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RESEARCH REPORT

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"The tactile realness of 'life' is hitting me in the face": Unprompted student reflections of dissection using formalin- and Thiel-embalmed donors

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Abstract

There is a wide variety of preservation techniques available, and anatomy departments can select an embalming method(s) that best suits their course outcomes. Thiel embalming is becoming popular due to the life-like color and flexibility it provides tissue. This study examined student-perceived impact of learning anatomy by dissecting Thiel-embalmed donors compared with formalin-embalmed donors, and evaluated the reflective learning portfolios of postgraduate anatomy students' over two different cohorts. The first cohort studied limb and back anatomy using formalin-embalmed donors, and afterward studied trunk anatomy using Thiel-embalmed donors. In the second cohort, the embalming methods (but not topics) were exchanged. Reflexive thematic analysis identified three themes: Comparison to formalin, Authenticity, and Approaches to Learning. The color and flexibility of Thiel tissues supported students to connect their anatomy learning to their future clinical practice; however, the same flexibility sometimes hindered student learning due to visceral structures losing their anatomical shape. Exposure to a different embalming method sparked reflections from more students in both cohorts, but more so from students who transitioned from formalin to Thiel. These same students felt the donor was rehumanized, prompting them to reflect on the importance of teamwork to support each other both academically and emotionally. This was not seen in students transitioning from Thiel to formalin, indicating that the order of exposure has importance. Educators should weigh up the advantages of using different embalming methods alongside their learning objectives and, *if* switching between embalming methods, should consider the impact that the sequence may have on student learning.

KEYWORDS
dissection, embalming methods, formalin embalming, learning reflections, student perceptions, Thiel embalming

INTRODUCTION

Techniques for the preservation of human body donors have evolved over time to meet the unique demands of anatomical programs. Formalin-based embalming techniques ("formalin" hereafter) are currently the most widely used, primarily because of their cost-effectiveness and their capacity to yield tissues that remain stable for many years, characteristics that make these methods suitable for prosections and dissection conducted over prolonged periods.[1] However, the toxicity associated with formalin requires careful monitoring[2] and regulatory safe workplace exposure limits have recently been reduced nationally and internationally, prompting anatomy facilities to reevaluate the embalming methods employed for anatomy education.[3] Formalin embalming processes also bleach and reduce the flexibility of tissues,[4] which can make the identification of anatomical structures more difficult and limit student appreciation of the relationship between form and function.

In contrast, Thiel embalming ("Thiel" hereafter) is a soft-fix method using salt compounds and very low amounts of formalin.[5] In recent years, Thiel has grown in popularity among anatomy facilities, especially within Europe and Asia. In 2010, there were only 11 centers using Thiel embalming, and all were in Europe.[6] This number has grown to 41 centers in Europe, 24 in Asia, 9 in the Americas, 1 in Oceania,[7] and 1 in Africa.[8] Thiel is presented as a favorable alternative to formalin due to its capacity for long-term preservation while maintaining more life-like coloration and flexibility in the embalmed tissue. Such properties can significantly benefit clinical instruction, learning, and the practice of surgical techniques.[9–13] It is the combination of these features that places Thiel (and other similar soft-fix embalming methods) at an advantage compared with other established preservation processes; for example, fresh-frozen tissue which has life-like coloration and flexibility but poor longevity,[14] and plastinated tissue which has longevity and sometimes life-like coloration but no flexibility.[15]

The many ways Thiel tissue has been used in research is summarized by Hammer's[7] systematic review. Survey-based education studies have compared Thiel to more traditional embalming techniques, highlighting the value of Thiel tissue's flexibility, color, and longevity in anatomy education.[8,10,16–18] Further to this, Kennel et al.'s research specifically, comparing the use of Thiel- and formalin-embalmed donors for learning through dissection additionally demonstrated an association between the use of Thiel and increased student confidence in identifying anatomical structures, although there was no direct benefit in improving student knowledge.[18] The positive impact of Thiel on student confidence raises the question of how anatomical educators determine the value of learning resources to their students. After all, while the primary objective of an educator is to facilitate learning, the implicit desired outcome is often an increase in learner confidence. The use of Thiel may thus have the potential to impact the student learning experience beyond simple knowledge acquisition; an aspect not prominently addressed in existing literature.

