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## The role of innovation technology in teaching and learning strategies in anatomy curricula in dental hygiene school

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**Abstract.** *Purpose.* This research aims to assess the diversification of pedagogical and learning methodologies, leveraging advanced technological tools within a dental hygiene educational framework. *Methods.* Students enrolled in the dental hygiene program were considered as population sample, divided in two groups: The test group (N=16) subjected to the investigation of the virtual dissection table (VDT) and the control group (n=17) who attended lectures using traditional teaching method. The control group's performance was assessed through a 40-item multiple-choice questionnaire and an open-ended question; the test group was evaluated via a final test consisting of a presentation on an anatomical topic and a 40-item multiple-choice questionnaire. The final grade derived from the mean score of the final tests, and it was assigned on a scale of 30/30. Additionally, the test group's perceptions toward the use of the VDT were gauged through an evaluative questionnaire comprising 7 questions. *Results.* The study found a statistically significant difference in failure rates between the control group and the test group. However, the average exam scores did not show a statistically significant difference between the two groups, despite the test group showing some improvement. The evaluation survey results indicated high levels of satisfaction with the use of the VDT, with the quality of the virtual images, anatomical resources, and the user-friendly interface. Additionally, students strongly supported integrating traditional lectures with VDT laboratory sessions, with no negative feedback reported. *Conclusions.* The VDT represents an innovative anatomy teaching tool, warmly welcomed by healthcare profession students, whose performances were positively affected.

**Keywords:** applied anatomy, anatomy teaching, gross anatomy education, novel teaching modalities, undergraduate education, virtual anatomy.

### INTRODUCTION

Human anatomy is that branch of the biomedical curricula of different schools in the field of biotechnologies and healthcare, concerning the study of the structure and organization of the human body, that involves the organs, tissues, cells and systems and how they interact (Turney, 2007).

Due to the importance of the knowledge of anatomy in laboratory and clinical procedures, it is mandatory to guarantee an effectiveness of anatomy learning (Bianchi et al., 2020; Goodwin, 2000). Professors and lecturers classically deliver their lessons using a digital presentation composed of captions, key words associated with the images which could reproduce a cadaver or a drawn of it (Meyur et al., 2011). Students have access to textbooks, diagrams, schemes, videos and atlas (Estai & Bunt, 2016). Due to the amount and complexity of anatomy subjects, students might apply a mnemonic learning method, resulting in low quality study of notions, and missing that information which are fundamental for clinical practice.

Commonly, human anatomy is included in the first years of curricula of medical, dental and healthcare professional schools. It can happen that the learning method, which differs from the one of high schools, is not well developed, with difficulties in acquiring permanently the important notions and information useful to progress in the academic and professional career (Iwanaga et al., 2021).

Other important factors which could affect the learning process in an academic environment are represented by the teaching time, increasing class size and increased cost of laboratory (Al Husaini et al., 2022).

For these reasons, the teaching and learning strategies represent a high-profile research topic and are currently being investigated by academic and pedagogic experts of the field.

Innovation technology is giving an aid to compensate for the lack of traditional teaching strategies. One of the most spread in the Western countries is the use of computer-based software providing a virtual cadaver and integrating notions and annotations (Moro et al., 2017). In addition, recently universities and institutions have been equipped with virtual dissection tables (VDTs) which provide and simulate the human anatomy dissection, histology and pathology, and clinical cases (Kavvadia et al., 2023).

All this material is useful in the undergraduate curricula and post-graduate, to diversify the learning strategies and refresh and review those notions that are used in clinical practices.

The students attending healthcare bachelor's degree have been reported in literature to face difficulties in the biomedical curricula, especially anatomy and physiology (Mitchell & Batty, 2009). The dental hygiene curriculum includes the study of gross anatomy at their first-year, and represent a sort of challenges for lectures and teachers to balance the gross anatomy notions, with the special area of head and neck, strongly appropriated to the type of this curricula (Kim & Kim, 2022).

