

Teaching anatomy in a modern medical course: an integrated approach at Vialba Medical School in Milan

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Abstract

Introduction

The course of Anatomy in Vialba Medical School – University of Milan, integrates systemic, topographic and development anatomy, dissection laboratory, peer-teaching, flipped classroom, clinical correlation to radiology and surgery.

Methods

An anonymous questionnaire based on a five-point Likert scale was submitted to 162 students who had passed the exam of Anatomy. Students evaluated the importance given during study to morphology, relations and variations of organs, the usefulness of different tools in preparing the exam of anatomy. Finally, the impact of the new design course of Anatomy on students' progress was assessed.

Results

The results showed that most of the students found very useful dissections, multimedia sources and 3D virtual models. 3D virtual models, dissections and physical models were indicated as the most important tools that should be available for learning Anatomy; instead, medical imaging received a low score. Students focused the study on morphology and relations between organs much more than anatomical variations. Lastly, students who followed the new design course of anatomy showed a significant better performance when compared to students of the previous academic years, in particular on the anatomy of neck, thoracic and abdominopelvic cavity, and neuroanatomy.

Conclusions

Our study underlines the positive impact of the integration of traditional methods and innovative solutions in learning anatomy, but also the critical approach to radiologic imaging and anatomical variability.

Keywords: Teaching Anatomy. Anatomy clinically oriented. Multiple choice tests. Peer-teaching. Value-based teaching model

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INTRODUCTION

Anatomy plays a critical role for all branches of medicine. Over the past decade, the importance of anatomical knowledge and competence as a critical facet for the provision of high quality health care has represented a fundamental point in medical curriculum (Böckers 2010; Sugand 2010; Estai and Bunt 2016). In the last years, two contrasting factors are having a noteworthy impact on anatomical curriculum in medical specialties.

On the one hand, the reduction both in the gross anatomy teaching hours and its context, the ever decreasing number of trained anatomists, the increasing costs of human cadaveric dissections and the related ethical uncertainties surrounding the use of human cadavers (Aziz 2002; Winkelmann 2016), have raised the perception that students' and doctors' knowledge is below an acceptable standard required for safe medical practice (Singh 2015; Steinberg 2015; Vorstenbosch 2016).

On the other hand, the advances in technology have introduced innovation tools in the learning of Anatomy. Beyond the countless websites proposing educational videos and other multimedia sources, including social networks (Bialy 2015; Sutherland and Jalali 2017), students can now dispose of virtual reality (VR) to explore the complexity inside a human body even in their own home. The learning benefits related to the creation of anatomical and realistic models in VR have been widely investigated in recent (Hacker and Handels 2009; Dalgarno and Lee 2010; Khot 2013; Falah. 2015). Moreover, head-mounted displays (e.g. Samsung Gear VR, Oculus Rift, etc.) allow to experience VR in an immersive way: the user is involved in exploring a virtual environment where he uses his motor skills (hand gesture, head rotation, etc.) to perform different tasks, thus enhancing learning process and problem solving (Mastrangelo 2003; Moro 2017).

Others emerging tools are Augmented Reality (AR), that allows to overlay digital information in the form of video, audio or 3D models onto real world (i.e., the human body) (Thomas 2010; Hugues 2011) and three-dimensional printing (3DP), which produces 3D physical models with high accuracy from medical CT/MRI data both for teaching purposes and surgical planning (Mcmenamin 2014; Vaccarezza and Papa 2015; Ploch 2016).

In this scenario, the use of medical imaging in teaching anatomy is widely increased (Miles 2005; Phillips 2013; Grignon 2016). Many Authors have underlined that the integration of radiological imaging with anatomical dissections improves the development of professional competences (Reeves 2004; Estai and Bunt 2016).

In this evolving context, there is a general consensus on the need to review critically the anatomical curriculum to increase teaching efficiency and enhancing instructional quality, by providing both teachers and students the ability to perform in the best manner of which they are capable (Lombardi 2014; Mathiowetz. 2016). Many studies have proposed multimodal teaching modalities by integrating modern digitalized methods, problem based learning and dissection procedures, but it is still matter of debate which is the most effective way and/or model to teach anatomy (Biassuto 2006; Johnson 2012; Sheikh 2016). This task is complicated by the differences in sample, exploration method, course organization, cultural diversity and available facilities that make it difficult to compare the different models and their impact on learning (Lochner 2016; O'Reilly 2016).