This paucity may be attributed to the, thus far, prevalent use of surveys to gather data on this topic. Survey questions, even when open-ended, generally prompt answers to specific questions rather than enabling participants to provide a more holistic response.[19] To investigate the broader impact of Thiel on students' perceptions of their learning and their learning processes, richer data sources are necessary. Reflective learning portfolios, which are typically used as a form of assessment,[20] have also been demonstrated to have utility as a source of data for qualitative research.[21–23] Reflection requires students to explore their thinking and feelings around learning experiences, becoming more self-aware learners.[24] Charon and Hermann[25] specify that the act of writing takes reflection one step further, making thinking visible and comprehensible to both the reflector and the reader. This discovery and articulation of one's perception and understanding of an experience makes reflective writing an inherently rich data source through which to explore the impact of a resource on learning.

Through analysis of reflective learning portfolios, the primary aim of this study was to examine the student-perceived impact of learning anatomy using Thiel donors compared with formalin donors. The secondary aim was to determine whether the order of exposure to Thiel and formalin donors for dissection influenced the student learning experience.

METHODS

To address these aims, data in the form of students' learning reflections were thematically analyzed. Here, we first describe the wider context of the study, including program and module design. With the scene set, we then describe the design of the study, the structure of the reflective learning portfolios, and the participants themselves. Finally, the process of thematic analysis is described alongside the researchers' positionality statements.

Study context

This study focused on the learning experiences of students on the one-year postgraduate MSc in Clinical Anatomy program at Hull York Medical School (HYMS), UK, in which students conducted whole-body dissection as part of consecutive core modules. During module inductions, the main characteristics of the relevant embalming method was communicated to students, alongside a practical introduction to the donors they would be dissecting during that module. Each module had a consistent structure, with students dissecting for three hours per week for eight weeks (24 hours). The first module (Clinical Anatomy of the Limbs and Spine—CALS) covered musculoskeletal anatomy, starting on the back and spinal column (two weeks), and then progressing to the lower limb (three weeks), and then upper limb (three weeks). The second module (Clinical Anatomy of the Trunk—CAT) predominantly covered visceral anatomy, beginning on the thorax (three weeks), abdomen

(three weeks), and finally the pelvis (two weeks). Students worked in groups of three or four per donor, although these groups would devolve into pairs when dissecting the limbs (pairs were not the same each week). Students decided their dissections groups themselves in their first week, and these groups remained the same throughout the entire program.

Study design

This study was not designed ahead of data collection, but rather logistical constraints on program delivery and module evaluations dictated changes to the delivery of the module across the two-year period, and the study was formed retrospectively to this. When the MSc in Clinical Anatomy program first began, the intention was to conduct the whole-body dissections solely on Thiel donors. However, the introduction of Thiel embalming to HYMS was slightly delayed, so Thiel donors were not ready for dissection during the first module (CALS). Instead, donors embalmed with our standard formalin-based solution were used. Later in the academic year, Thiel donors were introduced for dissection in CAT. Based on module evaluations in this first cohort, we learned that students struggled with the more flexible tissue structures of the internal organs embalmed by Thiel, which is later articulated as a theme. To address this challenge, in the second year of the program, we flipped the embalming methods used for each module to provide flexible Thiel tissues for learning musculoskeletal anatomy in CALS, followed by firmer formalin tissue for visceral anatomy in CAT. This study examines the experiences of these first two student cohorts on the MSc program using their reflective learning portfolios as a data source to understand if and how students perceived the embalming method to impact their learning. The alternation of embalming methods in the second cohort facilitated the investigation of the second aim, namely whether the order in which students learned using the two different embalming methods had any effect on their reflections. The relationship of embalming method, module, and student cohort is illustrated in Figure 1.

Source material

Submission of a reflective learning portfolio was an integral part of the summative assessment of both modules. Students' reflective learning portfolios were anonymized from the point of submission. Each portfolio was structured to include eight, 300-word weekly reflections and a 1000-word reflective essay (approximately 3400 words per student, per module). Students compiled these components into a single document at the end of the module and submitted their portfolio electronically. The portfolios were used by students to document their learning experience in the program throughout each term, and to foster their development as self-aware and critical learners. The final essay component required students to review their weekly reflections and delve deeper into an element of their

