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Anatomage virtual dissection versus traditional human body dissection in anatomy pedagogy: insights from Ghanaian medical students

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Abstract

Background Although traditional human body dissection has been the mainstay method for gross anatomy pedagogy, the popularity of virtual teaching methods has increased in recent years. The Anatomage table offers a life-size digital representation of the human body and allows visualization, manipulation, and virtual dissection. This study investigated the perception of medical students towards virtual dissection vis-à-vis traditional dissection in anatomy pedagogy.

Methods The cross-sectional survey included medical students at the University of Ghana who completed an internet-based questionnaire administered using Google® Forms. The questionnaire comprised 20 close-ended questions that solicited information on demographics, experience with traditional human body dissection and virtual dissection, and perception of virtual dissection. Data was summarized as frequencies and percentages with 95% confidence intervals.

Results Of the 297 participants, 295 [99.4% (95% CI = 97.3–99.9)] participated in human body dissection from which 93.2% had a positive and 6.8% had poor experiences. Whereas 223 [75.1% (95% CI = 69.7–79.8)] of the participants would participate in dissection again given the opportunity, 74 [24.9% (95% CI = 20.2–30.3)] were unwilling. Of 297 participants, 205 [69.0% (95% CI = 69.7–74.2)] had used Anatomage table, while 92 [31.0% (95% CI = 25.8–36.6)] had not. About 68% (95% CI = 60.8–74.0) of the 205 agreed with the relative ease of operation and use of the Anatomage table compared to traditional human body dissection while 9.4% disagreed. Inadequate operational skills [51% (95% CI = 48.9–53.4)] and limited accessibility [39% (95% CI = 35.2–42.3)] were limitations to Anatomage use. 66.8% (95% CI = 59.9–73.1) of participants agreed virtual dissection had a positive influence on learning anatomy while

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6.6% disagreed. Of the 205, 87.9% (95% CI = 82.3–91.8) discouraged virtual anatomy dissection completely replacing traditional human body dissection.

Conclusion Virtual dissection is an effective supplement to traditional body dissection but not a replacement. Its use alongside traditional methods improves anatomy learning. Integrating technology into anatomy education will enhance student engagement and learning.

Keywords Virtual dissection, Traditional body dissection, Anatomy pedagogy, Anatomage table, Medical Education, Ghana

Introduction

Anatomical sciences contribute substantially to the preclinical curricula of many health sciences programs and form a strong basis for clinical practice [1, 2]. A thorough understanding of human anatomy is vital in clinical practice as it forms the basis for medical examination, making diagnoses, operating surgeries, and performing other medical interventions [2–4]. Additionally, the anatomical sciences provide health sciences students with a reservoir of medical terminology applicable to professional practice and for proper communication with colleagues [5, 6].

In the anatomical sciences discipline, gross anatomy which studies the macroscopic architecture of the human body, takes a considerably large portion as a sub-discipline. Historically, human body dissection coupled with textbooks, has served as the bedrock of gross anatomy pedagogy and has provided hands-on experiences for the appreciation and comprehension of the macroscopic structural organization of the human body [4, 7]. Although this traditional method of hands-on dissection is acknowledged as fundamentally important in learning and teaching anatomy [1], the use of human specimens for teaching purposes is surrounded by emotional and ethical concerns [7, 8]. During dissection, students dedicate a significant amount of time to locating structures and in the process, inadvertently acquire knowledge about the adjacent tissues or structures and how they are interconnected. Consequently, students gradually develop a comprehensive three-dimensional comprehension of the human body. This exploration is considered an important part of the learning experience with the inherent advantage of leading learners to more active engagements with the human specimen [7].

With the global advancement in technology and its applications, computer-based and multimedia-assisted educational aids such as animations, movies, three-dimensional models, virtual reality, and virtual dissection tables presently feature prominently in anatomy education [9, 10]. Currently, there is the adventure into robotics as humanoid robots are being explored for their utility as teachers, instructors, or teaching assistants in anatomy education [11]. The evolution has been necessitated by the need for improved teaching and learning methods to understand the human body's complexities. There is an increased need for the use of innovative technologies in anatomy education. Some of the reasons are: the challenges with acquiring bodies for dissection, difficulties in preserving acquired bodies, the laborious nature of body dissection, increasing educator-to-student ratios, evolving learning habits of students [10, 12, 13] and cultural reservations toward human body dissection [14–16]. Although these technologies assisting in anatomy education lack the experiential value offered by human specimens, their accessibility, interactivity, cost-effectiveness, and avoidance of ethical and cultural concerns contribute to their widespread adoption among the current generation of students and universities.