Because of the changes in teaching approaches of the scientific community, this transition will necessitate adjustments and flexibility in the application of the teaching tools, in order to meet the individual needs of medical students characterized by multiple levels of ability, skills, attitudes and interest (Sugand 2010; Trelease 2016).

The aim of this study is to present the design of the course of anatomy in Vialba Medical School (VMS) – University of Milan and to investigate what students focused on while studying Anatomy and the problems they encountered in learning this subject. We have also quantitatively assessed the impact of the new design of the course of Anatomy on students' progress.

Materials and Methods

Design Course

The study was conducted by the Vialba Medical School (VMS), Department of Biomedical and Clinical Sciences "L. Sacco", University of Milan from 2015 to 2017.

The Authors declare that they have no external interest or any other remunerated engagements and/or other Significant Financial Interests in the study.

The course of anatomy at Vialba Medical School takes place in a 6-year-degree course and it is organized in three modules. Two modules take place in the first academic year. The first module focuses on gross anatomy of the bones, joints and muscles, basic embryology (week I through week IV of human development, including development of the skull, spine and limbs), while the second on topographical/systemic gross anatomy of the head, neck and body cavities (thorax, abdomen, pelvis), cross sectional anatomy and corresponding embryology (lectures on the development of the organs and functional systems precede gross anatomical presentations and include frequently occurring malformations).

In close co-operation with the teachers of anatomy, a radiologist carries out the teaching of the appearances of the normal medical imaging. This cooperation stimulates and improves the understanding of gross anatomy and stresses the importance of patient-specific anatomy and of variation description, all patients being different (Willan and Humpherson 1999; Fasel 2016). Moreover, the integration between departments of radiology with anatomy will also benefit postgraduate learning (Dettmer 2010).

In addition to that, orthopedic surgeons carry out a course in basic orthopedic anatomy with a focus on areas of interest to musculoskeletal

injuries commonly seen in clinical practice.

In the second academic year, the third module focuses on central and peripheral nervous system, organs of special senses and corresponding embryology. In this module, particular importance is given to central nervous pathways and to the anatomical basis of the reflexes (myotatic, tendon and those involving cranial nerves), that are critical for clinical diagnosis and for the basic understanding of the principles of motor control.

Video acquisitions during classic or laparoscopic surgery have been introduced to underline anatomical concepts and to transpose them into a clinical setting (for example, the importance of the knowledge of segmental liver anatomy in liver transplant, etc). Each video is followed by a discussion with the students involving surgeons, endoscopists and anatomy teacher. This morphologically/clinically driven approach could help students bridge the transition from academic preclinical study to clinical reasoning (Hammer 2015).

During the course, groups of students (five to eight students) are solicited to elaborate a brief report on selected topics, focused around both clinical and scientific problems and to present them as lecture to the rest of the class (i.e., power point presentation). Students elect a chair who leads the group through the process and keeps the group from falling into disorganization. To deepen the discussion about the related topic, the participating students frequent also medical and/or surgical Departments. Each oral presentation is followed by a debate on the issue, with anatomy teacher and other specialists participating in it (radiologists, surgeons, etc). In this context, the students learn also to analyse scientific articles as content for the critical analysis of quantitative information. This active educational process (Nandi 2000) promotes cooperation, critical thinking and self-organizational competences by exposing to real-life situations which act as a stimulus giving them a role in decisions that affects their learning for their learning (Botelho and O'Donnell 2001; Keren 2017). In our mind, this approach has the purpose to deepen the interest of the students in studying anatomy, encouraging them to set their own learning goals, and to underline the importance of Anatomy learning in clinical practice. Moreover, it could improve the effectiveness of their oral presentations, which is important during their clinical years and during practice (Halder 2012). Anatomy teacher supervised the elaboration of students' lectures, in order to provide an appropriate guidance and motivation to students on how to improve their performance (quality of the report, level and fluency of oral presentation and ability to carry out literature search) (Moore 2017). This student-centered approach received a positive feedback from all involved students in the different groups and also from the rest of the class (the audience students).

