



FACTORS AFFECTING KOREAN BIOLOGY TEACHERS' INTENTIONS TO TEACH DISSECTION

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Abstract. *Even as regulation policies prohibiting educational dissection have become more prevalent, some teachers continued to express an intent to perform it. This study attempted to empirically explore how biology teachers' intentions to teach dissection are constructed, focusing on four factors: the perceived educational effectiveness of dissection, self-efficacy in teaching dissection, concerns about dissection, and perceived effectiveness of alternatives. Survey data from 124 Korean biology teachers were analyzed using partial least squares structural equation modeling. The results revealed that the perceived educational effectiveness of dissection strongly predicted intentions to teach dissection, both directly and indirectly, through teachers' self-efficacy. Conversely, concerns about dissection did not directly impact intentions, but indirectly diminished them by reducing self-efficacy and enhancing the perceived effectiveness of alternatives. These results suggest that biology teachers' intentions to teach dissection are resilient as long as they perceive the educational effectiveness of dissection. Thus, it is crucial not only to emphasize concerns about dissection and the effectiveness of alternatives, but also to highlight the critical evaluation of the educational effectiveness of dissection in order to effectively mitigate teachers' psychological resistance towards regulatory policies.*

Keywords: *teaching dissection, intention to teach dissection, partial least squares structural equation modelling (PLS-SEM), South Korean biology teachers*

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Introduction

Animal dissection, a long-standing pedagogical activity in biology education, is increasingly being phased out of secondary science classrooms. This trend is largely driven by a heightened societal awareness of animal rights in recent decades, which has led to a global movement towards policies restricting or prohibiting animal dissection in educational settings. Several nations, including Switzerland, the Netherlands, Slovakia, Argentina, Israel, Sweden, Germany, and the United Kingdom, have implemented either outright bans on dissection or mandates for the adoption of alternative pedagogical approaches (Balcombe, 2001; Waltzman, 1999). Meanwhile, some states in the United States and Australia allow dissection under strict regulation (Osenkowski et al., 2015; Timoshanko et al., 2016), allowing students to refuse dissection and recommending alternatives. While specific regulatory approaches to dissection practices vary between countries or regions, the increasing implementation of ethical and legislative restrictions has compelled biology teachers to make complex decisions between their pedagogical beliefs regarding hands-on learning and regulatory constraints.

Recently, South Korea introduced laws and systems to regulate the educational dissection practices. Initially, it was planned to completely ban minors from dissecting animals, but due to a backlash from science teacher organizations, a bill was announced in 2020 that exempted dissection practices in schools (Kwon, 2020; Prohibition of Dissection Practice on Animals by Minors, 2020). According to this new law, animal dissection practices in schools must be approved by an "Animal Dissection Practice Review Committee" in schools or other research ethics committees in animal research institutions, which can review the educational and ethical considerations of the practice centered on the 3R principle: replacement, reduction, and refinement (Baek, 2018; Enforcement Rule of the Animal Protection Act, 2021; Russell & Burch, 1959)

As a result of these national-level legal changes, the debate surrounding educational dissection has become more active in recent years in South Korea, centered on the science educator community and animal protection organizations. Notably, both sides have reacted against this new law. Animal rights groups have criticized the law for its limited impact, as it still permits



dissection in schools. Additionally, science educator organizations were concerned that the new laws and policies, which make it harder to teach dissection, could discourage the use of hands-on experiments with various animals and specimens in biology. They argued that “Given the demonstrable competence of teachers in both the curriculum and animal welfare, their professional judgment should be recognized, allowing them to conduct dissection education under the school principal’s responsibility” (Kwon, 2020). This statement suggests that the policy approach of restricting dissection in the curriculum has not been well received by a considerable number of South Korean biology and science teachers. Furthermore, it implies that teachers’ professional decision-making regarding the implementation of dissection is a key consideration in the ongoing discourse on dissection practices in schools.

Although dissection is not explicitly mandated in the curricula or educational guidelines of numerous countries (De Villiers & Monk, 2005; Hart et al., 2008), studies have reported a tendency of biology teachers to continue teaching with dissection (King et al., 2004; Oakley, 2012a, 2012b; Zemanova, 2022). In this vein, the unilateral imposition of policies regulating dissection, targeting teachers inclined to maintain such practices, is likely to generate significant confusion and conflict within and beyond the educational community. How can the tension between this regulatory policy approach concerning school dissection practices and biology teachers’ stances be resolved? As mentioned above, the recent enactment of laws related to dissection, coupled with active social discourse in Korea, has established a pertinent sociocultural context for understanding the intentions of biology teachers to use dissection. Therefore, this study explored potential solutions by examining the psychological factors underlying Korean in-service biology teachers’ decision-making regarding the implementation of dissection in their teaching. To be specific, this study focused on the four factors related to biology teachers’ intentions to teach with dissection: Perceived educational effectiveness of dissection (PED), concerns about dissection, self-efficacy for teaching dissection, and perceived educational effectiveness of alternatives (PEA).