In the attempt to fulfill the Sustainable Development Goal (SDG) number 4 proposed by the United Nations (UN), which aims to increase the quality of education (UN, 2015), the study aims to evaluate the teaching and learning strategies diversifications, relying on the modern technological instruments used in dental hygiene school.

## MATERIALS AND METHODS.

### *Population*

The population on which the use of the VDT was investigated consisted of students from the dental hygiene degree program, divided in two groups: the test group (N=16) undertook the blended method proposed, while the control group (n=17) attended traditional human anatomy classes.

### *Teaching method and exam evaluation used in the control group*

The teaching approach used during anatomy lectures to the dental hygiene students included oral presentation of theoretical lectures; the total amount of the teaching classes was 30 hours of which 20 hours were dedicated to the traditional lectures and 10 hours consisted in laboratory practice on anatomical models. The curricula included the systematic anatomy topics (musculoskeletal system, cardiovascular system, respiratory system, digestive system, urogenital system, neuroendocrine system and stomatognathic system). The anatomy teaching approach tested was based on the combination of theoretical lectures given by the teacher with single sessions of two hours and a consequent one-hour-session of laboratory activities based on the study of the anatomy on traditional plastic models. The final evaluation consisted in a multiple-choice questionnaire of 40 questions composed of 5 choices of which only one answer was the correct one: no penalty was given if the one marked by the student was incorrect. In addition, an open-ended question about the stomatognathic system was part of the test. The final mark was obtained calculating the grade point average between the administered questionnaire and the open-ended question was given in a scale of 30/30.

### *Teaching method used and the final exam evaluation in the test group: the blended teaching approach*

The traditional teaching approach used during anatomy lectures to the dental hygiene students included

oral presentation of theoretical lectures for an amount of 20 hours and 10 hours dedicated to the lectures using VDT (Anatamage© Table Convertible). The curricula included the systematic anatomy topics (musculoskeletal system, cardiovascular system, respiratory system, digestive system, urogenital system, neuroendocrine system and stomatognathic system). The anatomy teaching approach tested was based on the combination of theoretical lectures given by the teacher with single sessions of two hours and a consequent one-hour-session of laboratory activities based on the study of the anatomy on traditional plastic models and virtual dissection activities on VDTs (8 students per table), including a training on the use of the table and a hands-on session conducted by the students who were supervised by a teacher and a PhD student. The students had as final task to take screenshots of their own dissection for home-revision.

The used software of the VDT (Table EDU 8.0) is based on advanced imaging technology, which enables users to explore the human body and exploit interactive functionality, using the information and the images from the Visible Human Projects®. The reconstructions and the developed software, together with the touch screen hardware allows users to manipulate (dissecting, rotating, zooming) anatomical models in real-time, gaining a comprehensive view of the human body. The software also offers a library of histological specimens of human biological tissues, as well animated rendering describing the functions of the different systems such as the joints and the hearth rates.

The final exam in the test group consisted in a digital presentation made by each student about a single topic randomly assigned from the anatomy teaching program developed during the theoretical lessons and a multiple-choice questionnaire of 40 questions composed of 5 choices of which only one answer was the correct one: no penalty was given if the one marked by the student was incorrect. The final mark was obtained calculating the grade point average between the power point presentation and the administered questionnaire and was given in a scale of 30/30.

#### *Outcomes: the opinions and the scores of the student*

The investigation aimed to evaluate both the opinion of the students on the use of VDT and the efficacy in terms of exam success rate and scores.