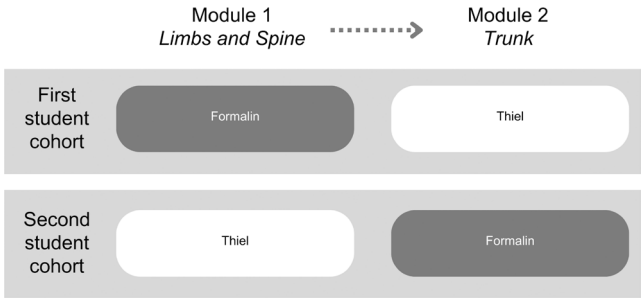

FIGURE 1 Study design—for both student cohorts, students completed the CALS module first and then the CAT module. Formalin donors were used for CALS dissection and then Thiel donors for CAT in the first student cohort. By contrast, in the second student cohort, students dissected Thiel donors for CALS and then formalin donors for CAT.

learning journey over the course of a module. This review piece provided students a further opportunity to reflect on their growth and development as both learners and professionals, and such meta-reflection is considered to be a beneficial step in reflective writing practice.[22]

It is important to note that there was no explicit instruction within the portfolio assessment guidelines that encouraged reflections on the embalming process used on the donors in the dissection sessions. Therefore, any statements within the portfolios regarding embalming were unprompted and included at the students' discretion as a factor that they considered had an impact on their learning. All the data used in this study were obtained from students' reflective learning portfolios and were acquired retrospectively as described in the following section.

Participants

The first and second cohorts of the postgraduate MSc program consisted of 15 and 14 students, respectively. In the first cohort, 12 intercalated from UK medical schools (following three or four years of medical training), two were practicing medics (both with prior dissection experience), and one student was from an allied health background. In the second cohort, nine were intercalating medical students (one with prior dissection experience), and five were from allied health backgrounds. In the first and second cohorts, 14 and 11 students, respectively, had previous experience of learning anatomy from human tissue. In all cases, such tissue was formalin embalmed. No students had prior experience working with Thiel or any other soft-fix embalming method. All students with clinical backgrounds (i.e., medicine intercalators, allied health professionals, and graduate medics) had experience working and learning in clinical settings.

Fully anonymized reflective learning portfolios compiled by these students (both cohorts and both modules) were used in this study. The portfolios were examined for this study after grading was finalized, and all contents remained anonymous. Each portfolio was manually reviewed for reflections relevant to either embalming

method. Relevant statements and their surrounding text were extracted and compiled into a cohort-specific document for analysis. Informed consent was retrospectively received from the students toward the end of their program, and ethical approval for the process of data collection, analysis, and dissemination was granted by the Hull York Medical School Ethics Committee (reference number 17 13). It is important to note that the student reflections were based on learning using human body donors who bequeathed their body to the medical school. All donors provided informed written consent for their body to be used in teaching and research.

Analysis

As reflections on the embalming method were not sought as part of the assessment, the proportion of students who reflected on the embalming method(s) was considered a valuable measure to gauge how important students perceived the embalming methods to be in the context of their learning. Cross-cohort comparisons were made, but also, cross-module, to see the effect of transition to a different embalming method on the proportion of students who shared spontaneous reflections.

Reflexive thematic analysis was performed on each cohort-specific document using the method described by Braun and Clarke.[26] Broadly, familiarization with the data, generating codes, constructing themes, reviewing potential themes, defining and naming themes, and, finally, producing the report. Two independent coders (KS and RQ) conducted the thematic analysis using NVivo (version 11.4.3). Themes, subthemes, definitions, and intertheme relationships were agreed upon, and a third researcher (PB) resolved any disparity.

Illustrative quotes are used to support the descriptions of the themes and have each been assigned to specific, anonymized participants using a three-part coding system. The first number (1 or 2) indicates whether the student is from the first or second cohort, respectively. The second number indicates which module's assessment the quote was derived (i.e. 1 for CALS, 2 for CAT). The third number (between 1 and 15) indicates a specific student in that cohort and in that module. For example, [1-2-9] would mark a quote as coming from a student in the first cohort, reflecting on the trunk module, whose reflective portfolio was entered into the analysis software in 9th place. It should be noted that the third number cannot be used to longitudinally track a student from CALS to CAT, as portfolios were not able to be matched due to anonymization.

Positionality statements of coders

In qualitative research, it is important to reflect on how the researcher's experiences relate to, and may influence, the interpretation of the data. In this section, the positionality of coders KS and RQ are stated. Due to the personal nature of such statements, these are presented in first-person.

