biology classes including health, forensic science, environmental studies, chemistry, physics, and at science clubs and camps.

Teachers cited a range of animals and animal parts dissected in class. The specimens cited, and the number of teachers who reported using them for classroom dissections, were as follows: fetal pigs (122), cow parts (e.g., hearts, kidneys, lungs, brains, uteri, eyes, and other "plucks") (118), frogs (85), worms (81), perch (66), sheep parts (65), rats (62), pig parts (52), grasshoppers (36), crayfish (26), cats (16), dogfish sharks (15), starfish (12), chicken parts (8), pigeons (8), mice (5), snakes (3), turtles (3), clams (2), minks (2), mudpuppies (2), squid (2), and many others cited a single time. The vast majority of teachers who conducted dissections reported purchasing the animals and parts from biological supply companies (98.6%), although some also reported obtaining them from supermarkets (26.4%), slaughterhouses (22.2%), and breeders and dealers (2.1%). One teacher reported using road kill and another said she obtained animal donations from a trapper.

The teachers predominantly spoke of the benefits of dissection but also reported having concerns with it. Tables 1 and 2 outline these findings, parsed into themes and ordered by the frequency each theme was cited among the teachers who identified benefits (n=133) and drawbacks (n=129) to animal dissection as a pedagogical technique.

Benefits of dissection. The primary benefit of dissection, as expressed by 74 teachers, was its pedagogical value. For many teachers, having students work with an actual animal and observe real-life interconnections between organs and systems was seen as the best possible way students can learn. "It is an ideal way for students to see the 'real deal,'" one teacher wrote, adding that "when the students are studying pictures all the time, they expect to see cartoon figures during dissections." In the related category of "realism," 62 teachers indicated that the reality conveyed by dissection cannot be matched by alternatives. Comparing dissection to virtual alternatives, many suggested simulations are "overly perfect" and unable to showcase abnormalities or variations from one specimen to the next. One teacher explained that when students first study images, and then proceed to an actual dissection, they are often surprised:

> They can't identify structures, because what the structures look like virtually and what they look like in reality, is different. [With a virtual dissection] you don't get the opportunity to look [at] what's in the stomach. And you don't get the opportunity to see if there was a pregnant female, and what that looks like. There are all these sorts of surprises to doing a dissection.

These "surprises," along with the hands-on nature of dissection, were cited as benefits only a physical dissection can provide. The fact that dissection is a kinesthetic experience that allows students to develop motor skills was also considered a strong benefit: "There are skills that they learn, like manipulating instruments … there's a high degree of safety involved with scalpels … and a delicacy of hand-eye coordination is required," one teacher explained.

Table 1

Teacher-Reported Benefits of Animal Dissection

Pedagogical: solidifies student knowledge of structure, function, placement, and interconnections of organs and systems; reinforces concepts covered in class/curricular materials; provides the most authentic/memorable/"best" way to learn about anatomy and physiology (74)
Realism: conveys reality and complexity; demonstrates similarities and differences between organisms (including those of the same species); allows for comparisons to the human body; "3D model" (i.e., actual animal) looks completely different than diagrams (62)
Experiential: provides hands-on learning; allows students to develop manual dexterity and experience with equipment, lab safety skills (58)
Student engagement/enjoyment: dissection is an exciting, one-of-a-kind experience that interests students and promotes desire for further studies in biology (58)
Ethics and respect: an opportunity for students to develop respect and admiration for life; loss represented by the death of an animal can teach about ethics (23)
Future learning: supports the development of students considering further biological or medical studies; prepares students for future dissections (14)
It is part of the curriculum and supported by the Ministry (8)

Table 2

Teacher-Reported Concerns with Animal Dissection

Health and safety: students' safety in the lab; proper ventilation in the room; exposure to formalin; proper disposal of specimens; bacteria levels (46)
Pedagogical: classroom management (e.g., dealing with immature students; ensuring proper respect is shown to specimens); students' learning and retention; addressing and evaluating students who refuse to dissect (30)
Costs (23)
Ethical: ensuring animals are not caught from wild populations (e.g., not contributing to the declining frog population); concerns about the humane killing of animals; is it necessary or justified to kill animals for this purpose? (21)
No concerns whatsoever (8)