Literature Review

Perceived effectiveness and concerns of educational dissection

Educational dissection has been recognized in numerous studies for its merits and potential drawbacks (Baek, 2018; Grigg et al., 2020; Kaiser et al., 2023; Offner, 1993; Osenkowski et al., 2022). On the positive side, dissection has been shown to enhance students’ comprehension of biological structures and functions, stimulate significant interest in biology, and facilitate the acquisition of experimental skills, thus offering benefits in biology education (De Villiers & Monk, 2005; King et al., 2004; Oakley, 2012b). Simultaneously, dissection has raised social concerns, particularly regarding safety issues, ethical considerations related to animal suffering, and emotional stress experienced by students (De Villiers & Monk, 2008; Holstermann et al., 2009, 2012; Oakley, 2012b).

In this vein, dissection is seen as a paradoxical activity in itself, with the opportunity to experience the complex interplay among biological understanding, negative and positive emotions (Holstermann et al., 2012). This complexity in the nature of educational dissection is also reflected in teachers’ perceptions of dissection. Several studies exploring teachers’ perspectives on dissection have indicated that they are cognizant of both the positive and negative aspects (Kim, 2022; Madrazo, 2002; Oakley, 2012b; Zemanova, 2022). For example, Oakley (2012b) reported that Canadian science teachers perceived the educational strengths of dissection to include enhancing understanding of living things, experiencing the reality of living things, acquiring experimental skills, fostering emotional enjoyment and respect for life, and preparing students for careers. Simultaneously, they acknowledged challenges such as students’ safety, classroom management, cost, and ethical concerns. Ultimately, previous studies suggest that both the perceived effectiveness and concerns on dissection significantly influence teachers’ intentions to teach it in their classroom. In other words, biology teachers might evaluate both benefits and drawbacks of dissection when deciding whether to incorporate dissection into their classroom.

Self-Efficacy for Teaching Dissection

Teachers’ self-efficacy encompasses their belief in their capacity to effectively facilitate student learning and help them achieve desired educational outcomes through proficient instruction, classroom management, or participation in educational decision-making (Bandura, 1997; Tschannen-Moran & Hoy, 2001). Teachers’ self-efficacy significantly influences their adoption of new pedagogical approaches (Guskey, 1988; Joo et al., 2018; Ma et al., 2021). Teachers with high efficacy are more likely to undertake the risks associated with a pedagogical approach if they perceive it as educationally valuable. For example, the intention to adopt technology-integrated instruction is

significantly affected by teachers' efficacy regarding technology or technology-enhanced teaching practices (Joo et al., 2018; Bai et al., 2024; Li et al., 2016). Although dissection is not a novel technology, but rather, a conventional practice with a long history of biology education (De Villiers & Monk, 2005; Fančovičová et al., 2013), the intention to conduct dissection could be also significantly influenced by teachers' efficacy in teaching dissection. It is closely related with previous studies addressed that teachers' self-efficacy has been considered an important factor for implementing inquiry-based approaches and science in their classroom (Enochs, 1995; Lakshmana et al., 2011).

Furthermore, the voluntary engagement in dissection by some teachers, even when not curriculum-mandated and despite acknowledged educational challenges, highlights the considerable motivational factors at play. For example, in medical education, where whole-body dissection has been declining, surgeons' motivation to teach anatomical dissection to medical students is directly linked to their sense of accomplishment, stemming from observing both their students' immediate and long-term achievements (Burgess & Ramsey-Stewart, 2014). Building on these previous studies, teachers' efficacy in dissection can be defined as their belief in their ability to achieve anticipated educational outcomes and manage associated challenges. And this efficacy is expected to significantly influence their intention to teach dissection.

Drawing on Bandura (1997), individual self-efficacy emerges from direct or vicarious successful experiences with positive results stemming from specific behaviors. In this framework, teachers who have directly or indirectly experienced the effectiveness of certain educational practices are hypothesized to exhibit elevated self-efficacy in conducting such practices. Conversely, teachers' direct or indirect experience with the difficulties of implementing a specific pedagogy is likely to reduce their self-efficacy for that approach. In this vein, teachers' self-efficacy in teaching dissection is assumed to be influenced by their perceptions of its educational effectiveness and the concerns associated with these practices. To be specific, when teachers encounter challenges or harbor significant concerns regarding dissection practices, they are likely to perceive these practices as considerably difficult, which in turn lowers their self-efficacy in teaching dissection.

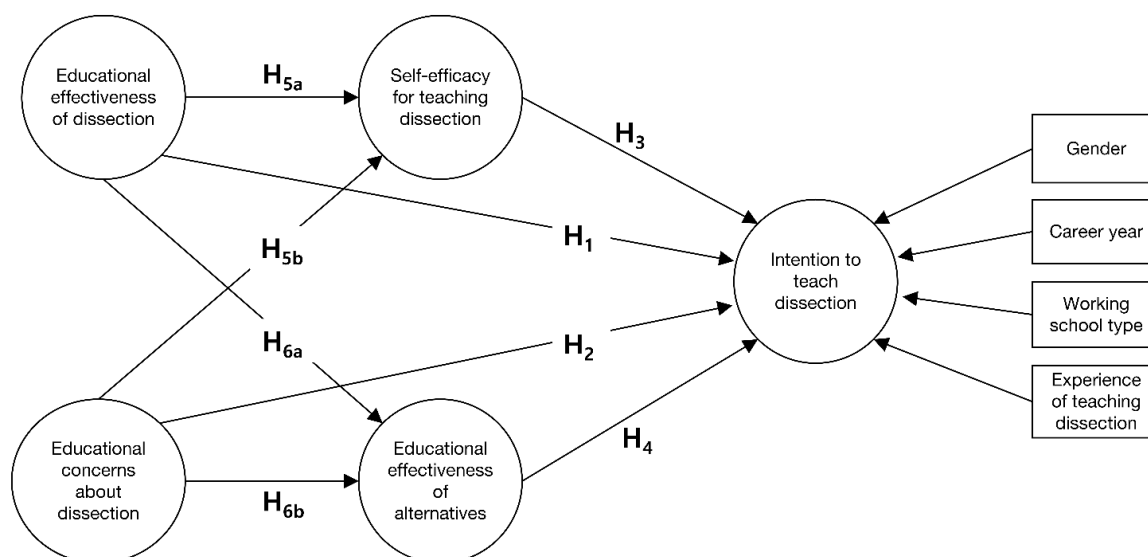
Perceived Educational Effectiveness of Alternatives