In terms of cost for most African countries, traditional body dissection comes across as being relatively less expensive to run compared to using Anatomage tables (acquisition, infrastructural set-up, operationalization, and maintenance). The UGMS's Department of Anatomy, for example, spends approximately USD 200 per body per year (which covers the cost of chemical preservatives, handling, electricity, and storage) which translates into USD 4000 for 20 bodies used per year. The cost is quite manageable for most African institutions when compared with the about USD 85 000 per Anatomage table besides the high cost of infrastructural set-up and maintenance. Also, contributing to the perceptual interests in virtual dissection and the adoption of technology are culture and religion. Generally in Africa, strong cultural and religious belief systems discourage the dissection of human bodies as it is viewed as an offensive sacrilegious mutation. The bodies of deceased persons are highly respected and exposing their nakedness and dismembering them through dissections is unacceptable. To many such cultures, burial is the only acceptable and dignified means to dispose off the remains of the deceased [14, 17].

The use of virtual anatomy dissection as a new educational technology in anatomy education is growing fast and is gaining popularity even among low-income economies such as in Africa. The Anatomage table, recognized in the field of virtual anatomy dissection, is a cutting-edge device that features an electronic table with a screen. As an educational tool, it provides a full-scale digital depiction of the human body and enables the observation, manipulation, and virtual dissection of

intricate anatomical components using detailed three-dimensional models [1, 4]. It incorporates advanced imaging technologies such as CT scan, X-ray, ultrasound, and MRI, which have been perfectly integrated into a user-friendly touchscreen interface [4, 18, 19]. Studies examining the impact of the Anatomage table on anatomy education reveal that students who utilized the table achieved comparable academic outcomes as those who employed conventional dissection techniques [4, 20, 21]. Other reports hail virtual dissection as having superior outcomes in anatomy education compared to traditional dissection as virtual dissection improved students' learning outcomes about three times compared to traditional dissection and textbooks [20, 22]. Students studying with virtual dissection tools including the Anatomage table are more excited before and after laboratory sections and tend to have a greater degree of learning evidenced by significantly higher mean scores in anatomy assessments [20, 23]. African medical educators express the view that virtual dissection serves as an invaluable addition to traditional cadaver-based approaches to anatomy learning [24].

In the past decade, several medical schools in Ghana have incorporated into their anatomy pedagogy some of the global technological innovations especially, the use of the Anatomage table. In 2020, Ghana's premier medical school, the University of Ghana Medical School, acquired two Anatomage tables for the Department of Anatomy to augment the teaching and learning of anatomy which had until then been by traditional human body dissection and microscopy. Since then, the use of virtual dissection has become an integral part of anatomy pedagogy in the institution. This study aimed to investigate the perception of medical students at the University of Ghana Medical School towards virtual dissection vis-à-vis traditional human body dissection and its perceived influence on anatomy learning. The study had two specific objectives; [1] to assess the perception of University of Ghana medical students on using the Anatomage table, and [2] to assess the perceived influence of the use of virtual dissection as an add-on to the traditional cadaveric dissection in anatomy pedagogy.

Methods

Study design

The study was carried out between May and June of 2023 and was a qualitative cross-sectional questionnaire-based study conducted among medical students.

Setting

The study was conducted at the University of Ghana Medical School (UGMS) at the Korle Bu campus of the University of Ghana in Accra in the southern part of Ghana. UGMS' Department of Anatomy has a faculty strength of seven, three technical staff, two research assistants, and a yearly average of three demonstrator/graduate assistants. The average class size of the 1st - 3rd years (pre-clinical level) is 220 students made up of medical and dental students. In the 4th -6th years (clinical level), the dental students separate into the School of Dentistry leaving the class size of the Medical School clinical years to an average of 160 students. Traditional whole-body dissection is incorporated into UGMS' anatomy curriculum taught in the 2nd year of the six-year MBChB program. Human dissection, the mainstay of the practical component of the gross anatomy curriculum, is spread over one academic year of two semesters with an average of 6 h of dissection a week for 16 weeks per semester. Though conducted by the regional approach, the whole body is dissected by the end of the academic year. UGMS has one large dissecting room with 16 dissection tables and a maximum of 15 students per table. With the introduction of virtual dissection (Anatomage table EDU 9.0.2) into anatomy pedagogy in the UGMS, which goes hand-in-hand with traditional dissection, students supplement their learning with the Anatomage table during practical periods with no particular strict schedule. UGMS has two Anatomage tables installed in two separate rooms labeled virtual anatomy laboratories. During regular practical periods, a maximum of 15 students are allowed on an Anatomage table at a time for one hour per group. Additionally, the virtual laboratory is accessible to students during school hours to provide extra time for students who need it.