A common thread running through the responses was that many students enjoy the unique experience of dissection and that this enjoyment connects to enhanced student learning. With 58 participants citing student engagement as a key benefit of dissection, it is evident

teachers believe students enjoy the process. Some noted that student interest could translate into dissection becoming a "selling feature" for students to pursue advanced-level biology courses. Comparing interest levels between physical and virtual dissection, some reported that the latter was less interesting to students—even those who dreaded dissection in the first place. One teacher explained:

> It [dissection] is one of the most memorable experiences for students. I have known a number of students who went from dreading the dissection (and wanting alternatives) to taking Grade 12 biology BECAUSE they discovered that they enjoyed the REAL dissection experience.

Ethics was one of the more complex benefits—and drawbacks—that teachers associated with dissection. While many agreed that alternatives can alleviate ethical problems associated with the killing of animals, 23 teachers positioned dissection as a unique opportunity for students to engage with ethical issues surrounding respect for life, mortality, death, and dying. In the comments section of the survey, four teachers commented that students today are too divorced from the reality of animal death: "Many students have no firm link to reality—their information is digital; few have caught …[or] cleaned a fish; their meat comes on Styrofoam. This is real," one wrote. Another shared an anecdote of how a classroom dissection may have contributed to instilling an ethic of respect in his students:

> I had several of my returning students discuss the action they took in removing earthworms from the roadway in front of their house and putting them back onto the grass during a good rainfall. They credited their learning and the opportunity to learn about earthworms' importance to the ecosystem and their ability to "feel," and they felt that by putting them back onto the grass they had reduced their suffering. Sweeeet eh?

Another cited benefit of dissection was that it could be helpful in preparing students for further studies in biology. One teacher explained: "Even though students may be able to successfully meet curriculum expectations when alternatives are provided, those that will be studying biology in university will be at a disadvantage if they have never performed a dissection in high school."

Finally, eight teachers expressed belief that dissection is supported by the provincial Ministry of Education, based on it being included in the Grade 10 and Grade 11 curricular documents (although the curricula state that students are to perform a traditional dissection *or* use a computer simulation or other type of alternative) (Ontario Ministry of Education, 2008a; 2008b). One teacher noted that dissection guides are also included in Ministry-approved textbooks and because of this he felt supported, and even encouraged, by the Ministry in his decision to dissect.

Concerns with dissection. Teachers expressed several concerns with dissection, the most common pertaining to health and safety. Forty-six respondents wrote that ensuring safe classroom practices was paramount and that they were most concerned with the possibility that students could harm themselves with scalpels, pins, or splashes from chemical solutions. Concern about chemicals and proper ventilation in the rooms was also expressed: several teachers mentioned they had health concerns about exposure to the formalin solution. While some teachers indicated they are now using formaldehyde-free specimens in classroom dissections, others continue to use formalin-preserved animals. One teacher wrote:

> I'm concerned for not only the health of my students, but for myself. For example, I had three classes of Grade 11 biology dissecting for three days, plus two lunch periods. To me this seems like a lot of exposure [to formalin] in such a short time.

The second most commonly cited concern involved classroom management issues and misbehaving students who deliberately mutilate, abuse, or otherwise disrespect the animals' bodies. "When I used to teach dissection in Grade 10, sometimes there would be really bad behaviour in, you know, chopping off an organ or saying, 'oh, let's cut the head off now,'" one teacher explained. This connected to concerns about whether students were gaining sufficient value from the dissection to make it worthwhile. Given the delicacy and complexity of the procedure—and the fact that one wrong cut can mean the process is compromised—some teachers stressed the importance of guiding students through the procedure maturely so that it would not become, as one teacher put it, "a slap-dash cutting job." Teachers who cited concerns in this category also wanted to ensure students showed proper respect for the animals, and some expressed concern that dissection could be interpreted as communicating the opposite. One teacher noted that her main concern was that dissection could lead to "kids feeling that it is okay to hurt or 'dissect' other animals that they come across… frog in ponds, et cetera."

Pedagogical concerns were also expressed about student learning and retention, and the difficulties that can arise when students refuse to dissect. One teacher described his main concern as "students not willing to participate even as a helper/observer, despite having the requirement in the course description." Another referenced the difficulty of "giving any students who have an objection to dissection a meaningful alternate project." Finally, others worried about the impact dissection could have on students who were opposed to it for animal rights or other reasons. One teacher summarized her primary concern as: "Turning some kids off science because they think it is gross!"