Based on a principle of replacement, which is the first principle of the 3Rs in animal testing, many studies developed the non-animal methods and reported the educational effect of it (Ormandy et al., 2022). While many studies consistently highlight the educational effectiveness of animal dissection alternatives, many teachers haven't fully recognized that dissection alternatives guarantee the same educational effectiveness as traditional dissection (King et al., 2004). How teachers perceive the educational effect of alternatives can directly influence their willingness to adopt them and their intentions regarding the continued use of traditional animal dissection (De Villiers & Monk, 2005; King et al., 2004; Hart et al., 2008; Oakley, 2012b).

Perceptions regarding the educational effectiveness of alternatives are contingent upon an individual's appraisal of both the educational effectiveness and ethical concerns associated with traditional dissection. Evaluations of these alternatives exhibit significant divergence, with some educators prioritizing the educational values of dissection, while others emphasize ethical and practical concerns. For instance, Oakley (2012b) observed that despite acknowledging dissection-related concerns, science teachers prioritized the perceived educational inadequacies of alternatives, leading to a continued preference for dissection. Conversely, Elmali (2024) recently reported that pre-service science teachers experiencing negative emotions such as guilt and stress during dissection demonstrated a stronger inclination toward alternatives.

Present Study

The research question guiding this study is: How do PED, concerns about dissection, self-efficacy for teaching dissection, and PEA exert their influence on the dissection teaching intentions of in-service biology teachers in South Korea? To answer this question, this study hypothesized a research model based on literature review and shown in Figure 1.

Figure 1
Hypothesized Model

This model contains eight hypotheses, represented by solid lines, which illustrate the hypothesized relationships between its five constructs. This study assumes that the four factors discussed above directly influence intentions to practice dissection. Therefore, this study proposes the following four hypotheses.

Hypothesis 1 (H_1): PED would positively influence the intention to teach with dissection.

Hypothesis 2 (H_2): Educational concerns regarding dissection would negatively influence intention to teach with dissection.

Hypothesis 3 (H_3): Teacher efficacy related to teaching dissection would positively influence intention to teach with dissection.

Hypothesis 4 (H_4): PEA would negatively influence the intention to teach with dissection.

Based on literature review, this study also assumed that the educational effectiveness and concerns not only directly influence teachers' intentions to conduct dissections but may also indirectly affect this intention through the mediating effect of both self-efficacy and PEA. In other words, this study aimed to examine each mediating effect of self-efficacy and PEA on the relationship between PED, concerns about dissection, and teachers' intentions to perform dissections. For examining the mediation effects of self-efficacy and PEA, this study proposes the following four additional hypotheses.

Hypothesis 5a (H_{5a}): PED would positively influence self-efficacy in teaching with dissection.

Hypothesis 5b (H_{5b}): Educational concerns regarding dissection would negatively influence self-efficacy in teaching with dissection.

Hypothesis 6a (H_{6a}): PED would negatively influence PEA.

Hypothesis 6b (H_{6b}): Educational concerns regarding dissection would positively influence PEA.

Additionally, a teacher's gender, teaching experience, type of affiliated school (middle or high school), and dissection teaching experience were included as control variables in examining the interactions between the four dependent variables and teaching dissection intention.

Research Methodology

Research Design

This study takes an exploratory approach to uncover the underlying structure of biology teachers' intention to teach dissection practice. Generally, exploratory research is conducted to elaborate new hypotheses or theories in the absence of a theoretical basis or comprehensive consensus for a particular problem. In terms of teachers' view on teaching dissection, previous research has explored teachers' general perceptions and attitudes toward dissection using descriptive statistics or qualitative methods (Hart et al., 2008; Hug, 2008). These previous studies confirmed that PED, their concerns about dissection, and PEA would have a significant impact on dissection factors. However, a comprehensive analysis of the psychological structure shaping the intention to implement dissection—particularly concerning the intricate relationships among its various constituent variables—remains limited.

To address this gap, this study adopted Partial Least Squares Structural Equation Modeling (PLS-SEM), one type of structural equation modeling, which is a variance-based approach for analyzing structural relationships among latent variables and indicators. PLS-SEM is often preferred for exploratory research, compared to Covariance-Based Structural Equation Modeling (CB-SEM), which is typically employed for confirmatory analysis with established theories (Dash & Paul, 2021; Hair & Alamer, 2022). PLS-SEM offers several benefits, including its ability to handle relatively complex models, its suitability for smaller sample sizes, and its reduced sensitivity to normal data distributions. Given the lack of established theoretical models regarding biology teachers' intentions to teach dissection, PLS-SEM was adopted to explore the structural relationships among factors influencing this intention.