Data was collected using an online questionnaire (Supplementary Data 1) that was administered via Google® Forms. The link (URL address) to the Google® form was distributed to the study population directly by WhatsApp® through class WhatsApp® platforms. Since the full target population could not be accessed for a representative sample, participants were recruited by a convenience sampling method, where those who were eligible and were willing to participate opted to. To access the questionnaire to participate in the study, it was mandatory to provide consent by completing an online informed consent form. Before consenting, individuals were made aware of their right to voluntary participation. The purpose, aims, objectives, potential risks, and benefits of the study were provided in an online document. Confidentiality and anonymity were ensured by requiring no participant's identifiers on the consent form and the questionnaire.

To develop the denovo questionnaire, a list of questions deemed appropriate with suitable options where necessary was created. Using the face validation approach, the question was administered to 8 administrative staff of the school with no knowledge of anatomy to confirm that on the surface the instrument seemed relevant and

appropriate for what it sought to assess. Subsequently, content validation was conducted. To do this a list of all what the questionnaire was meant to measure was created and the items on the face-validated questionnaire were checked against the items on the created list [16, 25]. A draft questionnaire was pilot-tested among staff and postgraduate students of the Department of Anatomy, UGMS. From their responses, the 23 questions were pruned by removing duplicate questions and restructuring some questions to improve clarity. The questionnaire finally comprised 20 close-ended questions that solicited information on demographics, experience with traditional human body dissection and virtual dissection, and perception of virtual dissection. The questionnaire was pre-tested among 2nd-year physiotherapy students at the School of Biomedical and Allied Health Sciences (SBAHS) at the University of Ghana who had also used the Anatomage table as part of anatomy pedagogy. Their feedback was vital in improving sentence construction and cleared the ambiguities in some of the questions.

Participants

Study participants were medical students of the University of Ghana Medical School as of 2023. The current 5th-year students (as of 2023) were the first cohort of students in UGMS to experience virtual dissection since its introduction in the institution in 2020 when they were in the 2nd year. Students in 2nd, 3rd, 4th and 5th years as of 2023 were eligible to participate in the study. First-year medical students were excluded from the study since dissection does not form part of UGMS' first-year curriculum and therefore had no exposure and experience. Final-year (6th year) students were also excluded since virtual dissection did not form part of their curriculum when they were in the second year in 2019.

Table 1 Sociodemographic characteristics of study participants

Parameter	Frequency (*n* = 297)	Percentage (%)	95% CI
Age (years)			
16–20	130	43.8	35.6–49.6
21–25	148	49.8	44.0-55.7
26–30	14	4.7	2.70-8.0
Above 30	5	1.7	0.6–4.1
Sex			
Male	156	52.5	46.7–58.3
Female	141	47.5	41.7–53.3
Religion			
Christianity	275	92.6	88.8–95.2
Islam (Muslim)	18	6.1	3.7–9.6
Atheist	3	1.0	0.3–3.2
Irreligious	1	0.3	0.02–2.2
Nationality			
Ghanaian	275	92.6	88.8–95.2
Non-Ghanaian	22	7.4	4.8–11.2
Year (Academic Level)			
2nd Year	116	39.0	33.5–44.9
3rd Year	103	34.7	29.3–40.4
4th Year	33	11.1	7.9–15.4
5th Year	45	15.2	11.4–19.9

Variables

The two main outcome variables of the study were [1] students' experience with traditional human body dissection and [2] students' experiences and perceptions of anatomage virtual dissection table use. Five different close-ended questions were used on the questionnaire (Supplementary Data 1) to assess students' experience with traditional human body dissection. Students' experiences and perceptions of anatomage virtual dissection table use were assessed using ten close-ended questions. Other variables included age, medical school level (year), nationality, and religion.

Biases

The convenience sampling method employed in participants selection has an inherent bias to recruit only easy-to-get and willing students to participate in the study and thereby, potentially missed out on some other useful information from hard-to-get or uninterested students.

Study size

The sample size for this study was calculated based on Slovin's formula [26] with a level of confidence of 95% and a margin of error of 5%.

$$n = \frac{\mathrm{N}}{1 + \mathrm{Ne}^2}$$

Where n is the estimated sample size, N is the population size (760), and e is the error margin of 5%.