KS—Prior to joining HYMS, I worked toward my PhD in epigenetics in Australia and worked at two Australian universities as an anatomy demonstrator. As part of these roles, I had some experience in dissecting and teaching dissection skills, but this was limited to formalin donors. During this time, I also developed my own reflective writing skills by completing the Anatomy Training Program through AAA and the Anatomical Society. When I joined the HYMS anatomy teaching team, my activities as an educator largely centered on teaching on the new MSc in Clinical Anatomy program, and I supported students from both cohorts through their dissections and other learning activities. Working with Thiel donors, especially during the CAT module for the first cohort, was a new experience for me as well as the students. At the time, learning through full-body dissection of Thiel donors was considered a unique feature of the MSc program, which may have inclined me toward focusing on positive experiences of using Thiel rather than formalin. Grading of the reflective learning portfolios was shared between me and PB. When grading the first cohorts' CAT portfolios, I observed that students were reflecting considerably on the impact dissection of a Thiel donor was having on their learning, compared with formalin in the previous module (CALS). I was acutely aware of this shift in reflective focus toward embalming methods when the second cohort started, and I consciously made a choice not to mention this to the cohort to see if the same pattern was observed when they transitioned to working with formalin donors. As a result of this awareness, I may have picked out certain phrases during thematic analysis that could bias my analysis. To counteract this, it was important that the other coder have independence from the program, cohorts, and the assessment process.

RQ—Before joining HYMS, I graduated from Cardiff University with a BSc (Hons) in Biomedical Science (Anatomy) with a Professional Training Year and had experience dissecting and teaching using formalin-embalmed donor material. My PhD was in Human Sciences and Medical Education, and I received a stipend through my role as a graduate teaching assistant on the Gateway to Medicine program, where I taught human anatomy, histology, and clinical imaging. I had minimal contribution to the MSc Clinical Anatomy program, helping only with an Anatomy Pedagogy workshop once a year. I was not involved in the planning, delivery, or assessment of the dissection modules and had started my PhD after the cohorts presented in this study had graduated. I therefore had no interactions with the students, maintaining anonymity.

RESULTS

As reflection on the impact of embalming method on learning was not explicitly stated as a topic for the reflective learning portfolio assessment, not all students included this in their reflections. It is therefore important first to establish how many students in each cohort included such reflections unprompted (Figure 2). In the first cohort, the proportion jumped from 33% ($n = 5$) of students for CALS *formalin* to 87% ($n = 13$) for CAT *Thiel*. For the second cohort, there

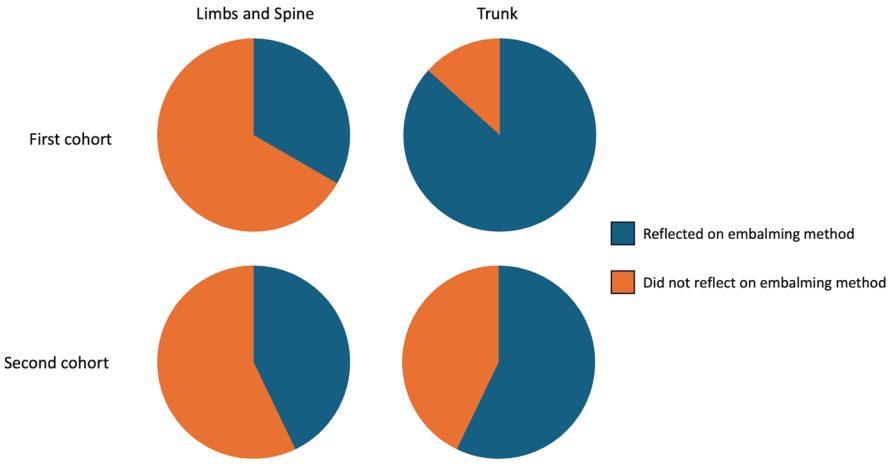

FIGURE 2 The proportion of students from the first cohort (formalin to Thiel) and second cohort (Thiel to formalin) who reflected on embalming method as part of their learning reflections in each cohort and module. In both cohorts, the proportion of students increased between the first module (CALS) and the second (CAT).

was a smaller increase from 43% ($n = 6$) for CALS *Thiel* to 57% ($n = 8$) of students for CAT *formalin*.

Themes

Three main themes were identified in both cohorts: *Comparison to formalin*, *Approaches to learning*, and *Authenticity*. However, within the *Approaches to learning* theme, the subtheme, *Teamwork*, was exclusive to the first cohort. These themes and their subthemes are described below.