Development of Measurement Items

For data collection, 23 items were developed to measure five constructs: five items for PED, three items for concerns regarding teaching dissection, five items for PED, six items for self-efficacy in teaching dissection, and four items for the intention to teach with dissection. Appendix A presents these items.

Item development was conducted by two authors who have actively researched biology teachers' perceptions and decision-making. To develop valid items, the authors reviewed various previous studies conducted on teachers' perceptions of the benefits and concerns regarding hands-on dissection and alternatives (Hart et al., 2008; King et al., 2004; Oakley, 2012b) and the effectiveness of dissection alternatives (Kinzie et al., 1993; Ormandy et al., 2022; Osenkowski et al., 2015). This study also referred to studies on teachers' self-efficacy in adopting specific educational approaches or technologies (Klassen et al., 2009; Dellinger et al., 2008) and their intentions to adopt specific subjects or technologies in their teaching (Al Breiki, 2023; Chuang, 2023; Meccawy, 2023; Shim, 2003). By synthesizing the findings of previous studies and focusing on characteristics deemed appropriate for measuring each construct, two authors developed the final items. This study included four control variables: gender, career year, working school type (middle or high school), and experience in teaching hands-on dissection to better understand the effect of the four independent variables on the intention to teach dissection. Each question was presented in Korean, and responses were requested on a five-point Likert scale. Item development took place in the latter half of 2020.

Sampling and Data Collection

A convenience sampling strategy was adopted in this study (Etikan et al., 2016). The rationale behind this approach stemmed from the researcher's participation as an instructor in a training program for biology in-service teachers, which afforded convenient access to cross-sectional data from numerous early-career biology teachers. The specific training program was a teacher retraining course, a professional development initiative supported by the South Korean government (under the Enforcement Decree of the Elementary and Secondary Education Act, 2024). It was exclusively for teachers with a minimum of three years of pedagogical experience, thus comprising relatively early-career professionals.

The researcher explained this study's purpose and participation methods and assured the teachers that there would be no disadvantages associated with their participation. In total, 124 biology teachers agreed to participate after hearing this explanation. Table 1 presents their demographic information. They were relatively young teachers with an average of 6.7 years of teaching experience, and 87 of them (70.2%) were female. Data collection was conducted through an online Google Form in January 2021.

Table 1*Demographics of respondents (N=124)*

	<i>N</i>	%
Gender		
Male	37	29.8
Female	87	70.2
Career year		
3-5 years	43	34.7
5-10 years	54	43.5
10-15 years	24	19.4
>15 years	3	2.4
Working school type		
Middle school	60	48.4
High school	60	48.4
Both	4	1.2
Experience of teaching dissection		
Have	92	74.2
Not have	32	25.8
Experience of teaching with alternatives		
Have	63	50.8
Not have	61	49.2

Data Analysis

The PLS-SEM analysis procedure proceeded in two parts: testing the measurement model and testing the hypothesis model. First, the measurement model was examined for internal consistency and two types of construct validity: convergent and discriminant. Internal consistency was assessed using Cronbach's alpha and composite reliability (CR). While both assess the internal consistency of latent variable measures, Cronbach's alpha assumes equal item weights for the construct, whereas CR assumes different weights for each item in their construct. Consequently, CR is generally considered a more reliable indicator (Peterson & Kim, 2012).

Convergent validity was examined using exploratory factor analysis and average variance-extracted (AVE) values. To assess the suitability of the data for exploratory factor analysis, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity were checked. AVE represents the extent to which the variance in the measured scores can be attributed to the underlying construct. Discriminant validity was examined by comparing the square root of the AVE and correlations among constructs based on the criterion suggested by Fornell and Lacker (1981). This study also examined the correlation of each construct to determine whether there was a significant correlation between them. In the case of high correlations, variance inflation factors (VIF) were examined to assess potential multicollinearity issues.

Common method bias, potentially arising from the simultaneous collection of independent and dependent variables via self-report surveys from the same respondents, could distort the data and interpretations. To address this potential bias, this study conducted Harman's single-factor test, which examines whether a single factor accounts for a dominant portion of the data's variance or not (Podsakoff et al., 2003; Podsakoff & Organ, 1986).

Second, the hypothesized model was examined using path coefficients, their statistical significance, and the explanatory power (R^2) of the model. This study also evaluated the mediating effects of self-efficacy in teaching dissection and PEA by comparing the direct and indirect effects of each independent variable on the intention to teach using dissection. The Smart PLS software was used for the analysis.

Research Results

Assessment of Measurement Model

As shown in Table 2, the Cronbach's alpha values for all constructs except for concern exceeded .80, indicating strong reliability. The Cronbach's alpha value for concerns regarding teaching dissection was comparatively lower, at .64. However, the CR values of all constructs ranged from .80 to .94, demonstrating acceptable reliability (Hair et al., 2009).

The convergent and discriminant validities of the measurements were acceptable. As shown in Appendix B, all factor loadings for each construct exceeded .60 and were higher than the loadings on other constructs, indicating satisfactory convergent and discriminant validity. All AVE values exceeded .50, demonstrating that each construct explained more than 50% of the indicator variance, thus supporting convergent validity (Fornell and Lacker, 1981). Furthermore, the square root of each AVE value exceeded the shared variance between that construct and the others (i.e., inter-construct correlations), supporting discriminant validity (Fornell & Larcker, 1981).