Due to the high costs associated with cadaveric programs and to the reduction in fundings, we have developed an alternative dissection program that we carried out during the second module. Students participate in small groups (three to four students) to dissection laboratory of selected animal organs (heart, kidney, lung, liver) under the supervision by fourth/fifth-year tutors, who have already passed the anatomy exam. Every dissection is preceded by a brief introduction drawn up by the tutors to get the attraction of the students on the critical anatomical features that have been given during the lectures. The supervision of tutors can effectively help students to increase communication skills and to ameliorate their knowledge of human anatomy, integrating the explanations given during frontal lectures. After this peer-teaching dissection, students performed a personal dissection on similar organs. To ensure continuity in the didactic activities, the same tutors are also involved in the exercitations on physical models. This method is indeed an effective approach by stimulating an active learning process, while also appreciating the three dimensions of anatomical structures (Youdas 2008; Hall 2013; Manyama 2016). Moreover, students learn through direct interactions from sharing similar discourse with tutors in a more informal and relaxed environment results (Glynn 2006; Field 2007). Equally, the tutors (i.e., students of the clinical years) reinforce their anatomy knowledge through instructing others. In our opinion, this approach creates a *continuum* among lectures, exercitations on physical models, dissection laboratory and other students' activities (i.e., report on selected topics), providing sufficient resources for students to process class information and transfer it to new problems.

To assess the knowledge base and the preparation of the students on the key concepts of the different subjects, eight multiple choice tests on specific topics are submitted to the students. Each multiple choice test is based on forty questions with five possible answers for every question. After each test, students receive formative feedback for their overall score (positive or negative), including a detailed breakdown of their performance. These tests, in addition to find out if students have achieved the learning outcomes of the course, serve to the students to assess their level of knowledge and understanding during the course. The tests are also useful for the teachers, because in such a way they establish the state of play (i.e., the design of the course and the assessment of student work).

Questionnaire based on a five-point Likert rating scale

We have generated a questionnaire based on a five-point Likert scale.

We guaranteed participants only anonymized data would be shared. The bulk of the questionnaire consisted of questions on the tools usage. All the answers were anonymously collected.

Students from the preclinical years who have already completed the course of Anatomy were asked to agree, disagree, or give no opinion (1 and 5 corresponded respectively to the lower and to the higher score). In particular, We have investigated: 1) what students focused on while studying Anatomy; 2) which educational resources students would like to have at disposal for their study and which ones they used in facts.

Lastly, to evaluate the impact of the new organization of our course of Anatomy, we have compared the results of the eight multiple choice tests in students of the previous academic years (when anatomy course included highly detailed lectures, exercitations on physical models with tutors supervisions) with those of the group of students involved in this study, who followed the course of anatomy after the introduction of the new design course. Each multiple choice test is based on the same topics (see Table 5 for the explanation).

Statistical analysis

Data have been analyzed using Chi-square test; a p-value < 0.05 was considered significant.

All statistical analysis was performed blindly using IBM Statistical Package for the Social Sciences (SPSS) 24.0 for Windows (SPSS Inc., Chicago, USA)

This study followed the principles of ethical research declared in the Declaration of Helsinki. The questionnaire was administered on a voluntary basis and the data which was collected could not identify individuals. As a quality improvement project, the study was exempt from institutional ethics approval processes.

Results

We have evaluated the “anatomy appeal” and the student’s approach to the study of anatomy (Table 2), the tools used by the students during Anatomy exam preparation (Table 3) and which tools should be available during the preparation of the Anatomy exam (Table 4). Chi-Square Test analysis was performed and for each frequency related to each ordinal variable, the Chi-Square Test was statistically significant ($p < .001$).

Therefore, we can reject the null hypothesis (i.e., the categories defined by each Likert item occur with the same probability) and conclude that all categories are not equally likely. Moreover, in the table Chi-Square Test, 0 cells have expected count less than 5 and the minimum expected count is 19.0. Therefore, the sample size requirement for the chi-square test of independence is satisfied.

Table 2 describes the student’s approach to the study of Anatomy. Most of the students rated positively the course and, during the preparation of the exam, they concentrated their focus on both morphology of organs (41.4% Yes, 25.9% Surely Yes) and relations among organs (54.3% Surely Yes, 35.2% Yes). The most intriguing result is the low agreement of the students (34.6% No) when considering the anatomical variations of organs.

Table 3 reports students’ evaluation about different didactic tools for preparing the exam. Most of the students reported positively the use of anatomical physical models (25.3% Yes, 44.4% Surely Yes), anatomical dissections (32.1% Yes, 27.8% Surely Yes), videos/multimedia (29.6% Yes, 24.7% Surely Yes) and anatomical 3D virtual models (23.5% Yes, 53.7% Surely Yes). On the contrary, medical imaging received the lower rating (11.7% Yes, 3.1% Surely Yes, 29.6% No). Figure 1 is a graphical representation of these data that well shows the opposite trend of medical imaging if compared in particular to anatomical physical models and 3D virtual models.