Comparison to formalin

This theme focused on students' thoughts about Thiel in contrast to their prior experiences either learning from formalin prosections during their undergraduate studies (second cohort) or dissecting formalin donors during the previous module (first cohort). These are categorized into subthemes of *distinctions* between the embalming methods, *positive* and *negative* views compared with formalin, and *adaptation* when working with a different embalming method.

Distinctions are factors that may be considered neutral or shifting between positive and negative experiences, depending on the situation. Differences in tissue presentation between the embalming methods were noted, and when considering working with living tissue in the future, students "highlighted the importance of experience in looking at tissues" *student 2-1-12*. The texture of tissue in "both types of cadavers were quite slippery although for different reasons" *student 2-2-12* and in formalin donors, tissue was found to be "more robust" *student 2-1-3*.

> Due to the physical constraints of working in the [thoracic] cavity, we ended up applying a lot of pressure to the lungs—a level that would have likely torn tissue in a Thiel cadaver. Despite the force, the lungs retained their structure very well.
>
> *Student 2-2-12*

Positive experiences when compared to formalin included the increased ease with which the tissues could be blunt-dissected (i.e., without bladed instruments)—"I am finding it easier to blunt dissect and to identify and clean some of the more delicate structures such as nerves and veins" *student 1-2-1*. In contrast, in formalin donors, this reduced ability to blunt dissect prevented identification of structures—"muscles of the thoracic wall tended to adhere to each other and were much harder to distinguish and identify than in the Thiel bodies" *student 2-2-1*. Another positive factor for using Thiel donors was tissue flexibility that "allowed us to see structures in action" *student 2-2-4*, in contrast to formalin where students used scalpels more frequently to "circumvent the issues of stiffer tissue…" which resulted in "…concern of cutting structures underneath" *student 2-2-13*.

Interestingly, while the flexibility of Thiel is often viewed as a positive, *negative* reflections focused predominantly on the drawbacks of greater tissue flexibility (i.e., the "flop" factor).

> I additionally found the increased mobility, [...] of Thiel unpleasant.
>
> *Student 1-2-8*

> In the first week, the lungs were relatively lung-shaped, but by the second week they had flattened out. This lack of fixation made visualizing spatial relationships very difficult.
>
> *Student 1-2-5*

The structural integrity of organs was reduced in Thiel donors—"It took all three of us to find the hilum and cut through it, it was like jelly!" *student 1-2-9*. In comparison, formalin "organs [were] more pronounced and easier to identify." *Student 2-2-4*.

Adaptation consists of the multifaceted ways students had to change their behavior when transitioning between formalin and Thiel material when moving onto the CAT module. This was generally viewed positively by the students as a learning opportunity to develop their manual dexterity skills in the dissection room.

> If I am to continue to improve my dissection skills [...] I will have to learn to adapt my technique to this new type of embalmed tissue.
>
> *Student 2-2-1*

Approaches to learning

The *Approaches to learning* theme captures the approaches students have used in their learning that relate to the nature of Thiel donors, or how they perceive Thiel to have had a direct impact on their learning experiences. Students considered their experiences in the dissection room in the context of working toward long-term career goals and how their learning approach had to change for them to achieve this.

> Working [...] on a much more life-like cadaver very much reminds me of the environment we observe in the operating rooms.
>
> *Student 1-2-2*

> Thiel cadavers are suggested to be better for surgical training [...]. Thus, to develop my learning, I must practice and learn how to use Thiel to the best of my ability, to give me needed professional experience.
>
> *Student 1-2-8*

Interestingly, the first cohort's reflective extracts were strongly linked to the importance of teamwork in learning through dissection of Thiel donors, but the subtheme of *Teamwork* was entirely absent for the second cohort. *Teamwork* was seen to be important within the first cohort primarily as a vehicle to support each other's learning, and some students naturally progressed to taking on a leadership role within the group to drive them toward their learning goals.

> Reviewing my reflections this term, I can identify two key themes in which this module was drastically different: (1) The experience of Thiel-embalmed bodies and how this technique has allowed us to work as a team, and (2) [...].
>
> *Student 1-2-2*

> In this semester, not only the type of embalming changed—from formalin- to Thiel-embalmed cadavers—but the structures I dissected were also very variable in comparing to last semester. Due to these changes, I noticed some barriers during dissection [...]. I had several moments where I felt uncomfortable but also noticed how fast this feeling disappeared. After the dissection sessions, I could not imagine that I was uncomfortable with it a few hours ago because I was totally fine with it afterwards. A reason for this was in my opinion the good teamwork. These barriers made the teamwork stronger. We all had barriers and wanted to help each other.
>
> *Student 1-2-7*

This last quote demonstrates how *Teamwork* moved beyond standard academic discussions and served as an emotionally supportive and empathetic environment. Elements of this are explored further in the *Authenticity* theme.