Correlation analysis revealed significant correlations between all the constructs. The correlations between the intention to teach with dissection and PED, and between the intention to teach with dissection and self-efficacy exceeded .70, indicating that they were highly correlated. However, the VIF values for these construct pairs (intention–PED and intention–efficacy) were below the threshold of 3, indicating no problematic multicollinearity. Therefore, the measurement model exhibited both convergent and discriminant validity.

Lastly, the KMO value of .891 and Bartlett's test ($p < .001$) confirmed the suitability of the samples for exploratory factor analysis. The result of exploratory factor analysis showed that a single factor explained less than 50% (40.91%) of the variance, thus indicating that common method bias is not a substantial concern for this study (Podsakoff & Organ, 1986).

Table 2
Correlation, Reliability, and Validity of Each Construct

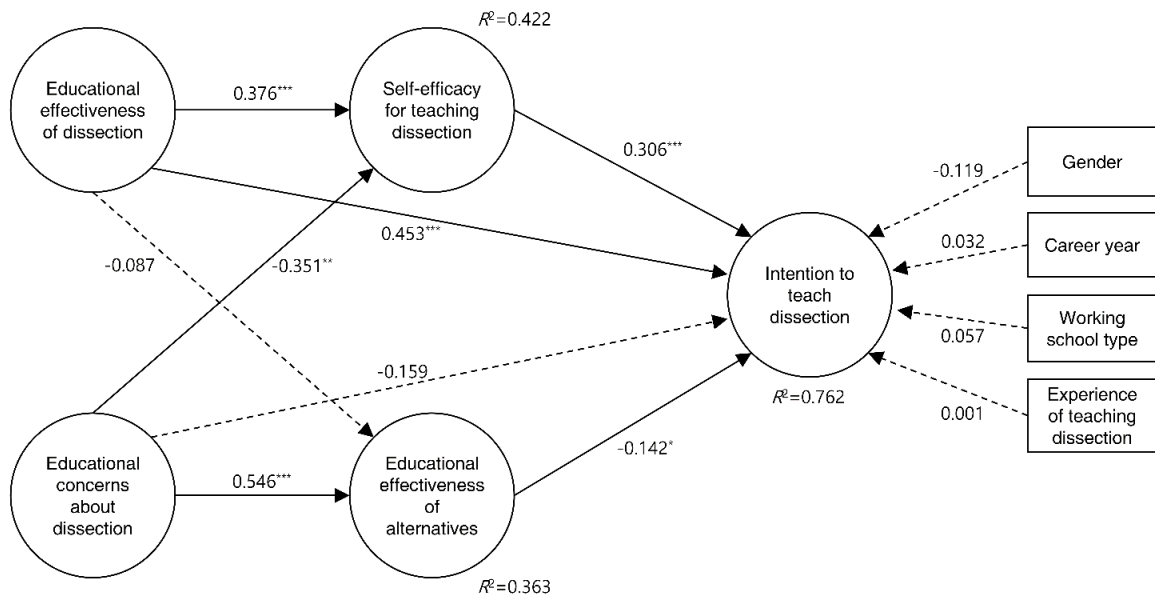
Construct	M	SD	(1)	(2)	(3)	(4)	(5)	Cronbach's α	CR	AVE
(1) PED	3.69	.91	.802**					.86	.90	.64
(2) Concern	3.45	.84	-.596**	.760**				.64	.80	.58
(3) Self-efficacy	3.48	1.07	.585**	-.575*	.806**			.89	.92	.65
(4) PEA	3.78	.88	-.413**	.598**	-.326*	.752**		.81	.87	.57
(5) Intention	3.16	1.28	.779**	-.695**	.713**	-.519**	.894**	.92	.94	.80

Note. The diagonal values represent the square root of the average variance extracted (AVE) for each construct, while the off-diagonal values represent inter-construct correlations.

* $p < .05$. ** $p < .01$.

Assessment of Hypothesized Model

The results of the assessment of the hypothesized model are shown in Figure 2. The intention to teach dissection was significantly influenced by PED, PEA, and self-efficacy in teaching dissection. Thus, the three hypothesized direct paths regarding the intention to teach with dissection (i.e., H_1 , H_3 , and H_4) were supported (Table 3). PED had a relatively strong positive effect on intention to teach with dissection ($\beta = .453$, $p < .01$), whereas concerns regarding dissection did not have a significant effect; therefore, hypothesis H_2 was rejected ($\beta = -.159$, $p > .05$). The biology teachers' gender, affiliated school type, years of experience, and prior experience in teaching dissection also did not significantly affect their intention to teach using dissection.