Therefore;

$n = 760/[1 + 760(0.0025)]$

$n = 292.31$.

The sample size was rounded to 292.

Statistical methods

IBM SPSS Statistics version 26 was used to capture and summarize the data as frequencies and percentages with 95% confidence intervals.

Results

Sociodemographic description of participants

Out of the about 760 eligible medical students, 297 participated giving a response rate of 39.1%. The sociodemographic characteristics of the study population are detailed in Table 1. Of the 297 participants, 52.5% (95% CI = 46.7–58.3) were males and 47.5% (95% CI = 41.7–53.3) were females. The ages of the participants ranged between 16 and 30 years with the majority [49.8% (95%

CI=44.0-55.7)] within the 21–25 years category while 1.7% (95% CI=0.6–4.1) were above 30 years old. The majority [92.6% (95% CI=88.8–95.2)] of the participants were Ghanaians while 7.4% (95% CI=4.8–11.2) were non-Ghanaians. In terms of religion, 287 [92.6% (95% CI=88.8–95.2)] of the participants identified as Christians, 19 [6.1% (95% CI=3.7–9.6)] as Muslims, and 4 [1.3% (95% CI=0.4–3.7)] as either atheist or irreligious. In terms of class distribution, 39.0% (95% CI=33.5–44.9), 34.7% (95% CI=29.3–40.4), 11.1% (95% CI=7.9–15.4), and 15.2% (95% CI=11.4–19.9) were in 2nd, 3rd, 4th, and 5th year, respectively.

Experience with traditional human body dissection

From Table 2 the majority [99.4% (95% CI=97.3–99.9)] of the participants had participated in traditional human body dissection as part of their study of anatomy though 7.5% (95% CI=4.8–11.2)] of such participants did not actively participate in it. Using an ordinal scale of satisfaction to assess the self-reported level of satisfaction among the 295 (99.4%) participants who had participated in traditional human body dissection, 53.9% (95% CI=48.0-59.7) reported having a "good" experience, 39.3% (95% CI=4.3–10.4) a "satisfactory" experience and 6.8% (95% CI=33.8–45.2) "poor" experience. Whereas 223 (75.1%) (*conditional* and *unconditional*) of the participants would participate again in human body dissection given the chance, 74 [24.9% (95% CI=20.2–30.3)] were unwilling. While 185 [62.3% (95% CI=56.5–67.8)] of the 223 participants willing to engage in dissection again would do so unconditionally, 38 [12.8% (95% CI=9.3–17.3)] would not if they had the chance to opt out. Of the 122 students who responded '*Yes (conditional)*' and '*No*', the top reasons for their unwillingness to participate in human body dissection when offered the opportunity as presented in Fig. 1 were the "risk of infection/contamination" [29.4% (95% CI=19.6–36.0)], "state of the dissection room" [28.6% (95% CI=21.0-37.7)] and "lack of skills" [22.3% (95% CI=15.3–30.7).

Participants' experiences and opinions on anatomage virtual dissection table

Table 3 summarizes the students' perception of the Anatomage virtual dissection table. Out of the total 297 participants, 205 [69.0% (95% CI=63.4–74.2)] used the Anatomage table, while 92 [31.0% (95% CI=25.8–36.6)] though knowing about it had never used it. When asked how often they have used the virtual dissection table, 18.7% (95% CI=13.6–24.7) of the 205 students used it frequently while 38.3% (95% CI=31.9–45.6) very rarely used it. About 32% (95% CI=26.9–40.1) and 37.4% (95% CI=31.0-44.6) of the participants respectively "strongly agreed" and "agreed" that the use of the virtual dissection table during anatomy practical sessions enhanced their understanding and appreciation of the location and relationship of different internal body structures. About 25% (95% CI=19.7–32.0) of participants were neutral while 2.8% (95% CI=1.2–6.6) strongly disagreed.

The majority [68% (95% CI=26.8–40.1)] of the students agreed it is relatively easy to operate and use the Anatomage virtual dissection table compared to traditional human body dissection. Still, on the relative ease of use, 9.4% (95% CI=5.8–14.3) disagreed and 22% (95% CI=16.6–28.4) remained neutral about it. Regarding the positive influence of the use of the Anatomage virtual dissection table on learning anatomy, 66.8% (95% CI=61.4–74.5) of the participants were in agreement against the 6.6% (95% CI=3.9–11.4) who disagreed. The majority [82.7% (95% CI=76.4–87.3)] encouraged the use of virtual dissection in the teaching and learning of anatomy, while 10.7% (95% CI=7.0–16.0) remained neutral and 6.6% (95% CI=3.9–11.4) disagreed. Out of 205 participants, a significant majority 87.9% (95% CI=82.3–91.8) disagreed with the idea of virtual anatomy dissection completely replacing traditional human