As regards the opinion of the students, an evaluation survey on the use of the VDT was administered to all the students who gave consent to participate in the study; the students which did not give the consent, were excluded from the surveys. The evaluation questionnaire

**Table 1.** Evaluation questionnaire on the use of the VDT.

1. Did you already have experience using a digital anatomical visualization system?	· Yes · No
2. How satisfied are you with the quality of the images and anatomical resources provided by the virtual dissection table?	· Completely Satisfied · Very Satisfied · Satisfied · Nor Satisfied nor Unsatisfied · Unsatisfied
3. Have you encountered difficulty using specific features of the virtual dissection table? If yes, please specify in "Other"	· No · Yes · Other: _____
4. How useful do you think the study of anatomy using the virtual dissection table is for your subsequent clinical activity?	· Very Useful · Useful · Neutral · Useless · Very Useless
5. If you had the opportunity to improve the functionality of the virtual dissection table, what would you suggest?	_____ _____
6. Did You enjoyed the presented anatomy lecture?	· Yes · NO
7. What would You suggest to improve the lecture?	_____

(Table 1) was administered at the end of the course, to all the compliant students. The survey was created using "Google online for Creator" on "Google workspace" and included seven questions administered in different types, thus five multiple choice questions and two open-ended questions. The Google Form was online, anonymous, and spread to the dental hygiene students using a link generated by Google form workspace.

The students were asked to evaluate their level of interest in the virtual dissection approach, their eventual experience with the same method proposed, the level of satisfaction about the lessons on VDT, the efficacy of its images, the grade of helpfulness of the software, and eventual proposals of improvement of the software itself and the way of developing of lessons on VDT.

#### *Statistics*

The parameters of the rate of failure and the mean values of the score were considered. Only the mean score of the students who successfully passed the final exam was compared between the two groups, who attended the lessons with the same teacher. The rate of failure and

the comparison between the two groups was evaluated using chi square tests on contingency tables. A result with a p value  $\leq 0.05$  was considered statistically significant. As regards the mean scores, unpaired t-student test was used to assess any significant differences, considering a p value  $\leq 0.05$ . The graphs and statistics were obtained using GraphPad Prism version 10.2.2 for Windows, GraphPad Software, Boston, Massachusetts USA, www.graphpad.com.

*Ethics*

The study was approved by the internal review board, with the reference number 41/2018, of which study project included this type of investigation on different curricula degrees.

According to the protocol of study approved by the internal review board, all the investigated students gave their consent before joining the study.

RESULTS

*Dental hygiene students population*

The number of students attending the test group of Dental Hygiene school was 16 and the number of students attending the control group was 17. All the students gave their consent to contribute to the study.

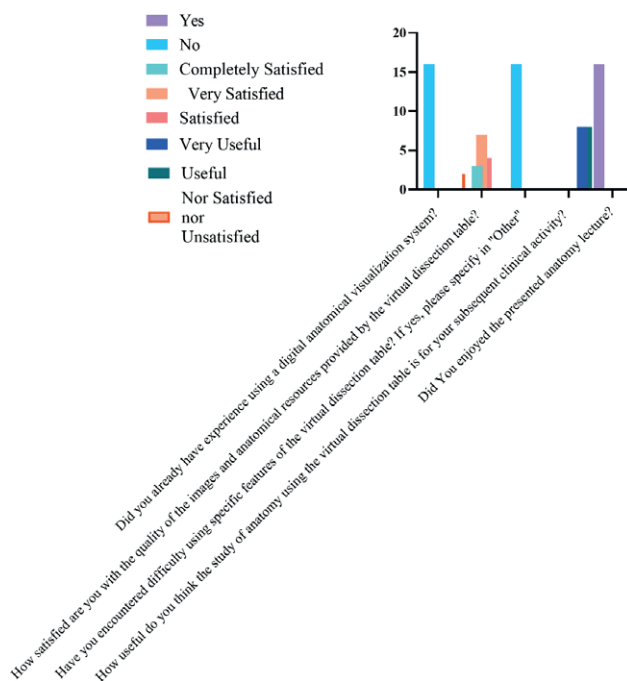
*Evaluation survey*

Overall, the answers to the survey were positive (Figure 1):16 students, even though without any previous experience with digital anatomical visualization, found easy to interact with the table and enjoyed the lectures. Half of the sample (n=8) found the blended method very useful for the clinical application and the other half (n=8) found the experience useful. As regards the quality of the images, most of the students was satisfied.