Figure 2*Results of the Structural Estimation Model***Table 3***Direct and Indirect Effects Among Variables*

Paths	β	t	p
Direct paths			
PED → Intention	.453	7.485	<.001
Concern → Intention	-.159	1.910	.056
Self-efficacy → Intention	.306	3.885	<.001
PEA → Intention	-.142	2.142	.032
PED → Self-efficacy	.376	3.373	.001
Concern → Self-Efficacy	-.351	3.064	.002
PED → PEA	-.087	0.986	.324
Concern → PEA	.546	6.037	<.001
Indirect paths			
PED → Self-efficacy → Intention	.117	2.289	.022
PED → PEA → Intention	.011	0.611	.541
Concern → Self-efficacy → Intention	-.109	2.535	.011
Concern → PEA → Intention	-.077	2.468	.014
Control measure			
Gender → Intention	-.119	1.124	.261
Career year → Intention	.032	0.690	.490
Working School → Intention	.057	1.307	.191
Teaching experience of dissection → Intention	.001	0.008	.994

Hypotheses H_{5a} and H_{5b} were supported, as self-efficacy in teaching dissection was significantly influenced by both PED and concerns regarding dissection. The explanatory power of self-efficacy in teaching dissection was .422. In addition, PEA was significantly influenced by concerns regarding dissection, but not PED. In other words, hypothesis H_{6a} was rejected, but hypothesis H_{6b} was supported. The explanatory power (adjusted R^2) of PEA was .363.

The analysis of the indirect effects revealed that the PED had a significant effect on the intention to teach with dissection, both directly and indirectly. Self-efficacy in teaching dissection had a significant mediating role in the relationship between PED and intention to teach with dissection ($\beta = .117, p < .05$). This suggests that high dissection teaching efficacy, coupled with the perceived effectiveness of dissection practice, leads to a strong intention to teach dissection.

Concerns regarding dissection had only indirect effects on the intention to teach using dissection, mediated through self-efficacy to teach dissection and PEA. Specifically, self-efficacy to teach dissection fully mediated the relationship between concern and intention to teach with dissection ($\beta = -.109, p < .05$). In addition, there was also a fully mediated relationship between concerns regarding dissection and intention to teach with dissection through PEA ($\beta = -.077, p < .05$). The overall explanatory power for the intention to teach dissection was .746. These results suggest that concerns regarding dissection indirectly reduce teaching intentions by decreasing teaching efficacy or increasing the perceived effectiveness of alternatives.

Discussion

Over the past two decades, educational policies have emerged in many countries to ban or conditionally prohibit the practice of dissection in the classroom; however, little attention has been paid to the psychological mechanisms of teachers who make decisions regarding teaching with dissection. Given that historical, cultural, and political values in biology and biology education are intertwined in the practice of teaching dissection, a multifaceted and holistic approach, rather than a simple pro-/anti-dissection debate, would be more effective in addressing the challenges posed by the practice (Hart et al., 2008). By examining the complex relationships between variables related to teachers' decisions regarding teaching dissection, this study attempted to provide a more nuanced understanding of how teaching dissection decisions are made and why dissections do not easily disappear from the classroom.

The results of this study showed that teachers' intentions to implement dissection were significantly driven by their perceived effectiveness of dissection and their teaching self-efficacy. Unsurprisingly, the perceived effectiveness of dissection had the strongest positive influence, followed by enhanced self-efficacy in teaching dissection. This suggests that perceived educational effectiveness is the primary motivator for teachers' dissection intentions. In contrast, concerns regarding dissection had no significant direct impact. Instead, concerns regarding dissection were found to indirectly diminish dissection implementation intentions through mediating effects, such as reducing self-efficacy or enhancing positive perceptions of alternatives.

These results indicate why dissection persists as a prevalent pedagogical practice, despite teachers acknowledging its merits and drawbacks from a seemingly balanced perspective (Oakley, 2012b). The results of this study suggest that, when teachers show similar levels of concern and perceived effectiveness, perceived effectiveness tends to exert a stronger influence on their intentions to implement dissection, thereby sustaining the practice. Moreover, the findings of this study demonstrate that substantial concerns regarding dissection do not necessarily lead to a significant reduction in teachers' dissection intention when they lack positive perceptions of alternatives or possess high self-efficacy in teaching using dissection.

Collectively, these findings suggest that policy interventions that exclusively emphasize concerns surrounding dissection may not be sufficiently effective in mitigating biology teachers' intentions to utilize this practice. Biology educators, although cognizant of the apprehensions associated with dissection, are likely to be hesitant to abandon practices deemed to offer significant scientific or biological educational value. In this context, rather than emphasizing the concerns associated with dissection or the merits of alternatives, it might be effective to equip biology teachers with the means for informed professional decision-making based on meticulous analysis and a reflective appraisal of their own educational effectiveness in dissection.

Previous researchers have suggested that biology teachers need opportunities to reflect actively and deeply on the ethical dilemmas of dissection (Oakley, 2012b). However, discussions regarding ethical dilemmas such as this often tend to focus on issues of animal rights, rather than on the educational value of animal dissection. Given the findings of this study, it would be more efficient to share diverse perspectives and empirical validation results regarding the educational outcomes of animal dissection with teachers to effectively minimize their intentions to practice dissection.



In addition to the ethical issues surrounding dissection, there is also a debate about whether it is educationally effective. The educational value of dissection is frequently highlighted in the literature, curricula, and statements of science teacher associations (NABT, 2019; NSTA, 2008). Previous studies have reported that teachers strongly recognize the biological education benefits of dissection and consider them key practices in biology curricula (King et al., 2004; Oakley, 2012a, 2012b). However, some studies have indicated that achieving these pedagogical goals presents significant challenges. For example, a recent meta-study by Ormandy et al. (2022) evaluated the educational effectiveness of dissection using animals compared to alternative approaches and found no superior effectiveness for dissections. And Hug (2008) analyzed dissection-based instructions and found that these classes primarily deliver procedural and factual knowledge, but often fail to facilitate meaningful sense-making regarding structure–function relationships, which is a major objective of biology classrooms using animal dissection. Furthermore, Hart et al. (2008) reported that the perceived educational goal of dissection is ambiguous among teachers, which consequently results in wide variations in their instructional behaviors.