Table 2 Participants' experiences with traditional human body dissection

Question and Response Options	Frequency	Percentage(%)	95% CI
Have you been involved in dissection in your training?	*n*=297		
Yes	295	99.4	97.3–99.9
No	2	0.6	0.1–2.7
Did you actively take part in the dissection?	*n*=295		
Yes	273	92.5	88.8–95.2
No	22	7.5	4.8–11.2
If yes, what was your experience?	*n*=295		
Good	159	53.9	48.0-59.7
Satisfactory	20	6.8	4.3–10.4
Poor	116	39.3	33.8–45.2
Are you ever willing to engage in traditional human body dissection?	*n*=297		
Yes (unconditional)	185	62.3	56.5–67.8
Yes (conditional)	38	12.8	9.3–17.3
No	74	24.9	20.2–30.3

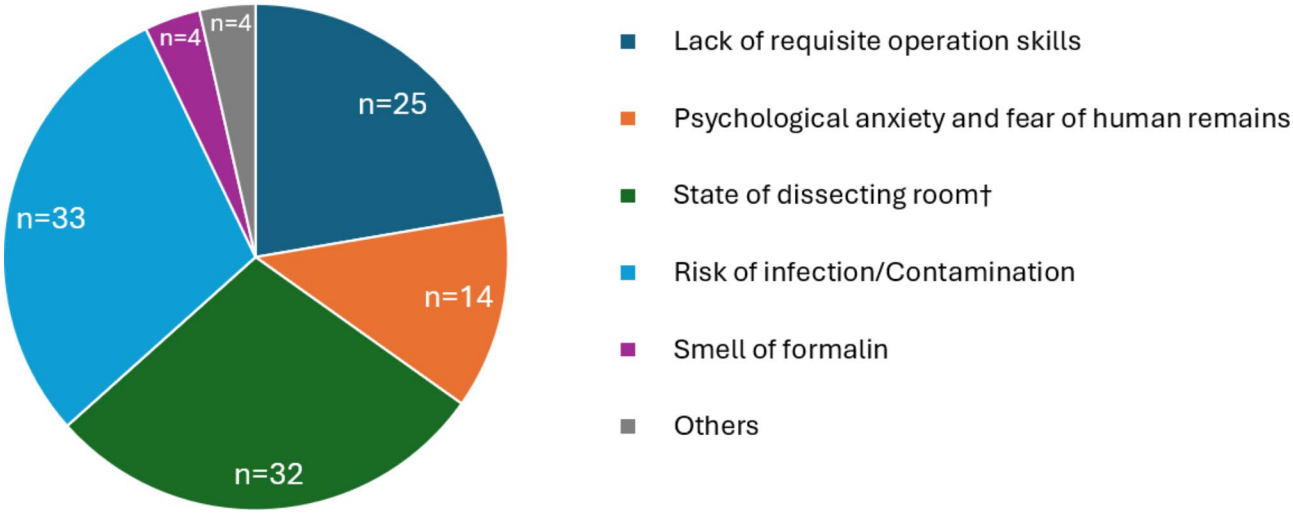

Fig. 1 A pie chart summarizing why some participants were unwilling to partake in traditional human body dissection. *n* = 112 comprising of *Yes (conditional)* and *No* from Table 2's "Are you ever willing to engage in traditional human body dissection?" † UGMS has one large dissecting room. Due to increasing student intake, some students feel crowded out in the relatively smaller dissecting room

body dissection. Figure 2A presents the limitations of the virtual dissection table and its use according to the participants. The primary constraints identified were insufficient operational proficiency [51% (95% CI = 48.9–53.4)] and restricted accessibility [39% (95% CI = 35.2–42.3)]. Twenty-five (25) of the participants who had experienced virtual dissection advocated for it to completely replace traditional human body dissection with their supporting reasons summarized in Fig. 2B.

Discussion

Key Findings from the study are summarized as [1] students had positive experiences with both traditional human body dissection and Anatomage table virtual dissection, [2] while traditional human body dissection remains an essential part of anatomy pedagogy, virtual dissection is a valuable supplement that enhances student engagement and understanding in anatomy, and [3] virtual dissection positively influences the learning of anatomy but should not completely replace traditional human body dissection in anatomy pedagogy.

