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PREDICTIVE POWER OF BIOLOGY TEACHER'S SELF-EFFICACY ON ACCEPTABILITY AND APPLICATION OF VIRTUAL AND HANDS-ON DISSECTIONS

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Abstract

Hands-on dissections of animals are traditionally regarded as an essential part of biology education. Nowadays, regardless of the reported educational benefits, there is a gradual change in the concept and acceptance of hands-on dissection, leading in many cases to its abandonment in schools and its replacement with alternatives such as 3D models, figurines, plastination and computer-based alternatives. However, the position of hands-on dissection has recently been challenged, mostly by computer-supported alternatives. The aim of the study was to explore whether teacher self-efficacy can be recognized as a predictor of the application of the different kinds of animals in hands-on and virtual dissections in Biology lessons. Based on responses from 405 Czech Biology teachers there are differences in the acceptability and implementation of organisms for hands-on and virtual dissection. It was established, that self-efficacy is not a predictor of either the acceptability of organisms or actual behaviour in both variants of dissection.
Keywords: *biology lessons, biology teachers, hands-on dissection, teacher self-efficacy, virtual dissection*

Introduction

In the biological sciences, observation with the naked eye or with the aid of instruments is a fundamental method of acquiring knowledge about living beings. However, biological knowledge is incomplete without knowledge of internal body structures. Thus, when researchers have wanted to know what is inside organisms, they have traditionally explored internal anatomy through dissection and, more recently, through non-invasive methods such as X-rays, ultrasound, and magnetic resonance, the latter of which are not appropriate for teaching in elementary and secondary schools. When educators want to show internal structures to their students, they cannot rely on verbal-textual presentations but must choose one of the alternatives to visualize the objects of interest. The presentations can alternate between teaching with the help of pictures, multimedia presentations, models, preserved specimens, hands-on dissection of real specimens and, more recently, with the use of computer-based interactive virtual laboratories (Havlíčková et al., 2018b). Each teaching tool has its advantages and

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disadvantages, and teachers must seek a balance between them when searching for the most beneficial teaching method. Likewise, teachers should think and reflect on the ethical aspects of the chosen methods (Balcombe, 2000). However, the best possible alternative is often not the one chosen - not because of the availability of resources, but because of teachers' abilities and personal characteristics and beliefs. In addition to such factors, perceived self-efficacy (Bandura, 1994) can be a source of biased decision-making when it comes to choosing or rejecting hands-on and virtual dissection as plausible dissection alternatives for teaching biology/science.

The added value of research can be recognized at several levels. On the national level, this is the first study of its kind on the population of Czech biology teachers. On the international level, it was not possible to find a similar study, even if every single aspect has already been researched, but not in the present context. The potential results of the study can also be recognized as a valuable addition to the arguments helping decision-makers to include or replace dissection in schools.

Background

Hands-on dissections of organisms and their body parts have traditionally been an essential part of teaching biology and science. The advantages and disadvantages have been thoroughly debated in the educational literature. Hands-on dissection is most often described in educational contexts as a valuable motivational tool that helps students strengthen their understanding and reinforce their knowledge of anatomy and morphology (Lombardi et al., 2014; Randler et al., 2012, 2015). Hands-on dissection is known to provide a more realistic and exciting experience (Franklin & Peat, 2005). It leads to progress in manual skills, observational skills, through the discovery of specific structures of the body and recognition of the complexity of living creatures (National Science Teachers Association [NSTA], 2008). Hands-on dissection is a common and widespread practice in schools; however, it should not be done solely to satisfy one's curiosity (Moore, 2001; Randler et al., 2012). Therefore, hands-on dissection should fulfil educational goals, such as developing observational and manual skills, and allow students to discover and share unique structures and develop greater value for life (NSTA, 2008).

Nowadays, regardless of the reported educational benefits, there is a gradual change in the concept and acceptance of hands-on dissection, leading in many cases to its abandonment in schools and its replacement with alternatives such as 3D models, figurines, plastination and computer-based alternatives. This transition can already be seen in documents: National Association of Biology Teachers (NABT, 2008), for example, promotes the inclusion of animals in the classroom and suggests that teachers should choose carefully between dissection and its alternatives. However, since the alternatives also have limitations, they should not be used uncritically to replace the use of animals (NABT, 2008). Some authors believe that hands-on dissection should be abandoned when an alternative of adequate quality exists (De Villiers & Monk, 2005). The reasons for such a stance are mostly ethical (Balcombe, 2000) and are justified by the higher costs and limited access to dissection materials and laboratory equipment (Havlíčková & Bílek, 2015). Additionally, changes at the curricular level are reflected in the introduction of the right for students to opt out of hands-on dissection (Balcombe, 2000).