Authenticity

Several subthemes arose around the *Authenticity* theme found in the extracts. This theme embodies the *Realistic* characteristics of Thiel donors and what this means for students in both a practical sense (e.g., identifying structures and simulating *Clinical applications*) and the *Emotional* reaction to working with donors that seem more life-like and authentic compared with formalin donors.

Realistic covers student perceptions that Thiel donors are somehow more real than those embalmed with formalin, and that Thiel embalming "made the body seem more 'human'." *Student 1-2-5*

> When I read my reflections again, I see that, during this module, I have continuously noted how the Thiel bodies are making me think that the body is a lot more 'real' than I had previously appreciated it to be. I realize that I had always thought about diseases as concepts or even personalized them without being able to grasp their physical realness. However, now that I have seen crusty arteries, gallstones spilling out like pebbles, and cut a human into two, the tactile realness of 'life' is hitting me in the face.
>
> *Student 1-2-2*

Comparatively, very few extracts from the second cohort were coded in the *Emotional* subtheme compared with the first, indicating a reduced emotional reaction to Thiel donors if the students started their dissection learning journey with Thiel, rather than transitioning to Thiel after working with formalin.

Positive emotions were coded only in the first cohort, centering on the association between learning and emotion, and the eventual desensitization to realness, allowing for more focused learning.

> This revived appreciation for the cadaver has helped me meet one of my learning targets from last week, to become more accustomed to Thiel bodies.
>
> *Student 1-2-8*

Contrastingly, *negative emotions* were apparent in both cohorts, though the nature of the emotions was different. In the second cohort, negative emotions centered on frustration with identifying structures, rather than an emotional response to the actual donors. In contrast, feelings of apprehension, being overwhelmed, upset, and repulsed appeared in the reflections from the first cohort.

> I think this was the only week when I personally struggled with the reality of dissection. [...] I realize that I became increasingly more aware of how emotionally challenging dissection was during this term too which was due to the Thiel technique.
>
> *Student 1-2-2*

> A recurring theme in my reflections this term was the difficulty of dissecting Thiel-embalmed bodies. I think it made the body seem more 'human', as it is softer and more life-like. This meant that when we did things like sawing the pubic symphysis, it was far more repugnant than usual.
>
> *Student 1-2-5*

Looking toward future professional careers in medicine and health-related fields, students were more attuned to the *Clinical applications* of the anatomy they were learning when working with the more authentic, life-like nature of Thiel tissue. Reflections centered around the long-term aspirations of the students and their future clinical practice were apparent, whether their goal was to pursue a surgical career, or to practice non-surgical procedures in a safe environment.

> Thiel is likely to better prepare me for my professional life, allowing me to appreciate that a patient to be operated on does not have nice, fixed structures, but is more fluid, moveable and difficult to understand.
>
> *Student 1-2-8*

> ... [Thiel] bodies felt much more realistic and are more representative of what the human body will be like in medical practice and surgery.
>
> *Student 1-2-6*

There were no similar reflections from students working on formalin donors, indicating that the clinically relevant learning benefits of dissection are more strongly linked to the availability of Thiel material.

DISCUSSION

Three distinct themes were identified across both cohorts, with teamwork and emotions being important elements of student learning specifically for the first cohort when they transitioned from formalin to Thiel donors. The primary aim of the study was to determine the student-perceived impact of learning anatomy using Thiel donors compared to formalin donors.

The study has revealed two key impacts of learning anatomy on Thiel compared to formalin donors. The first impact was that of distinctions in experience between the two modalities which were either positive, neutral, or negative. These distinctions related primarily to tissue quality and the experience of handling and distinguishing macroscopically between tissues. Key here was that the oft-reported benefit of Thiel over formalin—tissue flexibility—was perceived as a detriment. This dissonance possibly reflects the fact that tissue flexibility is often discussed in the literature in relation to authenticity—typically regarding the simulation of surgical applications of tissue. In this study, the emphasis of students' reflections was on the negative impact of such flexibility on learning anatomy by dissection, that is, the "flop" factor, particularly regarding the organs of the trunk. For example, once a Thiel lung is removed and placed on a tray, the organ may flatten and spread out, limiting the clarity with which defining features (e.g., impressions on the medial surface) may be identified. This Thiel-specific issue was also reported by Antipova et al.[16] More profoundly, this tissue flexibility has the demonstrated potential to elicit significant emotional responses in students,[23] a perspective that is important to the provision of pastoral (and academic) support for students learning anatomy by dissection of Thiel donors.