In this context, this study suggests that biology teachers should engage in opportunities that facilitate the critical evaluation of the pedagogical value derived from their own experiences with dissection, not only by delving into the ethical considerations surrounding the use of animals in this context. This process might encompass an introspective analysis of whether the intended educational benefits have been effectively realized within their own teaching and learning experiences, as well as whether dissection can be implemented in their own class as an educationally meaningful practice, rather than just a conventional lab practice. Engaging in reflective practices regarding the pedagogical value of animal dissection also contributes to a more nuanced ethical debate regarding its educational use in the classroom. Consequently, this leads to both a reduction in indiscriminate dissection and an improved educational effectiveness of carefully considered dissection activities, particularly in areas where they are conditionally allowed, such as South Korea.

The exchange and discussion of authentic problems and dilemmas encountered during dissection instruction among different teachers can serve as a valuable opportunity for teachers to reflect on their educational effectiveness. Sharing these real-world experiences encourages teachers to not only reflectively assess the educational merits of dissection, but also to evaluate their capacity to address the inherent challenges of its implementation. This process facilitates a critical self-assessment of teaching competence to moderate their sense of dissection teaching efficacy.

Although the perceived effectiveness of dissection alternatives is significantly related to dissection concerns, it is not related to the perceived effectiveness of dissection. This suggests that teachers view dissection alternatives as a strategy for addressing the drawbacks of dissection, rather than as equivalent pedagogical tools that guarantee educational outcomes. This observation reinforces previous research that reported teachers' enduring doubts about the ability of alternatives to match the educational value of actual dissection (King et al., 2004; Oakley, 2012b). The increasing availability of dissection alternatives with the rapid development of digital technologies such as virtual reality, augmented reality, and metaverse has been a key basis for policies banning or providing conditional restrictions on dissection in many countries over the last two decades (Elmali, 2024; Lalley et al., 2010; Ormandy et al., 2022; Shim et al., 2023). However, despite the increasing availability of alternatives and technological advancements, the findings of this study suggest limitations in the adoption of alternatives as a full replacement for dissection, as long as the educational effectiveness of hands-on dissection is strongly recognized.

Given these findings, there is a need to provide teachers with data and opportunities to rigorously compare the effectiveness of various alternatives and educational merits of animal dissection (King et al., 2004; Ormandy et al., 2022). For example, proactively informing Ormandy et al. (2022)'s findings of a meta-analysis regarding the relatively low effectiveness of dissection to teachers may consequently reduce their intentions to employ dissection. In addition, given that a teacher's perceived educational effectiveness of a particular activity depends more on his or her own experience, this study proposes engaging teachers in the process of comparing and deliberating on the educational impacts of alternatives within their own instructional contexts. This will allow them to discern the extent to which alternatives can replicate the pedagogical effects of animal dissection and to identify inherent limitations, ultimately fostering thoughtful and evidence-based decisions on educational dissection.

In terms of generalizability, this study is constrained by the socio-cultural context of South Korea. Variations in cultural interpretations of dissection in classrooms across countries may significantly impact teachers' intentions to use dissection. For example, in countries like the United States and several European nations, where ethical debates and policy adjustments regarding dissection education began much earlier than in Korea, or in some cultural spheres (e.g., Buddhist cultures) where the killing or harming of various living beings is more strongly discouraged due to religious or cultural perspectives, a consensus concerning worries about dissection practices may be relatively more prevalent among biology teacher groups. It's also possible that teachers in countries with an absolute



ban on educational dissection would exhibit different outcomes than those in nations, such as South Korea, where it's partially allowed. In such contexts, unlike the results of this study targeting Korean biology teachers, the path where educational concern negatively impacts intention to teach dissection might appear statistically significant in the hypothesized model. By contrast, in nations where societal discourse and regulatory policies regarding educational dissection have emerged relatively recently, much like in Korea, the results of this study are likely to hold similar relevance.

Consequently, further research should explore the mechanisms underlying these intentions in relation to socio-environmental factors. Specifically, conducting multiple group analysis based on SEM to examine parameter differences within hypothesized models across groups would facilitate the verification of how the model identified in this study functions distinctly across countries or cultures. Therefore, international comparative studies could extend the findings of this study. Additionally, the participants of this study, predominantly female and early career biology teachers, necessitated further examination to assess the applicability of the model of this study to a more representative demographic.

Lastly, while this quantitative study, utilizing PLS-SEM, was effective in modeling the overall cognitive structure of a large number of participants, it had limitations in understanding the contextuality and diversity of their reasoning. Building upon the model identified in this research, subsequent mixed-methods studies will be needed to qualitatively explore the relationship between biology teachers' reasoning regarding their intention to conduct dissection and relevant contextual variables.

Conclusions and Implications

In an era demanding ethical and responsible scientific practices, policies regulating dissection in science classrooms are inevitable. However, the significant discrepancies between policy approaches and teachers' perceptions of dissection may undermine the effectiveness of such policies. To be specific, policy change may be difficult to accept for teachers who have personally experienced the educational benefits of dissection. By empirically exploring the complex relationships among the factors that influence biology teachers' intentions to teach using dissection, this study sought to propose directions for effective dissection regulation policies that align with biology teachers' perspectives.