Recently, the greatest potential for replacing traditional hands-on dissection has been attributed to virtual and interactive computer-based alternatives (Havlíčková & Bílek, 2015; Havlíčková et al., 2018b). In addition to ethical reasons, the most commonly reported advantages of virtual interactive dissection are lower cost, independence of time and place, the possibility of immediate feedback, simplification of natural complexity (Balcombe, 2000; Volf, 2012), and the possibility of dealing with normally inaccessible animal species and their internal parts (Havlíčková et al., 2018b). Swan and O'Donnell (2009) report that virtual dissection can simulate objects and processes that are difficult to explain or show during instruction, which promotes critical thinking and analysis during the lesson (Kuech et al., 2003). Virtual dissection is a tool with significant instructional potential because students can repeat the activity until they are able to complete it and eliminate errors (Lalley et al., 2010). Swan and O'Donnell recognized virtual dissection as a tool that can facilitate online group discussions among users and an approach to course material and exercises (Swan & O'Donnell, 2009) without fear or discomfort. By some, these tools are perceived to supplement information gathering prior to actual hands-on dissection (Predavec, 2001), as they provide additional information (Swan & O'Donnell, 2009).

Virtual dissection has both opponents and proponents. They mostly criticize the oversimplification and low degree of realism of such simulations, which leads them to be considered as a game rather than a real experience (Allchin, 2005). Furthermore, virtual dissections do not allow for the establishment of a relationship with the dissected object or other ethical aspects of the activity (Oakley, 2012). In contrast, one of the most important considerations in the adoption of virtual technology is knowledge gain compared to traditional methods. The results of studies on knowledge gain are mixed and do not allow for clear conclusions (Špernjak & Šorgo, 2018). All of the above reasons could contribute to teachers having negative attitudes towards virtual dissection (Oakley, 2012).

Hands-on dissection and its alternative can be done as a demonstration by the teacher or as individual or group work by the students. Both approaches have advantages and disadvantages and, as shown in the study by Havlíčková et al. (2018b), Czech teachers prefer dissection as an individual, hands-on activity carried out by their students to demonstrations. The reason for their preference for active engagement in dissection as individual or group work is most likely their desire to provide students with first-hand experience and fear of failure when using digital alternatives.

Attitudes towards hands-on and virtual dissection can be described as mixed, leading to the conclusion that the issue is not black and white for or against these alternatives. Moreover, students and teachers do not necessarily share the same opinions and neither group is isolated from the influence of those who are directly and indirectly involved in teaching, such as parents or peers. From the study by Havlíčková and Bílek (2015), it is obvious that students are opposed to a complete replacement of hands-on dissection with virtual or other alternatives, and although many students struggle with the acceptance of hands-on dissection, they see it as necessary for their education. In some cases, it has been recognized that students prefer hands-on dissection to alternatives (Lombardi et al., 2014; Špernjak & Šorgo, 2017). These students often adopt attitudes towards dissection alternatives and share them with their teachers. A gap between teacher and student opinions may go unnoticed and unaddressed by researchers. For example, Balcombe (1997) found that there were many more negative student responses than were self-reported by teachers. One source of bias may be the perception that teachers should be more sensitive to students who express certain reservations about hands-on dissection (Moore, 2001). The rationale may lie in the intuitive claim that students learn more when they work in an enjoyable way (Balcombe, 2001). However, even when students have the opportunity to use virtual and other alternatives, they do not necessarily want to use them (Lombardi et al., 2014; Špernjak & Šorgo, 2017; Swan & O'Donnell, 2009). One reason for the reluctance to use alternatives could be a lack of experience with section alternatives (mainly virtual sections) among both students and their teachers (Havlíčková et al., 2018b).

The most likely reasons for using or avoiding practical or virtual sections are emotions. As Randler et al. (2016) wrote, anxiety and other negative and positive emotions are predictors of approaching hands-on dissection. Emotions are strongly associated with motivation and learning (Randler et al., 2016), as well as self-efficacy (Areepattamannil et al., 2011; Hidi & Renninger, 2006). A frightened or disgusted person views him or herself as less capable than one who is not frightened (Holstermann et al., 2010). Some animals, as well as sick people and substances such as vomit, can cause the development of disgust (Petrowski et al., 2010; Rozin et al., 2000). This feeling also reduces motivation and leads to the rejection of studying biology (Holstermann et al., 2009); also, someone who feels disgust towards certain animals (e.g., amphibians) usually does not reach the same level of knowledge (Randler et al., 2005). Therefore, their knowledge remains at a lower level than students who do not experience fear or disgust. Students experience disgust for animals across the scale. The most disgusting animals students perceive are macroinvertebrates, while the least disgusting animals are mammals (Randler et al., 2013), and the most disgusting activity is hands-on dissection of fish. In general, there are many species of animals that students categorize into several groups based on attractiveness: those with lower attractiveness (reptiles, amphibians, and insects) and higher attractiveness (mammals and birds), as well as some with very negative ratings, such as spiders, snakes, or insects (Bjerke et al., 1998; Prokop & Tunnicliffe, 2008; Randler et al., 2013). Ondrová (2012) wrote that her respondents had the most experience with hands-on dissection of earthworms, pig or bull eyes, bees, fish or chickens, etc. Similar results were found by Organization Svoboda Zvířat (2011). They wrote that their respondents mentioned alternatives but had no experience with these alternatives. This could be the correct reason for the differences in the use or avoidance of the two decomposition alternatives found in this study. It is similar to the study of Havlíčková et al. (2018a), where the respondents also had no experience with virtual dissection.