The educational landscape in Africa is evolving especially with the emergence of COVID-19. Many African universities are integrating modern and virtual ways of teaching. Dissection is a mandatory part of the Gross Anatomy curriculum at the University of Ghana Medical School. Except for two of the participants, all the participating students had engaged in dissection as part of their medical education. Over the last few years, UGMS received transfer students from Ukraine during the Russian-Ukraine war to complete their medical training. Some of the students joined UGMS from the 3rd year and beyond and missed UGMS 2nd -year's curriculum where anatomy is taught as part of the basic sciences. The two students could be transferring students from institutions where traditional human body dissection is excluded from the anatomy pedagogy.

Generally, students had positive experiences with traditional human body dissection. Underpinning this exciting experience is that medical students are usually enthusiastic about using human bodies to learn the human body anatomy [27]. Students' enthusiasm further deepens when they are adequately sensitized by their anatomy educators about dissection and are guided by their anatomy instructors every step of the way till they gain sufficient confidence to dissect themselves and adapt to the associated environment. A universally acclaimed advantage of human body dissection is that it provides a near-life three-dimensional perspective of structures and their relationships, thereby deepening understanding and lasting knowledge [7, 28, 29]. Despite the advantages, stress, depression, and emotional trauma, unpleasant smell, nausea, and irritation from formalin are some significant reasons for people to have negative experiences with human body dissection [8, 28] and advocate for its complete replacement. Particularly for students, negative perceptions of human body dissection arise from factors such as it being time-consuming, difficult to identify structures, and the dislike of the smell of preservatives [28, 30, 31].

Not all the responding students had been involved with the Anatomage table for virtual dissection. Understandably, many 4th and 5th -year students may belong to this category. At the time of its introduction in 2020, when they were in 1st and 2nd year, respectively, student interest in the Anatomage table was low and with weak operational adeptness. Furthermore, the implementation of virtual dissection at UGMS occurred during the period

Table 3 Participants' experiences and opinions on Anatomage virtual dissection table

Summarized Response to Questions	Frequency	Percentage (%)	95% CI
Experience and use of the Anatomage table	*n* = 297		
Yes	205	69.0	63.4–74.2
No	92	31.0	25.8–36.6
Frequency of Usage	*n* = 205		
Very rarely	79	38.3	31.9–45.6
Seldomly	88	43.0	36.1–50.0
Frequently	38	18.7	13.6–24.7
Use of Anatomage Enhances Understanding of Concepts	*n* = 205		
Strongly disagree	6	2.8	1.2–6.6
Disagree	5	2.3	0.9–5.9
Neutral	52	25.7	19.7–32.0
Agree	77	37.4	31.0-44.6
Strongly agree	68	31.8	26.9–40.1
It is easy to use Anatomage	*n* = 205		
Strongly disagree	5	2.4	0.9–5.9
Disagree	14	7.0	3.9–11.4
Neutral	45	22.0	16.6–28.4
Agree	72	35.0	28.7–42.1
Strongly agree	69	33.6	27.3–40.6
Anatomage use has a positive influence on learning anatomy	*n* = 205		
Strongly disagree	3	1.4	0.4–4.6
Disagree	11	5.2	2.9–9.7
Neutral	57	26.6	21.9–34.6
Agree	78	36.4	31.5–45.1
Strongly agree	62	30.4	24.1–37.1
Anatomage use in teaching and learning should be encouraged	*n* = 205		
Strongly disagree	7	3.3	1.5–7.2
Disagree	7	3.3	1.5–7.2
Neutral	22	10.7	7.0–16.0
Agree	67	32.7	26.4–39.6
Strongly agree	102	50.0	42.7–56.8
Virtual dissection supplements traditional methods	*n* = 205		
Strongly disagree	3	1.4	0.4–4.6
Disagree	8	3.7	1.8–7.8
Neutral	19	9.3	5.8–14.3
Agree	65	30.4	25.5–38.6
Strongly agree	118	55.2	50.5–64.4
Virtual dissection should completely replace traditional methods	*n* = 205		
Yes	25	12.1	8.2–17.7
No	180	87.9	82.3–91.8

restrictions were imposed in Ghana due to the COVID-19 pandemic, which severely disrupted academic activities and unintentionally limited access to the equipment. Following the normalization of academic activities, student use of the Anatomage table and interest in virtual dissection improved. Notwithstanding, restricted accessibility to the Anatomage table and operational deficiencies on the part of the students are major demotivating factors to the regular involvement in virtual dissection. UGMS has two Anatomage tables installed in dedicated rooms which are accessible to undergraduate students only during regular school hours. During practical sessions, students are free to switch between the traditional human body dissection and the virtual dissection whenever they deem appropriate. This sometimes, unintendedly, results in crowding around the tables and may not provide students with adequate time with the equipment. Additionally, the majority of students live far away from the medical school campus, a situation that deprives them of access to the table after school hours when permitted. Finally, the practical examination for students is centered around human bodies and consequently, students tend to allocate more time to the human bodies in comparison to the Anatomage table. The aforementioned reasons explain the infrequent use of the Anatomage table among some students. Certainly, the two tables will have to be better managed to equitably satisfy the accessibility needs of all the students.