The findings of this study suggest that biology teachers' intentions to practice dissection are resilient as long as they perceive the educational effectiveness of dissection. Approaches based on a critical evaluation and analysis of the educational effectiveness of dissection practices may be more effective in modulating teachers' intentions to practice dissection, compared to merely emphasizing concerns about dissection or the effectiveness of alternatives. To do this, academics need to continue to critically examine and conduct empirical research on the educational benefits and limitations of teaching dissection in secondary classrooms, and biology educators need to actively share this research with both pre-service and in-service biology teachers. This would facilitate teachers' reflective examination of their current practices of dissection.

In addition, given the necessity of pedagogical practices to align with specific educational contexts, this study proposes that teachers need to reflect on and discuss the educational benefits of dissection practice as experienced in their own classrooms, coupled with a critical assessment of their own capability to respond to challenges in achieving those benefits. Such a reflective analysis of the educational effectiveness of dissection practices can contribute to preventing indiscriminate use of dissection among teachers, while fostering more thoughtful decisions on teaching dissection practices in areas where they are conditionally permitted, such as South Korea.

The sociocultural context of South Korea, where this study was conducted, may restrict its direct international applicability. Nonetheless, this research offers novel insights into the cognitive structures related to dissection among biology teachers, who serve as crucial decision-making actors in their classrooms. The identified model is particularly significant as it can be useful groundwork for subsequent international comparative analyses of the varied teachers' perception regarding educational dissection. Ultimately, this will contribute to exploring ways in which dissection policy regulations can be effectively implemented, thereby fostering more ethical science education practices.

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Declaration of Interest

The authors declare no competing interest.

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Appendix 1
Measurement Items

Code	Item
PED1	I think hands-on dissection is an effective way for students to understand animal structure and function.
PED2	I think hands-on dissection is an effective way for students to improve their skills in biology experimentation skills
PED3	I think hands-on dissection is an interesting activity to increase students' learning motivation.
PED4	I think hands-on dissection is an important opportunity for students to see the reality and complexity of organisms.
PED5	I think hand-on dissection is a necessary experience for students who pursue biology-related careers in the future.
PEA1	I think alternatives (models, videos, AR, VR, etc.) are good to drive the educational advantages of animal dissection.
PEA2	I think dissection alternatives (models, videos, AR, VR, etc.) are effective in addressing ethical issues about hands-on dissection.
PEA3	I think dissection alternatives (models, videos, AR, VR, etc.) are less expensive than hands-on dissection.
PEA4	I think the limitations of recent dissection alternatives (models, videos, AR, VR, etc.) are relatively small compared to the challenges of hands-on dissection.
PEA5	Technological advancements may eventually provide perfect alternatives to hands-on dissection, potentially eliminating dissection from education.
Concern1	I think students' experience of dissection will undermine their respect for the dignity of life.
Concern2	I think the emotional stress on students who participate in hands-on dissection experiences is quite high.
Concern3	Dissection practice offers comparatively limited learning compared to other inquiry-based methods.
Efficacy1	I believe I would be able to teach a hands-on dissection well.
Efficacy2	If I were to teach hands-on dissection, I believe I would have no trouble preparing for it.
Efficacy3	If I were to teach a hands-on dissection, I believe that I would make students engage well.
Efficacy4	If I were to teach a hands-on dissection, I believe that I will help students understand the purpose of the dissection and keep them engaged.
Efficacy5	If I were to teach a hands-on dissection, I believe that I would be able to handle the students' emotional reactions during the dissection class.
Efficacy6	I would not have any problem teaching a dissection.
Intention1	I am positive about having hands-on dissection in secondary biology classes.
Intention2	I am positive about having hands-on dissection in extracurricular activities such as biology clubs.
Intention3	I would be willing to have a class where I do hands-on dissection with students, given enough support and environment.
Intention4	I would like to teach a hands-on dissection in my teaching career.

Appendix 2
Factor Loadings

Code	PED	PEA	Concern	Efficacy	Intention
PED1	.797	-.364	-.604	.426	.627
PED2	.832	-.400	-.517	.533	.715
PED3	.753	-.303	-.405	.397	.525
PED4	.805	-.274	-.493	.460	.582

Code	PED	PEA	Concern	Efficacy	Intention
PED5	.820	-.301	-.365	.514	.647
PEA1	-.270	.764	.391	-.223	-.413
PEA2	-.286	.834	.429	-.218	-.375
PEA3	-.117	.610	.393	-.156	-.266
PEA4	-.407	.746	.434	-.227	-.415
PEA5	-.408	.787	.570	-.361	-.449
Concern1	-.482	.453	.834	-.555	-.609
Concern2	-.345	.568	.707	-.341	-.508
Concern3	-.551	.327	.733	-.397	-.448
Efficacy1	.533	-.320	-.505	.906	.662
Efficacy2	.275	-.198	-.347	.612	.362
Efficacy3	.557	-.296	-.506	.894	.635
Efficacy4	.477	-.171	-.412	.822	.544
Efficacy5	.451	-.196	-.482	.854	.602
Efficacy6	.478	-.373	-.501	.706	.579
Intention1	.716	-.473	-.689	.634	.906
Intention2	.616	-.473	-.532	.573	.840
Intention3	.780	-.455	-.639	.646	.913
Intention4	.660	-.457	-.615	.691	.915

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