It should be noted that disgust protects us from possible diseases, injury, etc. (Randler et al., 2013). Nevertheless, disgust, fear, and other negative emotions could be reduced through various methods (repeated exposure to dissections and animals). For example, Pugh and Salud (2007) used models to reduce the fear of hands-on dissection. And Arraez-Aybar et al. (2004) used verbal information and videos that showed images of human dissection. It is evident that disgust or other previous negative emotions have a negative impact on attitude and reduce the quality of activities performed, along with the quantity of knowledge acquired (Holstermann et al., 2009; Randler et al., 2012, 2016). It could be predicted that positive experiences and attitudes lead to better outcomes. The quality of the acquired knowledge and performed activity also depends on positive emotions.

Self-efficacy can be recognized as an individual's belief in his or her own ability to achieve desired goals in a particular domain. In fact, it can be recognized as a person's belief in his or her ability to influence events that affect his or her life (Bandura, 1994). It can also influence cognitive, motivational, and affective processes (Bandura & Locke, 2003; Randler et al., 2015). Self-efficacy affects all areas of human endeavour. It is part of the mechanism for developing a psychologically resilient personality and a person's belief that they have control over events (Alt, 2018). Belief in one's self-efficacy influences whether people perceive themselves as self-efficacious or self-defeating and how well they motivate themselves or persevere in the face of difficulty (Bandura & Locke, 2003). This means that the self-efficacy of a happy person is much higher than the self-efficacy of a person who is sad or depressed (Forgas et al., 1990; Randler et al., 2012; Salovey & Birnbaum, 1989).

Self-efficacy is strongly associated with motivation to continue studying biology, working scientifically, or performing related activities (Šorgo et al., 2017), which means that positive emotions and experiences significantly increase self-efficacy, while negative emotions and experiences decrease it. As Holstermann et al. (2009) and Randler et al. (2012) found, disgust and fear are the negative predictors that significantly reduce motivation to perform a practical dissection. As Randler et al. (2016) found, we acquire less knowledge about a species when we feel fear of it. When someone feels disgust, their intention is to avoid the stimulus. And at that moment, self-efficacy plays a crucial role because it can lead to a willingness to perform or repeat a certain activity.

Research Aim

There exist many concerns about the position of the hands-on dissection of animals in schools as the source of authentic learning experiences of students. Hands-on dissections can be replaced by alternatives such as models and most recently by virtual laboratories. The most important factor in the selection between alternatives is teachers. The aim of the study was to explore their acceptance of organisms for dissection in school which may depend on many factors, such as availability of the organisms, availability of (digital) tools, cost, emotion, self-efficacy, and motivation. The focus of the study was to answer the question if the self-efficacy of teachers would be a statistically significant predictor of the choice of different kinds of organisms for dissection as hands-on or virtual activity.

Research Questions

Research questions were related to finding reasons for implementing or not implementing hands-on and virtual dissection in biology classes in the Czech Republic. Based on the hypothesis that self-efficacy is highly related to the choice of an organism to dissect and the manner in which dissection is performed, the research questions were as follows.

(1) Are there differences in the acceptability of different types of organisms between hands-on and virtual dissection?
(2) Are there differences in the use of different types of organisms in the classroom between hands-on and virtual dissection?
(3) Are there differences in perceived self-efficacy between practical and virtual dissection?
(4) Is there a statistically significant relationship between self-efficacy and acceptance of organisms in hands-on and virtual dissection?
(5) Is there a statistically significant relationship between self-efficacy and classroom use of organisms in hands-on and virtual dissection?

Research Methodology

General Background

To obtain the answers to research questions, a survey administered to a sample of Czech pre-service and in-service biology teachers working in lower and upper secondary schools was a choice. The survey instrument was a questionnaire with subscales asking about demographic data, frequency of using organisms in the classroom, acceptance of organisms, and a self-efficacy scale focusing on real and virtual dissection. The work was conducted as a doctoral project, with some of the aspects discussed in Havlíčková and Bílek (2015) and Havlíčková et al. (2018a, 2018b).

Data Collection

In order to obtain a general overview of the views and practice of dissection among Czech teachers, the target population consisted of pre-service and in-service biology teachers. The focus was on lower secondary and upper secondary schools, where it was assumed that hands-on dissection is an optional part of the biology curriculum, depending on whether teachers choose this method or not. A call for participation in the survey was made to teachers and prospective teachers through a variety of in-person, formal, and informal channels. All of the contacted prospective teachers were in the Master's programme and had previous experience of teaching in schools as part of their compulsory teaching practice. Two options for completing the questionnaire were offered. The first was a paper-and-pencil form, and the second was an online form set up as a Google form. The questionnaires were distributed in paper form or as a note with a link to the form between September 2015 and February 2016. Completion of the questionnaire was voluntary, and anonymity was guaranteed. No benefits were offered to those who provided responses.