Further, a key impact of Thiel over formalin in learning anatomy was the spontaneous and unsolicited rehumanization of the donor (Reifler, 1998),[27] the resulting emotional response to death and the dead, and coping mechanisms employed to deal with learning anatomy in the shadow of the stark humanity of the donor. This rehumanization may explain why changing between formalin to Thiel tissue elicited a change in the behavior of students with relation to their dissection skills and approaches to learning. The impact of rehumanization of the donor has been discussed in the literature with regard to its utility in fostering the development of medical professionalism.[28,29]

What this study highlights is that rehumanization is not merely a factor of the revelation of the identity, personal information, or medical history of the donor but also has a relationship to the method of preservation and the response of the student to differentially preserved donors. It also reinforces Rechowicz and Elzie's[23] argument that reflective writing in this context generates a "shared view of humanization and person centeredness."

The secondary aim of this study was to determine whether the order of exposure to Thiel and formalin donors for dissection influenced student learning experience. The transition from formalin to Thiel sparked a larger increase in the proportion of

students reflecting on the embalming method than when transitioning from Thiel to formalin (Figure 2). Much of this increase was linked with the *emotional* subtheme of the *authenticity* theme; there was a significant emotional response from students commencing work on Thiel-embalmed bodies after working with formalin. This finding is comparable to that of Balta, Lamb, and Soames,[17] who observed that 32.7% of undergraduates felt more uncomfortable with Thiel donors than formalin donors because of their realistic, more life-like appearance. Students in the first cohort began their dissection work on formalin donors and transitioned to Thiel. This sparked a stronger response to the Thiel donors in comparison with formalin, which they had previously held to be the norm. By moving them onto Thiel, the stark differences in appearance, feel, and life-likeness became more apparent, causing them to consider the emotional side of working with human body donors more deeply.

The emotions tied to the learning process provided an additional and exclusive motivating facet to their educational experience.

> It is a positive learning experience to have these powerful experiences for me because I find it easier to associate my knowledge to these senses.
>
> *Student 1-2-2*

Indeed, the experience of working with more realistic Thiel donors seems to have generated a beneficial *learning landmark* ("vivid experience that is memorable in itself and provides access to the educational content associated with that context"[30]). This strong emotional response when moving from formalin to Thiel could be considered a learning landmark for the first cohort of students, which was not explicitly present in the second cohort. The absence of this experience may not be a bad thing for the second cohort; emotional stress can either improve or impair learning[31]; and the complex emotions caused by facing the reality of death with more life-like donors in a dissection environment may have had a detrimental effect on the first cohort of students. It is also not possible to say with certainty that the emotional responses stemmed purely from the change in embalming method to Thiel. The second module included examination of pelvic anatomy, which can impact student learning experiences due to sociocultural sensitivities around nudity and genitals manifesting as discomfort.[32,33] Such discomfort was likely enhanced by Thiel embalming, as the tissue flexibility allows abduction and external rotation of the lower limbs to more fully expose the perineum. It is therefore likely that the increase in proportion of students reflecting on the embalming method in the first cohort was due to the combined effect of the embalming method and the anatomical region of study. Further investigation is needed into the impact of student emotional responses to donor-based anatomy learning. Lai et al.[34] recently demonstrated the complex emotional responses of students learning anatomy by dissection compared with prosections, and this study takes that one step further, introducing students to more life-like dissection experience. Would students benefit from an experience akin to the first cohort's Thiel-inspired learning landmark, and if so, how this could then be incorporated into curriculum design?

In contrast, the second cohort had their first dissection experience with Thiel donors, which perhaps then seemed to be the norm. Without the context first provided by formalin donors, they did not have an emotional reaction to this. By starting their dissection program with Thiel donors, the "shock factor" caused by a transition was removed and emotional reactions were ameliorated. Indeed, it might be considered as the emotional equivalent of "ripping off the band aid." However, the absence of the *teamwork* subtheme in the second cohort is surprising. From direct observations of the students in the dissection room, it is apparent that the students were working effectively within teams, so why did they not reflect on this in their portfolios? This could be due to different cohort dynamics but may also come back to the personal challenges created by transitioning from formalin to Thiel in the first cohort. The strong sense of teamwork was not just fueled by academic needs, but also as a mechanism by which students could support each other emotionally while they adjusted to working with Thiel donors. This demonstration of solidarity provides a strong foundation on which to build a successful team.[35] Without the emotional drive and challenge of being confronted with a highly realistic embalming technique starkly different from the previously established norm, the students in the second cohort were not as motivated to supplement their academic teamwork with a support system, were likely less conscious of their teamwork, and thus were not sufficiently aware of it for it to then feature unprompted within their reflections.