Cost and declining budgets were cited by 23 teachers as a concern. Some explained that they attempt to moderate costs by partnering students or having them work in small groups, although this was seen as a less-than-ideal arrangement because it meant not all students could take an active role in dissecting. Other strategies for mitigating costs included using slaughterhouse "plucks" or, in the case of one teacher, having students pay for the animal they were going to dissect.

Ethical concerns were expressed by 21 teachers. In particular, teachers mentioned having concerns about two of the most commonly dissected animals—fetal pigs (e.g., some questioned whether pigs are bred for the purpose of supplying fetal pigs to schools), and frogs (some acknowledged the declining amphibian populations and noted they had stopped dissecting frogs as a result). Other concerns related to whether animals came from wild populations, and for those perceived to be "grown in a lab" (e.g., mice), whether they were raised and killed humanely. Finally, some questioned whether the ethical costs of killing animals justified the activity in the first place. Noting that dissection is not necessary for students' success in high school biology, one teacher asked, "Is it wrong for animals to be killed just so we can use them as lab specimens?"

Teacher Practices and Perspectives: Virtual and Other Dissection Alternatives

Among the 153 teacher participants in this study, 125 reported using alternatives in their classroom, predominantly as supplemental teaching aids in conjunction with physical dissection (77.4%) and/or in lieu of dissection for students who choose not to dissect (71.8%). In response to the question of what alternatives they used, teachers cited CD-ROMs or computer programs (80.0%); charts, posters, textbook diagrams, and/or overheads (76.8%); 3D anatomical models

(67.2%); videos (56.8%); and "other alternatives" (21.6%). "Other alternatives" included written assignments, websites, field trips and virtual field trips, dissection picture cards, and other creative teaching strategies, such as asking students to build 3D models out of clay or asking them to create a board game illustrating their understanding of anatomy and physiology.

Similar to the findings on dissection, teachers identified both benefits and drawbacks to using alternatives. Tables 3 and 4 summarize the reported benefits and drawbacks, as well as the frequency each theme was reported among the teachers who responded to the questions (n=124).

Table 3.
Teacher-Reported Benefits of Virtual and/or Other Dissection Alternatives

Supplemental teaching aid to physical dissection: alternatives allow students to become familiar with the intricacies of dissection *before* they dissect; provide a model of a properly dissected organism; offer additional information for students to extend their knowledge; allow for the viewing of specimens not normally dissected in class (96)
Provide an alternative learning option for students who do not want to dissect (e.g., for ethical, religious, or cultural reasons) or who cannot attend classes due to extenuating circumstances (92)
Reusable: alternatives can be re-used year after year and revisited at a later date during the school year (68)
Costs: it is less costly to use (some) dissection alternatives than to dissect (58)
Environmental footprint: dissection alternatives leave less of an environmental footprint (46)
Ethics: dissection alternatives do not involve taking an animal life (38)
Time savings: less time is needed for set-up/clean-up (2)
Alternatives alleviate teacher discomfort with dissection (1)

Table 4.
Teacher-Reported Concerns with Virtual and/or Other Dissection Alternatives

Pedagogical: alternatives are not pedagogically comparable to physical dissection—they lack realism; do not showcase diversity within a species; cannot capture the fascination of examining a real specimen; provide a less effective educational experience; are not hands-on or experiential (86)
Availability of school resources: limited or outdated school resources (i.e., computers) make it difficult to use alternatives (64)
Lack of information/teacher professional development opportunities to assist in the selection of appropriate alternatives and their use (21)
Costs: some alternatives are expensive/have to be renewed year after year; budget limitations (21)
Student disinterest (10)
Ethics: alternatives may desensitize students; there is no opportunity to develop an ethic of appreciation toward animal life (6)
Teacher discomfort with students spending time on computers: students are sufficiently "wired" (2)

Benefits of alternatives. Ninety-six teachers reported that the primary benefit of alternatives comes from using them as a supplemental teaching aid. Many of the teachers who commented in this category spoke of the value of using alternatives prior to a real dissection to familiarize students with the intricacies of the procedure and to facilitate deeper learning. One teacher explained:

> I use the computer simulations to prepare the kids better for the dissections … I use it as a pre-dissection tool, as well as a dissection tool, because it sets the kids up for learning much more deeply about of the actual dissection itself.