Sample

In a realised survey, there were 489 responses from biology teachers. The sample was large enough for the intended statistical analyses (Hinkin et al., 1997). Cases with a large number of missing responses and responses from individuals who qualified as subject teachers or worked in jobs where dissection was not applicable (e.g., principals) were removed from the list prior to analysis. Therefore, it was finally gained with a sample of 405 prospective biology teachers ($N = 196$; 48.4%) and biology teachers ($N = 208$, 51.4%) who indicated that they belonged to the group of "teachers of a subject in which dissection is applicable." The sample included 304 (75.1%) women and 101 (24.9%) men, reflecting the feminisation of the profession.

Instrument and Procedures

Acceptance Scale

The acceptability of organisms for hands-on or virtual dissection was measured using two identical 5-point Likert scales, one for hands-on and the other for virtual dissection (Havlíčková et al., 2018b). Nine groups of organisms were listed (Table 1) and the respondents' task was to rate their acceptability for inclusion in biology (science) lessons. Given the response format-one (completely unacceptable) to five (completely acceptable)-the nine-point total score had a theoretical range of 9 for someone for whom dissecting all types of organisms is unacceptable to 45 for someone for whom all organisms are acceptable (Table 1). Cronbach's alpha for acceptability of organisms for hands-on dissection was .85, and for virtual dissection was .93; therefore, no item was dropped from the pool.

Dissection Practice Scale

Identical five-point Likert scales to those used for acceptability were used; the only difference was that respondents were asked about their real-world experiences with hands-on and virtual dissection (Havlíčková et al., 2018b). The range on a 5-point Likert scale was from one (never) to "on every possible occasion". Given the response format of 1 to 5, the nine-item summary score had a theoretical range of 9 for someone who never dissects and 45 for someone who dissects every organism on every possible occasion (Table 2). Cronbach's alpha for using hands-on dissection was .87, and for virtual dissection was .97. Given the very good scores, the items were not removed from the pool.

Self-efficacy Scale

Self-efficacy in hands-on and virtual dissection was measured using the General Self-Efficacy Scale (Schwarzer & Jerusalem, 1995). The General Self-Efficacy Scale is a 10-item psychometric scale developed to measure optimistic self-beliefs (Table 3). Respondents were provided with two identical scales and instructed that they should answer the first scale in the context of hands-on dissection and the second scale in the context of virtual dissection. The Czech language version, available on the website of the Free University of Berlin (http://userpage.fu-berlin.de/~health/selfscal.htm), was used in the study. The scale has been shown to be suitable in an international context (e.g. Scholz et al., 2002; Schwarzer et al., 1997; Šorgo et al., 2017). The response format used in the study was as follows: strongly disagree (1), hardly true (2), moderately true (3) and exactly true (4). Due to the response format of 1 to 4, the ten-point summary score had a theoretical range of 10 to 40. The Cronbach's alphas for self-efficacy for hands-on dissection (.89) and virtual dissection (.95) were large enough to accept both scales as reliable; therefore, no item was discarded from the pool.

Data Analysis

Data from the Google forms and paper-and-pencil questionnaires were combined into a single spreadsheet file and transferred to IBM SPSS 24. All cases with a large number of missing items were excluded from the analysis. Because of the non-normal and partially skewed distribution, non-parametric statistics was a choice. Frequency analyses, Spearman correlation coefficients, and Mann-Whitney nonparametric tests were performed. The reliability of the scales was assessed using Cronbach's alpha (Gliem & Gliem, 2003). Effect sizes were calculated as Cohen's d using the *Psychometrica Online Engine* (Lenhard & Lenhard, 2016) and verified using the formula $r = -z/\sqrt{N}$ (Field, 2009, p.550).

Before proceeding with the analysis, the differences in the summative scales between prospective and actual teachers and between genders were calculated. The only statistically significant difference was found in the scales that assessed the acceptability of organisms for use in hands-on dissection (Mann-Whitney $U = 17423.5$; $p = .012$); however, the effect size value ($r = .13$) ranged from not significant to very small, so it was proceeded with the analyses by treating prospective and in-service Biology teachers as one group, regardless of gender. Correlations (Figure 1) were calculated from the sums of answers as obtained by the scales described above.