As regards the suggestions to improve the VDT, the majority (n=9) suggested to add Italian language (Table 2). As regard the suggestions to improve the teaching methods, only two comments were reported: increasing the hours in the laboratory and to integrate the use of plastic models (Table 2).

*Exam scores*

The number of students of the control group who failed the exam was 4. None of the 16 students who expe-



**Figure 1.** Graphical representation of the survey results. Graph obtained using GraphPad Prism version 10.2.2 for Windows, GraphPad Software, Boston, Massachusetts USA, www.graphpad.com.

**Table 2.** Most notable answers from the students' comments.

Question	Notable Comments
If you had the opportunity to improve the functionality of the virtual dissection table, what would you suggest?	Add Italian Language Add More Language
What would You suggest to improve the lecture?	Increase the laboratory hours Continue to use both VDT and Plastic Models

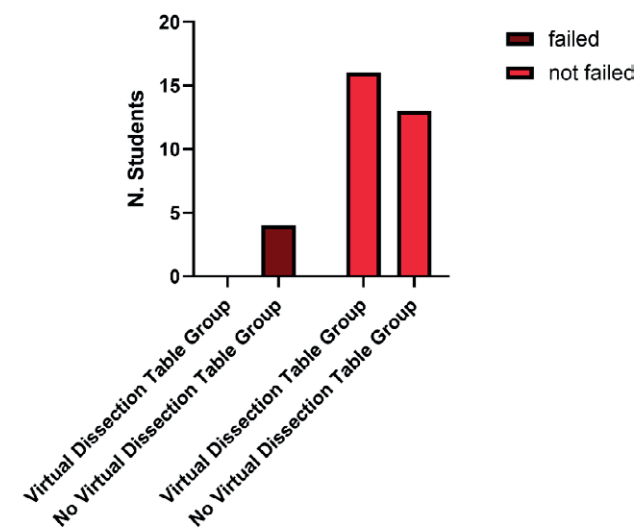
rienced and integrated the VDT teaching and learning strategies failed the exam. The chi square test on contingency table resulted statistically significant (Figure 2)

The quality of the test group exam in terms of scores was better than the control group, but not statistically significant (Figure 3).

DISCUSSION

*The blended teaching method was effective on students' performances*

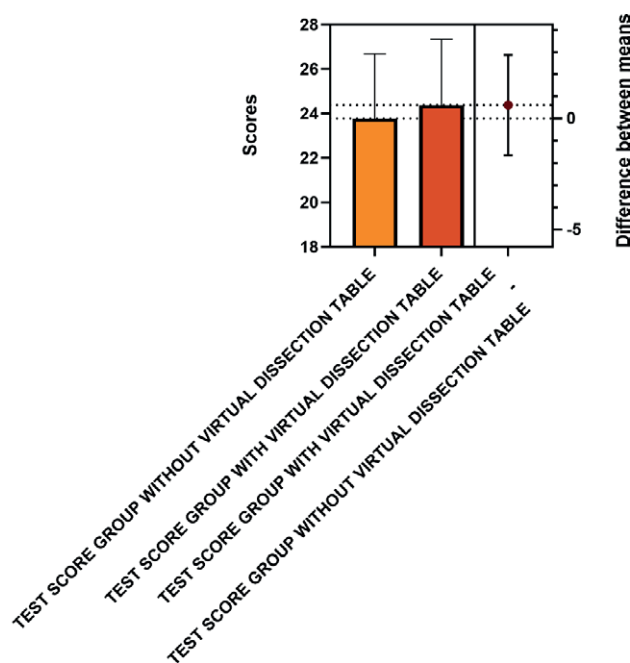
The core of the anatomy curricula in the undergraduate courses aims to provide the right and neces-



	failed	not failed
Virtual Dissection Table Group	0	16
No Virtual Dissection Table Group	4	13
P value and statistical significance		
Test	Chi-square	
Chi-square, df	4.284, 1	
z	2.070	
P value	0.0385	