Many teachers also considered alternatives beneficial in providing non-dissecting students with a way to learn. Opinions were unevenly split, however, as to whether the alternatives were pedagogically adequate in this regard: only 32.3% agreed that alternatives could provide a "pedagogically sound way for students to learn." One teacher opined: "I consider [alternatives] a better-than-nothing for those opting out entirely … There are some excellent virtual dissection programs out there, but they don't come close to being realistic as far as I am concerned." Others, however, expressed confidence that alternatives can adequately meet curricular demands:

> I feel that it should be the student's right to decide if they would like to have that experience [of dissection] or learn through an alternative means. Whether they learn through the dissection or through an alternative, the curriculum expectations can still be met and achieved.

Teachers also indicated that a benefit of alternatives is that they can be re-used year after year: "Less time is required for teacher set-up and no storage is required when using computer/models, etc.," one teacher noted; another simply cited the "ability to revisit at a later time/date" as a benefit. In some instances, the re-usability of alternatives was also connected to the benefit of them being more cost-effective, in the long run, than conducting a physical dissection.

Given that several teachers expressed ethical concerns with dissection, including its impact on wild animal populations (see Table 2), it is not surprising that 46 teachers reported that alternatives have a lighter environmental footprint and 38 found benefit in the fact that alternatives do not involve taking an animal life. As one teacher wrote, "I feel that killing animals/plants etc. for the sole purpose of a high school dissection is not valid. I am concerned especially about frog dissections and the amphibian populations in general." Finally, the time savings associated with using alternatives was cited as a benefit by two teachers, and one teacher noted that alternatives provide a viable option for *teachers* who do not want to dissect. "If a teacher is uncomfortable teaching it, they should not feel that they have to," one teacher wrote, adding that "it needs to be a choice, both for the teacher—whether or not to be offering that kind of opportunity to their students—and again to the students, if the teacher does choose to offer it."

Concerns with alternatives. Pedagogical drawbacks topped teachers' list of concerns with dissection alternatives. Some of the commonly cited concerns were that alternatives lack realism, fail to showcase diversity, are not hands-on in the same way as physical dissection, and do not capture the wonder students feel when dissecting a real animal. Some teachers suggested these drawbacks lead to a less valuable experience for students: "The relationship the student has with the animal is valuable," one teacher suggested, "and the whole aspect of life/death and respect for life is valuable." Another wrote that virtual alternatives can compromise student learning: "Their quality simply isn't high enough to be an "alternative" ... and the knowledge retention by students

following that route is nowhere near as good as what is experienced with dissections." A third teacher said that virtual simulations lack excitement and are overly leading:

> The simulations for me are boring. I mean, they're good training tools, but they're no different than the textbook. They take you through the process in a more hands-on way, but it still isn't hands-on. It's like an oracle or something telling you what's going to happen.

Sixty-four teachers indicated that limited or outdated resources in their schools made it difficult for them to use alternatives, particularly computer-based ones. One teacher explained: "We have tried a number of programs in the past … and found that our computer systems were too dated to run them, or if they ran, they were very unsatisfactory as an educational experience (rated by teachers and students)." Another noted that "providing alternatives is a hassle as many schools do not have computers in the science rooms (students are not supervised if sent out) and finding alternatives that consistently work is very time-consuming." It can be particularly time-consuming for teachers who lack professional development opportunities to help them in the selection and use of quality alternatives, as 21 teachers noted.

While many teachers considered alternatives more cost-effective than conducting a traditional dissection, 21 listed costs as a *drawback.* Although there are no costs associated with using the Ontario Ministry-licensed software *Froguts* that is available to all teachers in this research sample (OSAPAC, 2011), other alternatives, such an anatomical models, may be cost-prohibitive. One teacher, who disliked the lack of physicality associated with virtual dissection programs, wrote that "models instead of computers would be best, so that students still get a hands-on approach. I looked into those and they were around $300 each! Impossible to get a class set." Others indicated that the need for computer upgrades or a lack of computers in the first place made alternatives too costly.