Research Results

Acceptance of Different Kinds of Organisms as a Hands-on and Virtual Activity in School

The results of acceptance of different types of organisms as a hands-on and virtual activity in school are presented in Table 1. The results are sorted by decreasing means and modes, which means that at the top of the table are the organisms that are accepted for dissection by the majority of teachers. The differences between acceptance in the real and virtual world are clearly visible. In the virtual world, all classes of organisms and organs, except human tissues, are above the median of 5, which means that they are completely acceptable for dissection for more than half of the respondents. On the other hand, the acceptability of organisms to be used in a hands-on dissection falls into two distinct groups. In the first group (*Med* = 5; *Mod* = 5) are plants, arthropods, lower invertebrates, and animal organs that can be purchased in supermarkets or obtained from slaughterhouses for human consumption – all of these organisms are recognised by the majority of teachers as acceptable for dissection. In the second group are whole vertebrate animals and human tissues. All differences in acceptability between hands-on and virtual dissection in the first group are within a small range. In all cases, except for plants, acceptance is higher for the virtual alternatives. In the second group (vertebrates and human tissues), the differences in effect size fall within a large range in favour of virtual dissection.

Looking at the overall acceptance from the central tendencies of the totals of all organisms on a scale of 9 to 45 (Table 1), it can be seen that the effect size is in favour of the virtual dissection in a large range (.86). It is worth noting that for 164 (40.5%) of the respondents, all organisms and tissues in the virtual world are acceptable for dissection. The high level of acceptability is also visible in the value (43) of the median. In the real hands-on world, the acceptance is lower; however, the median of 33 is significantly higher than the midpoint at 27 points.

Table 1
Frequencies of Acceptability of Different Kinds of Organisms for Use as Hands-on and Virtual Dissection in a School (N=405)

Organism	Hands-on dissection *M*	*SD*	Mode %	Median	Virtual dissection *M* *SD*	Mode %	Median	Cohen's *d*	Effect size
Plants	4.88	0.53	(5) 92.6	5.0	4.79 0.67	(5) 87.2	5.0	-0.15	Small
Arthropods#	4.42	0.93	(5) 64.2	5.0	4.63 0.78	(5) 76.3	5.0	0.25	Small
Lower invertebrates##	4.33	1.01	(5) 60.7	5.0	4.59 0.87	(5) 75.8	5.0	0.28	Small
Animal organs###	4.26	1.12	(5) 61.2	5.0	4.45 1.04	(5) 70.9	5.0	0.18	Small
Whole fish	2.41	1.09	(2) 47.2	2.0	4.36 1.11	(5) 66.7	5.0	1.77	Large
Whole reptiles and amphibians	2.80	1.42	(1) 27.4	3.0	4.13 1.30	(5) 59.5	5.0	0.98	Large
Whole birds	2.77	1.44	(1) 28.4	3.0	4.02 1.32	(5) 54.6	5.0	0.91	Large
Whole mammals	2.61	1.40	(1) 31.4	3.0	3.95 1.36	(5) 52.3	5.0	0.97	Large
Human tissue	1.97	1.28	(1) 55.1	1.0	3.74 1.43	(5) 45.9	4.0	1.30	Large
Sum	31.96	7.24	(35) 6.9	33.0	38.65 8.23	(45) 40.5	43.0	0.86	Large

Note. #Arthropods (e.g., insects and crabs); ##Lower invertebrates (e.g., snails, worms); ###Animal organs that can be purchased in supermarkets or obtained from slaughterhouses for human consumption (e. g. pig kidneys; ox eyes)

Differences in the Use of Different Types of Organisms in the Classroom between Hands-on and Virtual Dissection

The results of the differences in the use of different types of organisms in the classroom between practical and virtual dissection are shown in Table 2. The results are sorted by decreasing means and modes. The differences between dissection practice in the real and virtual world are clearly visible. The results show that only plants are regularly dissected hands-on in school, followed by invertebrates and occasionally animal organs and fish. Virtual dissection has not found its way into regular school practice. From the positive, albeit small, effect size values, it appears that only vertebrates and human tissues are dissected more frequently in the virtual world, if at all.

Table 2
Frequencies of Differences in Classroom Application of Different Kinds of Organisms between Hands-on and Virtual Dissection (N=405)

	Hands-on dissection				Virtual dissection					
Organism	M	*SD*	Mode %	Median	*M*	*SD*	Mode %	Median	Cohen's *d*	Effect size
Plants	4.06	1.26	(5) 52.8	5.0	2.25	1.64	(1) 58.8	1.0	-1.24	large
Arthropods#	3.15	1.41	(3) 25.7	3.0	1.99	1.41	(1) 61.7	1.0	-0.82	large
Lower invertebrates##	2.90	1.44	(1) 25.9	3.0	2.01	1.45	(1) 60.7	1.0	-0.62	intermediate
Animal organs###	2.65	1.45	(1) 32.3	3.0	1.86	1.36	(1) 65.4	1.0	-0.56	intermediate
Whole fish	2.51	1.44	(1) 38.3	2.0	1.87	1.32	(1) 64	1.0	-0.46	intermediate
Whole mammals	1.51	0.97	(1) 72.1	1.0	1.63	1.18	(1) 71.9	1.0	0.11	small
Whole reptiles and amphibians	1.49	0.90	(1) 72.3	1.0	1.83	1.28	(1) 63.7	1.0	0.31	small
Whole birds	1.45	0.89	(1) 73.67	1.0	1.65	1.18	(1) 70.9	1.0	0.19	small
Human tissue	1.29	0.78	(1) 84.7	1.0	1.59	1.09	(1) 71.6	1.0	0.32	small
SUM	21.01	7.6	(19) 7.7	20.0	16.68	10.60	(9) 49.1	10.0	-0.47	intermediate