Responses from participants exposed some positives why medical students favored the Anatomage table and

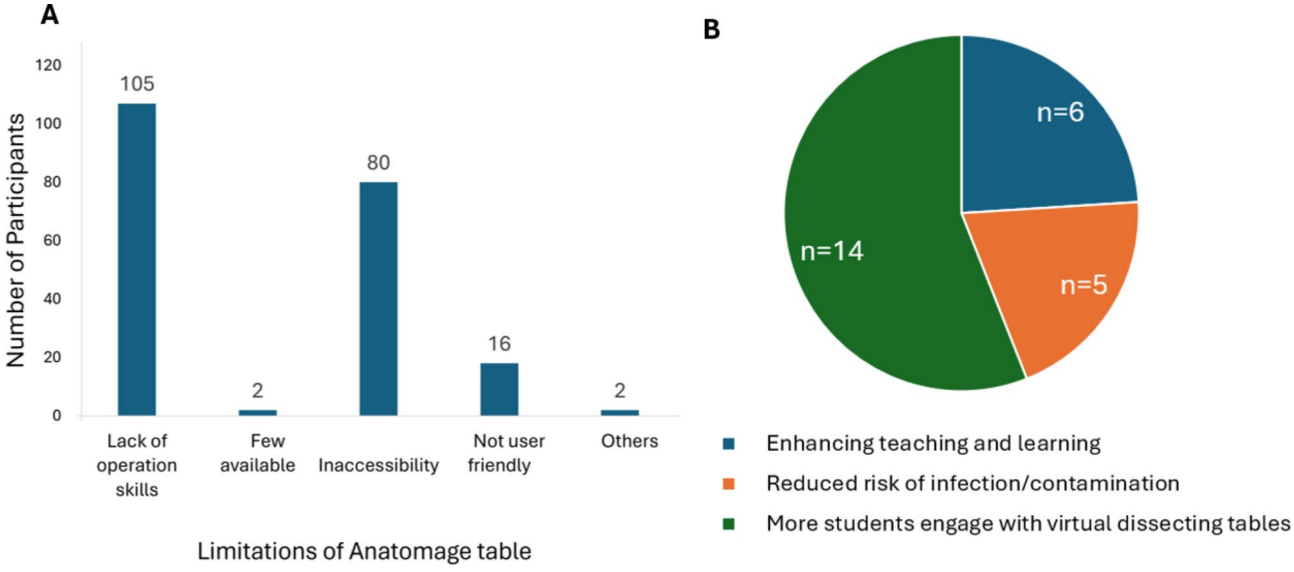

Fig. 2 **A** is a bar graph summarizing the view of participants on the limitations of the Anatomage table. *n* = 205, participants answering *Yes* to "Experience and use of the Anatomage table" in Table 3. **B** is a pie chart of reasons virtual dissection should completely replace traditional methods. *n* = 25, participants answering *Yes* to "Virtual dissection should completely replace traditional methods" in Table 3

affirmed its use. About 97% of the participants were 16–25 years old and belonged to 21st-century students nicknamed 'joystick generation' for their extraordinary agility and adaptation to technology use [1, 32]. Expectedly, to them, the use of the Anatomage table came with relative ease and improved their understanding of anatomy, particularly about the location and relationships of various internal body systems similar to previous reports [33–35]. Virtual dissection compared to traditional human body dissection as a learning modality for gross anatomy, reportedly results in improved students' learning and performance [20, 24, 36, 37]. The high-resolution imaging which improves visualization and the ease of manipulation with the ability to view structures in different planes facilitate understanding and internalization of concepts [1, 4, 34]. Additionally, though important, students in virtual dissection, save time by avoiding the laborious process of dissecting from skin to muscle, and thus have more time to learn and memorize the easily recognizable structures [38]. These advantages to the 21st-century 'joystick generation' students make them proponents of the inclusion of virtual dissection in the teaching and learning of anatomy. Some students further acquire applications like Visible Anatomy and Complete Anatomy to maintain access to these learning resources in situations where the Anatomage table is unavailable. Beyond the welcomed advantages to students, some new medical schools in Ghana, for instance, are embracing teaching with technology (using Anatomage and Complete Anatomy) exclusively for convenience and avoid the expensive setup of morgues and the difficulty in acquiring and preserving bodies for teaching anatomy.