Student disinterest in alternatives was referenced by 10 teachers, some of whom labelled the alternatives "disappointing" or "boring" for students. Others (6) wrote that students' lack of emotional involvement with alternatives meant they could not develop an ethic of appreciation toward life. One teacher stressed that biology, as the study of life and death, *should* involve using real organisms for dissection to help students develop respect alongside skills and technique. Expressing his feelings toward virtual simulations, he wrote:

> They are not equivalent to actually dissecting an organism—the sensory experience is completely different. I also find that students demonstrate delicacy when dissecting as they realize that they are handling an actual organism which can be easily damaged. They show respect for living things (I appreciate the irony here, since these are dead things!).

Finally, two teachers explained that they did not want to teach using computers, and for that reason disliked alternatives. One teacher said she believed students spend enough time (or too much time) on computers already: "I personally do not enjoy using computers in the class. The students are wired enough and I prefer not to have to battle with the equipment," she wrote.

Discussion

More than 20 years ago, scientist and animal advocate Barbara Orlans (1988) argued it is time for teachers to "take a hard look at the use of dissection in the classroom, to review its history, to analyze its pros and cons, and to become familiar with educationally sound alternatives" (p. 37). The results of this research suggest educators *do* attribute pros and cons to dissection, holding mixed impressions of it. Yet despite this seemingly balanced perspective—and despite the fact that teachers numerically associated a higher number of benefits with alternatives than with

dissection—the predominant classroom practice of teachers in this sample was to use dissection as a primary teaching method and alternatives as supplemental teaching aids or options for students who do not dissect. With 94.1% (144 of 153 teachers) reporting conducting dissections in their classes and 56.3% of these (81 of 144) agreeing that "there are no substitutes for real animal dissection," it is evident the teachers in this study strongly favoured traditional dissection.

Madrazo (2002) writes that ethics are at the heart of the dissection debate, guided by the question of whether or not killing animals for an educational activity is justified. The findings of this research suggest that the ethics of dissection cannot be characterized in simplistic, polarized categories of "right" or "wrong," however. As participants articulated, ethical benefits and drawbacks can be associated with both dissecting *and* using alternatives (see Tables 1, 2, 3, 4). For example, teachers characterized dissection as an opportunity to develop an ethical orientation toward animals *and* a problematic activity involving the unethical killing of animals; similarly, alternatives were described as both an ethical means to avoid killing animals *and* a technology that can hinder students from developing an ethic of appreciation toward animal life. That the ethics of dissection can be argued both ways complicates the assumption that teachers who dissect do not care about the ethical implications of the practice.

In spite of this, the issue of ethics remained low on teachers' lists of concerns with dissection. The animals' deaths (and whether they were humanely killed) ranked only fourth of their concerns, following concerns about student health and safety, classroom management, and costs (see Table 2). Given the low ranking of ethical concerns, it would appear that teachers are not engaging very deeply with the ethical dilemma dissection presents, including the reality that alternatives can alleviate the killing of animals. As Balcombe (2000) writes, there is an ethical question underlying the justification of killing animals to learn how they work, even if this is thought to be the best way to teach.

This ethical question gains momentum from a set of principles created to guide the ethical use of animals in science and education: the tenet of the "Three Rs," introduced over 50 years ago by scientists William Russell and Rex Burch (Russell & Burch, 1959). The Three Rs guideline is an animal welfare initiative that pertains to the *replacement*, *reduction*, and *refinement* of harmful animal use in science and education. Today in Canada and internationally, the Three Rs are a recognized part of the culture of animal-based science and considered important from an ethical standpoint, given that research involving animals can cause them suffering, pain, distress and death (Canadian Council of Animal Care, 2010; King, 2004; Robinson, 2005). An application of the Three Rs would likely lead to the full replacement of animals used in classroom dissections. The Canadian Council of Animal Care (2010) supports this in writing that:

> [T]he use of animals in science is acceptable ONLY if it promises to contribute to understanding of fundamental biological principles, or to the development of knowledge that can reasonably be expected to benefit humans, animals or the environment. Animals used for educational purposes are not being used to discover, prove or develop new ideas or techniques, but rather to demonstrate principles which are already well-known or to learn manual skills and techniques. Thus, before engaging in any discussions on the use of animals for the purposes of teaching, efforts should initially focus on finding a replacement alternative. (para. 1)