**Figure 2.** Separate graph bar showing the differences between the students who attended the blended teaching method using the virtual dissection table and the control group. The table inset reports the contingency table and the related Chi Square test. P value is < 0.05, showing the difference is statistically significant.

sary knowledge of human body and oral cavity features for clinical application. The VDT blended method has showed a significant adjuvant role in the anatomy education, when combined with the traditional teaching methods, represented by topographical anatomy textbooks and cadaveric dissection sessions, representing a new blended-learning approaches as Chytas et al. investigated conducting a general review on this fundamental topic in 2023 (Chytas et al., 2023). The proposed blended teaching method, represented by the combination of traditional lectures and innovative laboratory activities conducted on VDT resulted effective in students' academic performances. The difference in terms of failure rate between the control group, composed of 17 students who did not attend to VDT activities, and the test group of 16 students who experienced the blended teaching method, was statistically significant. However, the differences between the two classes in term of mean of the exam scores, even with an improvement in the test group, were not statistically significant. The efficacy of using VDT as alternative method of teaching human anatomy was showed by different studies: in the study of Patniak et al., the authors



Parameter	Value
Unpaired t test	
P value	0.5862
P value summary	ns
Significantly different (P < 0.05)?	No
One- or two-tailed P value?	Two-tailed
t, df	t=0.5510, df=27
How big is the difference?	
Mean of column A	23.77
Mean of column B	24.38
Difference between means (B - A) ± SEM	0.6058 ± 1.099
95% confidence interval	-1.650 to 2.862
R squared (eta squared)	0.01112

**Figure 3.** Estimation plot showing the differences between the means of the scores assigned to the students who attended the blended teaching method using the virtual dissection table and to the control group. The table inset reports the Unpaired t test, the mean of the scores, the 95% confidence interval and the related Chi Square test. P value is > 0.05, showing the difference is not statistically significant.

evaluated the effectiveness of Anatomage© virtual dissection as a teaching tool in comparison with traditional dissection in Neuroanatomy curriculum for 3rd year Physiotherapy students, showing that test scores in the group of students who were taught using the VDT were better than the group of students taught using the traditional cadaveric method (Patnaik et al., 2024). In the study conducted by Rosario et al., VDT was investigated as a supplemental learning method, similar to the blended method proposed by the current study. However, the study investigated the traditional dissection method combined with the use of VDT in the study of Head and Neck Anatomy, showing that VDT implemented the learning flow of the students (Rosario, 2022).

### *The positive opinions of the students*

The results of the evaluation survey based on the level of satisfaction on the use of VDT demonstrated positive perceptions of this innovative teaching and learning instrument. Indeed, the majority of the students was well satisfied with the use of the virtual dissection table which was never experimented, highlighting the satisfaction with the quality of the provided virtual images and the anatomic resources. Furthermore, the interface of the VDT appeared user-friendly to the whole test group of students who had no issues in interacting with it.

About the usefulness of integrating traditional lectures with laboratory on virtual dissection table, the evaluation survey showed a very positive results from students' opinions, without any negative feedback, showing the effectiveness of using VDT as demonstrated by different authors: in the study of Alasmari et al., authors administered to medical students an electronic questionnaire composed of 6 questions regarding the effect of using a 3D VDT (Anatmage®), combined with cadaveric dissection activities, to 78 medical students. The majority reported a great level of satisfaction in using VDT, thanks to the imaging facility available on the table, which was useful to improve their knowledge in human anatomy (Alasmari, 2021).