Note. #Arthropods (e.g., insects and crabs); ##Lower invertebrates (e.g., snails, worms); ###Animal organs that can be purchased in supermarkets or obtained from slaughterhouses for human consumption (e. g. pig kidneys; ox eyes)

Results of the Self-Efficacy Scale

It can be seen from Table 3 that the differences in self-efficacy in both contexts are insignificant or bordering on insignificance in one case (d = .15). In the context of hands-on dissection, the mean score of the scale is 29.70 (SD = 4.48). The scale is slightly negatively skewed (skewness = - .41) and deviates from normality (Kolmogorov-Smirnoff test = .10, p <.001). In the context of virtual dissection, the mean of the scale is 29.28 (SD = 5.96). The scale is skewed (skewness = -.88) and deviates from normality (Kolmogorov-Smirnov test = .129, p <0.001). The characteristics of the Czech version of the scale are close to the results of other international studies (e.g., Scholz et al., 2002; Schwarzer et al., 1997; Šorgo et al., 2017). Cronbach's alpha of the instrument was good at .89 for hands-on dissection and excellent at .95 for virtual preparation. The difference in effect size between the sums obtained for hands-on and virtual contexts was not significant (d = .08).

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Table 3
Opinion on Self-Efficacy (N=405)

	Hands-on dissection				Virtual dissection					
Statement	*M*	*SD*	Mode %	Median	*M*	*SD*	Mode %	Median	Cohen's *d*	Effect Size
I can always manage to solve difficult problems if I try hard enough.	3.20	0.72	(3) 52.1	3.0	3.12	0.75	(3) 56	3.0	-0.11	Small
If someone opposes me, I can find the means and ways to get what I want.	2.93	0.70	(3) 59	3.0	2.92	0.70	(3) 62.2	3.0	-0.01	Insignificant
It is easy for me to stick to my aims and accomplish my goals.	2.99	0.69	(3) 56.8	3.0	2.97	0.71	(3) 60.5	3.0	-0.03	Insignificant
I am confident that I could deal efficiently with unexpected events.	2.94	0.74	(3) 54.1	3.0	2.89	0.72	(3) 59	3.0	-0.07	Insignificant
Thanks to my resourcefulness, I know how to handle unforeseen situations.	2.86	0.72	(3) 53.8	3.0	2.81	0.74	(3) 56.5	3.0	-0.07	Insignificant
I can solve most problems if I invest the necessary effort.	3.07	0.64	(3) 63	3.0	2.97	0.70	(3) 61.5	3.0	-0.15	Small
I can remain calm when facing difficulties because I can rely on my coping abilities.	2.85	0.71	(3) 57	3.0	2.86	0.70	(3) 61	3.0	0.01	Insignificant
When I am confronted with a problem, I can usually find several solutions.	2.84	0.69	(3) 57	3.0	2.83	0.74	(3) 57	3.0	-0.01	Insignificant
If I am in trouble, I can usually think of a solution.	3.01	0.61	(3) 68.4	3.0	2.96	0.71	(3) 61.7	3.0	-0.08	Insignificant
I can usually handle whatever comes my way.	3.00	0.65	(3) 65.2	3.0	2.94	0.69	(3) 62.5	3.0	-0.09	Insignificant
SUM	29.69	4.87	(30) 14.3	30.0	29.27	5.90	(30) 21.5	30.0	-0.08	Insignificant

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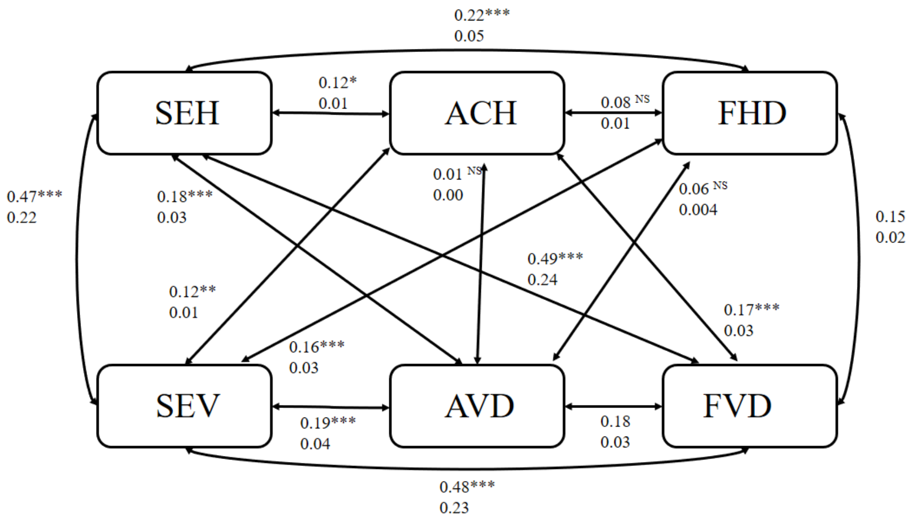
Correlations between Self-Efficacy, Acceptance of Different Organisms, and Actual Dissections