Limitations

A significant limitation of this study is the source material. Reflective learning portfolios were assigned as assessments and were primarily intended to record students' reflections on their learning. For some, the experience of using formalin and Thiel donors had such an impact on their learning that, unprompted, they reflected extensively on it. But not all portfolios contained substantial reflections on their experience in the dissection room and instead focused on seminars and personal studies that were not relevant to this research. This is characteristic of secondary analysis where information created, compiled, or archived for a purpose distinct from scientific enquiry is subsequently studied.[36] Collecting primary data to capture the impressions of all students regarding embalming techniques and dissection would thus require a questionnaire or interviews asking specific question, as was done by Antipova et al.[16] when comparing student perceptions of Thiel and glycerin-ethanol embalmed donors. However, such data may not be as rich, as reflective writing requires time

to think, process, and articulate an experience—time that an individual may not dedicate to a survey response, or be able to do quickly enough to verbally respond in an interview. In this study, the excerpts analyzed from student reflective learning portfolios produced themes that were formed from students' initial and prevalent impressions of how embalming methods had a direct impact on their learning. While not all-encompassing of the student experience, this approach does facilitate the most important factors impacting student learning to be brought to the fore.

The anonymized nature of the portfolios also prohibited the longitudinal analysis of data from each student between their experiences of formalin and Thiel embalming. The themes produced in each module were thus established as a snapshot of experience rather than being able to trace an individual's changing perceptions during the transition between Thiel and formalin. However, themes produced from such cohort analysis are more generalizable to future cohorts and other programs than to individual data,[37] and they are more suitable for the future application of these results to other institutions.

Finally, based on student feedback (gathered in these reflective learning portfolios and through formal module evaluation methods), in the subsequent years of the program, a hybrid embalming method (Thiel embalming, with formalin added to the thoracic and abdominal cavities) was introduced to address the challenges students reported in this study when dissecting the viscera. Furthermore, the assessment method changed to reduce the quantity of reflective writing and associated guidance. While it would have been beneficial to increase the number of cohorts studied, and thus participant numbers, these changes meant that we were not able to expand participation in the study without introducing significant confounding variables.

CONCLUSION

This study shows that there are differences from students' perspectives, over and above learning anatomy per se, in their learning experience on Thiel and formalin donors. Key here is that tissue flexibility is not always a benefit and can indeed be detrimental and emotionally taxing. This is also the case when students transition between formalin and Thiel donors.

It is also important to note that the choice of embalming method may influence the responses of students to donors—perhaps even instigating their rehumanization. When an educator chooses an embalming method, therefore, care must be taken to consider which method would best facilitate learning yet simultaneously lessen the likelihood of unforeseen impacts that may be detrimental to the student journey. Additionally, care should be taken when students are exposed to differentially preserved material during their learning to minimize any unforeseen deleterious effects on their learning.

Finally, while this was not a direct aim of the study, it has demonstrated the utility of learning portfolios in fostering active reflection and reflexivity in students' approaches to learning anatomy by dissection. It also reinforces Rechowicz and Elzie's[23] claim as to the utility of anatomy learning reflections in providing a rich source of data for the interrogation and understanding of how students learn anatomy.

AUTHOR CONTRIBUTIONS

Kat A. Sanders: Conceptualization; data curation; formal analysis; methodology; project administration; writing – original draft; writing – review and editing. **Rebecca J. Quinn:** Data curation; formal analysis; writing – review and editing. **Louiza Whiteley:** Investigation; validation; writing – review and editing. **Peter J. Bazira:** Project administration; supervision; writing – review and editing.

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The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

Ethical approval for the process of data collection, analysis, and dissemination was granted by the Hull York Medical School Ethics Committee. The donors that were dissected as part of the MSc in Clinical Anatomy were all bequeathed to Hull York Medical School, and all donors provided informed written consent for their body to be used in teaching and research.

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