Overwhelmingly, the teachers in this study did not consider alternatives as adequate replacements for dissection. Although teachers did identify several benefits to using alternatives, they generally characterized them as inferior substitutes. The expressed belief that alternatives do not measure up pedagogically (see Table 4) is a possible reason why teachers are not shifting

toward humane science education practices, such as those outlined by the Canadian Council of Animal Care. If so, this may be indicative that teachers lack knowledge of the scholarly research showing that student learning with virtual dissection programs can be comparable to a traditional dissection, particularly in terms of student knowledge acquisition and student ability to identify animal anatomy (HSUS, 2008; Kopec, 2002; Lalley et al., 2010; Maloney, 2005; Montgomery, 2008; Youngblut, 2001). The overall conclusion of comparative research is that dissection alternatives can and do work, but the findings of this study suggest teachers continue to believe alternatives cannot measure up to a traditional dissection.

There are other reasons, beyond negative attitudes toward alternatives, why teachers may continue to dissect. Some participants reported experiencing barriers to their adoption or use of alternatives in the classroom, including limited or outdated technological resources, a lack of professional development to help them in the selection and use of quality alternatives, and budgetary constraints hindering their ability to purchase alternatives. These issues must be considered and addressed by schools and school boards, as they reflect institutional barriers to humane science. Additionally, teachers need to be involved in discussions of humane science practices and why they are desirable, ethically progressive, and in keeping with international guidelines for animal-based research. These conversations should occur as a part of teacher education training and via professional development opportunities that familiarize pre-service teachers with dissection alternatives.

The overall finding of this study is that teachers continue to see conventional dissection as the best way students can learn, characterizing it as a hands-on practice that heightens student interest and demonstrates the complexity of biological organisms. It is undeniable that alternatives are not "the same" as conducting a traditional dissection, but this does not mean they are less pedagogically effective, and an important question remains as to whether dissection is ethically justified. From the standpoint of international guidelines for animal-based research, school-based dissections are *not* justified, and teachers need to consider this reality. This research demonstrates that the dissection debate is far from resolved in educational contexts, but in exploring teacher attitudes toward dissection and alternatives, a deeper picture emerges about the barriers and opportunities for moving toward more humane science practices.

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Fen Bilgisi Öğretmenleri Diseksiyon Tartışması: Hayvan Diseksiyonu ve Alternatiflere Yönelik Perspektifler

Araştırma, Ontario Fen Bilgisi ve Biyoloji öğretmenlerinin hayvan diseksiyon ve diseksiyon alternatiflerine yönelik tutumlarını ve uygulamalarını incelemiştir. Veri, fen bilgisi ve biyoloji öğretmenleriyle online anketler (n=153) ve telefon görüşmeler (n=9) yapılarak karışık yöntemler yaklaşımıyla toplanmıştır. Bulgular, öğretmenlerin hem diseksiyon hem de alternatifleriyle ilgili sahip oldukları güçlü ve zayıf yönleri belirledikleri sonucunu ortaya koymuştur. Fakat, çoğu güçlü bir şekilde geleneksel diseksiyonu öne çıkarmaya devam etmiş ve bunu biyoloji eğitiminde hayati görmüştürler. Ayrıca, öğretmenler diseksiyonla ilgili kaygılarını ifade etmişlerdir ve kaygıları bütün olarak alternatiflerle tatmin olma sonucunu gölgede bırakmıştır. Öğretmenlerin diseksiyonla ilgili etik sorular ve onun öğrenme çıktılarının insanoğlunun fen bilgisi eğitim uygulamaları dikkate alınarak nasıl başarılabileceği konusunda derinlemesine düşünmeleri gerektiği tartışılmaktadır. Ayrıca, fen bilgisi öğretim programlarının diseksiyonlar ilgili tartışmalı konular hakkında etik tartışmaları içermesi ve öğretmen adaylarının alternatiflerle aşinalık kazanmalarını sağlayacak şekilde eğitimlerinin sağlanması gerektiği düşünülmektedir.

Anahtar kelimeler: hayvan diseksiyon, diseksiyon alternatifler, ortaöğretim fen bilgisi eğitimi, öğretim uygulamaları, etik