In Africa, interest in technological innovations in medical education is growing with learners and educators equally enthused about integrating technology into the pedagogical processes. However, on the part of educators, such technological tools especially the Anatomage table in anatomy education, should not replace the traditional human body dissection. In their opinion, the traditional human body dissection is the gold standard for teaching gross anatomy [24]. Some African anatomy educators are hesitant to wholly embrace the use of the Anatomage and argue that since human bodies are readily available in many African institutions for teaching, there is very little motivation to switch to Anatomage. In countries or areas where there is a shortage of human bodies for dissection, the exclusive use of virtual dissection is highly recommended [24, 39]. Reasons for some anatomy educators' reluctance to embrace virtual dissection fully vary but may be summarized as follows. Haptic experience with cadaveric dissection which virtual dissection eliminates is important while performing surgeries to better perceive and identify structures. The touch sensation between medical doctors and patients is essential and best learned early in body dissection [20, 40]. There is also the concern about limited realism with virtual dissection. Though the stereo images are highly detailed, they do not fully capture the subtleties and variations of real biological specimens [7]. Additionally, in many low-income countries, challenges associated with virtual dissection are rife. These challenges include technical issues such as software crashes and internet connectivity problems.

Notwithstanding the benefits of virtual dissection, the positives of traditional human body dissection cannot be overlooked. Some experts advocate for the reinstatement of body dissection as the core instructional method for gross anatomy pedagogy to ensure safe medical practice as it provides the foundation critical to the development of clinical skills [32]. They opine that the value of traditional body dissection extends beyond simply serving as a pedagogical tool. Compared to virtual dissection, traditional body dissection provides the opportunity for the acquisition of essential professional competencies including patient-doctor interaction, teamwork, self-awareness, medical epistemology, and an understanding of medical ethics [7, 41]. Ultimately, traditional body dissection is believed to enable the learning of anatomy with relevant clinical correlates and helps to build discipline-independent skills which are essential requirements of modern healthcare setup [32].

A limitation of this study is the inability to quantify the number of hours students spent in virtual dissection. Individual preferences based on learning strategies and modes influence the student's choices, thereby varying the time each student devotes to virtual dissection. Secondly, the study focused only on students' perception of the influence of virtual dissection on learning anatomy. No assessment-based test was conducted to objectively quantify the impact of virtual dissection on student learning outcomes. Another limitation is the inclusion of students in the 4th and 5th years. Time had passed since taking 2nd year anatomy and their recall may have been affected by a degree of decay. Lastly, the convenience sampling method used in the study participants selection may have an inherent bias of recruiting only easy-to-get and willing students to participate in the study. Consequently, other useful information from hard-to-get or uninterested students may have missed out.

Conclusion

This study revealed positive attitudes towards both traditional human body dissection and virtual dissection. While traditional human body dissection remains an essential part of anatomy pedagogy, three-dimensional virtual dissection is seen as a valuable supplement that enhances student engagement and understanding. Encouraging the use of the virtual dissection table as an adjunct to traditional methods could potentially improve anatomy education and address some of the challenges associated with traditional human body dissection. However, proper training and improved accessibility are crucial for the full maximization of the benefits of the virtual dissection table in modern medical education. This will require regular training programs to be mounted that aim to increase the operational competencies of students and educators in the use of the Anatomage table. For further studies, assessment-based studies should be conducted to fully understand the impact of virtual dissection on student learning outcomes in the given population.

Supplementary Information

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Supplementary Material 1

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Author contributions

Conceptualization: BA-B, NK-KK, AOA. Design, Data Generation & Data Analysis: AOA, BNAA, JA, BAH, KA-O, MA-R. Manuscript Development: BA-B, BNAA, AOA, NK-KK. All authors critically revised and approved the final draft.

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Data availability

All relevant data are included in the manuscript. Request for source files should be made to the corresponding authors.

Declarations

Ethics declarations

Ethical clearance (approval number UGMS-CHDRC/034/2023) was received from the Ethics and Protocol Review Board of the Dissertation Review Committee of the Department of Community Health, University of Ghana Medical School. Informed consent was obtained from all participants and/or their legal guardian(s).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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