From the results presented in Figure 1, it can be seen that all correlations between the considered constructs are in the medium range (.40 - .59) or below and fall in the weak (.20 - .39) or even very weak and insignificant (.01 - .19) range. Self-efficacy as the construct of interest correlates (*r* = .48) between both hands-on and virtual contexts, so it can be considered as the same underlying construct explaining willingness to introduce or not any kind of dissection. The finding was already indicated by the insignificant value of the effect size (Table 3). Self-efficacy can be identified as a better predictor of the frequency of virtual dissection than as a predictor of hands-on dissection. The explanation can be that teachers were educated in hands-on but not in virtual reality during their university courses. The influence of self-efficacy on both types of acceptance is missing and is very weak in terms of correlations. It is surprising that there is no correlation between the acceptance of organisms and actual dissections.

Figure 1

Correlations among Self-Efficacy, Acceptance of Different Organisms and Actual Dissections (N=405)



Note. *** p < .001; ** p < .01; * p < .05; NS = nonsignificant; SEH= self-efficacy in a hands-on context; SEV= self-efficacy in a virtual context; ACH = acceptability of hands-on dissection; AVD= acceptability of virtual dissection; FHD= frequency of hands-on dissection; FVD = frequency of virtual dissection

Discussion

Differences in the Acceptability of Organism in a Hands-On and a Virtual Dissection

The acceptance of an organism for dissection can only be identified as a potential obstacle in the case of hands-on dissection. This is because the majority of respondents consider virtual dissection to be completely acceptable, with the exception of virtual dissection of the human body, which is somewhat less acceptable. This uniformity in acceptability is not evident in practical dissection. Respondents easily accept hands-on dissection of plants, invertebrates, and animal organs, with differences regarding virtual dissection calculated as effect sizes in the small range. The differences in favour of virtual dissection are in the large range for whole vertebrates and human tissues, indicating the potential for virtual dissection to complement dissection in cases where effect sizes are small and to be suggested as an alternative to hands-on dissection when teachers would not do it anyway.

For hands-on dissection, obtained results support Randler et al. (2013) recommendations that teachers should choose animals used for consumption and avoid cute animals, blood, and other body products. This is because the inclusion of such animals can increase the level of disgust and protest and lead to ethical debate - which is not the case in the virtual world.

Differences in the Use of Different Types of Organisms in a Hands-On and a Virtual Dissection

There is a large gap between accepting an organism for dissection and putting it into practice. The gap is wider in the virtual world, where virtually all organisms are accepted by the majority of teachers, but few or none of them subsequently perform the dissection in the classroom. Since ethics, availability, and price of organisms can be ruled out as barriers, it can be predicted that the most likely major barriers (besides lack of sufficient computers and/or software) are unfamiliarity with this work and insufficiently developed pedagogy for virtual lab work.

Since the application of hands-on dissection in the classroom depends on the species, most teachers will exclude organisms that evoke negative attitudes and emotions and raise perceived ethical concerns (Randler et al., 2013, 2016). Turning negative experiences into positive ones is not easy (Tomažič et al., 2017), so one possible choice is to use animals with negative status (e.g., an agricultural crop pest - Arion vulgaris) or those found in everyday use (e.g., in gastronomy: crustaceans, animal organs, etc.), an approach recommended by Randler et al. (2013).

From the position of the educational value of hands-on dissection and the desire not to completely abandon this technique, the order of introduction of organisms may be important. It was found that teachers regularly used only the hands-on dissection of plants. According to Bernstein (2000), this is the first step in introducing the hands-on dissection of other organisms; the next step should be the dissection of lower invertebrates, leading to the dissection of mammals. Indeed, Randler et al. (2013) note that the animal species should be chosen carefully, as a poor choice could lead to demotivation of students. This is the most likely reason why teachers use plant dissection because plants are readily available, and there are no ethical issues to consider, which leads to the introduction of other organisms; however, sooner or later, they gradually stop. Respondents regularly use hands-on dissection of invertebrates (arthropods and lower invertebrates) and occasionally use hands-on dissection of fish. Dissection of mammals, whole reptiles and amphibians, whole birds, or human tissues is never included in the education, likely related to ethical and legal constraints. At this breaking point, one can see that virtual dissection is an alternative. However, virtual dissection has not currently found its way into regular school practice. From the positive, albeit small, effect size values, it appears that only vertebrates and human tissues are more commonly dissected in the virtual world, if at all.