In another study conducted by Ralte et al., authors investigated the blended learning method in first year of Bachelor of Medicine and Bachelor of Surgery (MBBS) students through a semi-structured questionnaires whose results confirmed that the use of VDT (Sectra®) followed by cadaveric dissection was preferred as a teaching method by the 60% of the students (Ralte et al., 2023).

Similar studies have investigated the adjuvant role of VDT when combined with the traditional teaching and cadaveric dissection methods using both two parameters of investigation, thus the rate score resulted from the final exam following to the academic curriculums and an evaluation questionnaire administered to the students: in particular, in the study of Malhotra et al., a comparative study was conducted in order to assess the eventual effectiveness of VDT in comparison with the cadaver dissection laboratories, demonstrating that students achieved more than 50% marks thanks to the blended method; however, the evaluation questionnaire revealed a particular data about the role of VDT, demonstrating that student appreciated the virtual dissection study as a complementary method associated to the cadaveric dissection which still remains fundamental and not replaceable from the VDT (Malhotra et al., 2016).

The positive outcome of using VDT as supplemental reaching method was also demonstrated by Deng et al. in 2018 who assigned 120 medical students into 4 classes divided in two groups: the test group was represented by two classes who attended blended teaching sessions composed of traditional methods and digital virtual simulation (DVS) method, while the control group was assigned to the traditional methods used alone; the result of the final exams showed a statistically significant difference between the two groups, revealing an higher mean score achieved from the test group than the control group. At the same time, students demonstrated their approval of DVS as adjuvant teaching method (Deng et al., 2018). Furthermore, a recent study conducted by Emadzadeh et al. in 2023 confirmed the potential for virtual dissection to increase anatomical education: their investigation consisted in evaluating the performance of second-year undergraduate medical students after studying gross anatomy by VDT, representing the test group, or topographical anatomy textbooks as control group. The final score and the evaluation survey following the completion of the anatomy curriculum showed a significant gain in results and satisfaction about the tested teaching method, when compared to the traditional one (Emadzadeh et al., 2023).

Finally, the survey administered in the current study specifically asked students to propose eventual improvements of the software Table EDU 8.0. Most of the students, speaking mainly Italian language, proposed to implement the software with their mother tongue language, while some students proposed to increase the number of teaching hours on virtual dissection table combined with the direct manipulation of plastic models. However, most of the students showed that there was not the necessity of improving or changing the actual blended method proposed.

### *Strengths, limitations and future perspectives*

The current study showed how the use of innovative technology lead the students to an enthusiastic learning approach and environment. However, the small sample size represents a strong limitation. Exploiting the new instruments which academics have in place is fundamental to improve the quality of teaching methods, and, as consequence, the learning flow of students. The need of allowing the students to learn in the most effective way, and more practically, an eventual another pandemic, such as the COVID 19 one, motivate governments and institutions to invest in the technology (Varvara et al., 2021). The current development of the augmented reality system represents the future which paves the way

for the study of human body thanks to the new tools and the possibility of perceiving the anatomical structure through innovative visual and haptic instruments such as haptic gloves and virtual reality glasses (Bisht et al., 2019).

Indeed, the manipulation moments during hands-on sessions, being on cadaver or models, is crucial in the medical and healthcare education (Varvara et al., 2021). As reported by Sajdłowski study on education online due to COVID19 pandemic, the hands-on and practical training sessions represent unique moments, unreplaceable by e-learning or only-digital session (Sajdłowski et al., 2021).

On the other hand, another challenge is represented by the integration of the virtual reality (VR), augmented reality (AR) and mixed reality (MR) which are involved in the application of metaverse to enhance learning and teaching of human anatomy (Iwanaga et al., 2023).

## CONCLUSIONS

Anatomy course is always reminded by medical, dental, and healthcare former students as the first difficult exam in their curricula. Innovation technology, when integrated for the diversification of the teaching strategies, allows students to improve their learning strategy, keeps in their mind the memory of the anatomy course as a positive experience, and increase their interests in the topic.

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