Differences in the Self-Efficacy in a Hand-On and a Virtual Dissection

Self-efficacy is considered key to performing an activity or not (Bandura, 1994; Bandura & Locke, 2003). Based on the finding that only hands-on dissection of selected organisms is regularly used in schools, it was expected that the cause might lie in the different levels of perceived self-efficacy toward the hands-on and virtual dissection variants. Surprisingly, the differences for most items were not statistically significant (Table 3) and tended towards higher perceived self-efficacy. This means that teachers perceive themselves as quite capable of achieving their chosen goals in both dissection variants and of choosing between using the use of hands-on dissection and its alternatives (Havlíčková et al., 2018b). Obtained claims are supported when hands-on alternatives are considered but not when virtual options are considered.

Prior experience with hands-on dissection has a positive influence on the next performance (Holstermann et al., 2010). In the case of hands-on dissection, social aspects (Palmer et al., 2015) are the most likely reasons for including or excluding certain organisms in the classroom, which can act as positive feedback that increases already high self-efficacy. Students should not feel pressured to perform hands-on dissection (Holstermann et al., 2010), which could mean that teachers should look for new solutions and procedures and not abandon dissection based on the knowledge that hands-on dissection and activities can influence interest across a broad spectrum (positive, neutral, and negative) (Holstermann et al., 2009). Self-efficacy refers to a person's self-belief that they can overcome difficulties (Holstermann et al., 2009) and cope with unpleasant situations, which also applies to the virtual world.

By analogy, Randler et al. (2012) found that regular and progressive exposure of prospective biology teachers to hands-on dissection led to an increase in motivation, despite their uncertainty in implementing it in junior high school. Therefore, Randler et al. (2016) tested the use of a video clip prior to dissection and now recommend it to overcome feelings of fear, disgust, etc. Based on Randler et al. (2012) statement that students become accustomed to hands-on dissection, it is very likely that the more it was implemented virtual dissection in the preparation of prospective biology teachers, the more willing they will be to implement virtual dissection in their classroom.

Relationship between Self-Efficacy and Acceptance of Organisms in a Hands-On and a Virtual Dissection

Correlations between self-efficacy and acceptance of organisms in hands-on and virtual dissection are insignificant or small. Even if the values are small, it remains an open question why self-efficacy towards hands-on dissection is weaker than towards virtual dissection despite more experience with hands-on dissection. It is not possible to provide answers at this point, but it could be speculated that these low scores could be caused by a lack of confidence, experience, fear of failure, cost, legal considerations, hygiene, lack of time, and other unidentified reasons as main predictors (Havlíčková et al., 2018b).

The correlation between acceptance of virtual dissection and self-efficacy is slightly higher but not in the significant range. A plausible reason for the rejection of virtual dissection could be a lack of experience with virtual dissection and insufficient ICT equipment at schools (Havlíčková et al., 2018b).

Relationship between Self-Efficacy and Use of Organisms in a Hands-On and a Virtual Dissection

The correlation between self-efficacy and the use of organisms in hands-on and virtual dissection is much higher than the correlation with acceptance. The reason for this is that acceptance of an organism for dissection does not mean that teachers will actually dissect it. This is clearly seen in the case of virtual dissection, which has a high acceptance rate but is not subsequently implemented in practice. There is no correlation between acceptance and actual implementation of hands-on dissection, nor between hands-on dissection and acceptance of virtual dissection. This means that the actual application of hands-on dissection depends on more than the acceptability of the organism. Although it was found that teachers are convinced that the choice of dissection method depends only on themselves (Havlíčková et al., 2018b), in reality, it is not related to their self-efficacy, but to other factors such as materials, school conditions and so on (Havlíčková et al., 2018b). Self-efficacy can therefore be considered only a low or moderate predictor of actual dissection. The correlation is much stronger in the virtual world than in the hands-on variant. It is counterintuitive to discover that the correlation is lower in actual hands-on dissection, where teachers have more experience, suggesting that other factors, such as ethical concerns, are most likely stronger reasons for including an organism in daily practice. Self-efficacy is a much better predictor in the virtual world, where teachers using non-traditional methods have much higher confidence. A similar but anecdotal finding was reported in a study by Špernjak and Šorgo (2018), who found that teachers are more afraid of damaging computers than they are of possible injuries to their students (Havlíčková et al., 2018b) during lab work.

Conclusions and Implications

The results obtained from the survey of biology teachers can be summarised by saying that virtual and hands-on dissections should coexist in experimental school practice. Based on the analysis of the results, teachers' self-assessment as a predictor of acceptance of both worlds cannot be seen as a barrier to their implementation in successful teaching either. However, it can be considered as a plausible reason for using or not using a particular dissected organism in school practice.

It is reasonable to predict that dissecting, for example, a virtual carrot has no plausible future. On the other hand, the dissection of amphibians, reptiles, mammals, birds and humans should be encouraged because if they are not in the virtual world, they will not be dissected at all. So, if students have a choice, the first step should be the production of high-quality virtual applications in local languages, followed by intensive teacher training, not so much in the technology as in the pedagogy of virtual alternatives to traditional dissection.

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Declaration of Interest

The authors declare no competing interest.

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