Table 4 shows which tools students would recommend for the preparation of the exam. There was a general agreement on the use of anatomical physical models (21.6% Yes, 53.3% Surely Yes), anatomical dissections (38.9% Surely Yes) and anatomical 3D virtual models (26.5% Yes, 29% Surely Yes). By contrast, videos/multimedia (40.7% No vs only 7.4% Surely Yes) and medical imaging (37% No vs only 9,2% Surely Yes) received both a lower evaluation.

Figure 2 is a graphical representation of these data that well shows, on the one hand, the similar trend of medical imaging and videos/multimedia and, on the other, their opposite trend if compared in particular to anatomical physical models.

To evaluate the impact of our design course on students’ progress, we have compared the results of the eight multiple choice tests on specific topics (the arguments of each test are outlined in detail in Table 5) that have been submitted to the students before (Group old, 200 students, academic years from 2011 to 2014) and after (Group new, 162 students who answered the questionnaire, academic years from 2015 to 2017) the introduction of this new teaching approach (Table 5). Results show that in Group new there has been a significant better performance for those tests centered on gross and regional anatomy of neck, thoracic cavity (test IV) and abdominopelvic cavity (test V) and on neuroanatomy (tests VII and VIII), when compared to the performance of Group old in the same tests.

Figure 3 shows the changed evaluation among the same subjects at the questions related (a) to the use of video/multimedia in preparing the exam and (b) to recommend this resource for the study of anatomy.

Discussion

Vialba Medical School is characterized by a multidisciplinary and integrated approach to teaching. This effort starts at the very beginning from the preclinical courses, and in particular from the Anatomy course.

In the last years, even if the original percentage of hours devoted to laboratory (exercitations on physical models, dissections) and to lectures has remained constant, the general organization of our course of Anatomy has been supplemented with alternative teaching approaches, in order to get students more closely involved and to stimulate student's learning without overwhelming them.

In this study, we have focused on students' approaches and problems during the anatomy course.

The questionnaire we prepared to assess student's perception on human Anatomy learning showed that, when considering the "anatomy appeal" (*I have enjoyed Anatomy Course*: Tables 1 and 4), the Course received a good appreciation from the students, with the higher percentage in Groups M, S and B. The students' approach to the study of anatomy showed that "relations among organs" and "morphology of organs" represented a key point during exam preparation (Tables 2 and 5).

On the contrary, "anatomical variations of organs" received a low score from the majority of students. This data, apparently negative and contradictory, needs to be interpreted. It must be underlined that this result refers to a very specific question: "*in preparing the exam, I gave importance to the anatomical variations of the organs*". It is somehow comprehensible that students approaching to the study of Anatomy aim to learn the "normal" human morphology (i.e., the more frequent), on which they will base their future medical knowledge. Conversely, this doesn't mean that students skip over the concept of individual variability of shape and vascularization of the organs (a critical issue in the formation of medical students). In fact, this subject is already included in the multiple choice tests. According to our experience, what's really important in this contest is to instill in the medical students the concept (i.e., a reasoned approach) of anatomical variability (with a description of the more common examples, i.e., the anatomical variations in the position of the appendix) and not a rote and boring learning of names and structures.

Then, in the clinical years of the medical curriculum this concept will need to be retained and strengthened, since the anatomical variability plays an essential role in clinical activity (Sañudo 2003; Yammine and Violato 2015), markedly influencing medical choices and, above all, surgical practice (Marcos 2000).

Concerning the tools for learning Anatomy, physical models, dissections, video and multimedia resources and anatomical 3D models, received a good appreciation (Tables 3, and 4).

Videos and multimedia resources deserve a careful discussion. These tools have been used during the preparation of the anatomy exam by the majority of students (Table 3). On the contrary, they received a negative score from the majority of students when considering the item "*which tools should be recommended for the study of anatomy*" (Table 4). This trend is also illustrated in Figure 1.

Nowadays, an impressive number of videos and other educational sources is available on the internet and students can easily access them (Boulos 2006; Lee 2016). In the same way, many educational websites, computer software and apps for mobile devices (smartphones, tablets, etc.) that use 3D virtual models to explain anatomy have been developed and can be bought at low prices or even for free (Lewis 2014; BinDhim and Trevena 2015). Digital atlas and 3D anatomical models (web-based or computer-based models) allow the user to rotate and manipulate structures from various views to identify anatomical structures (Tworek 2013; Pujol 2016). Many studies have investigated the role and the impact of three-dimensional models on understanding of anatomy structure and relationship among organs, but the results are often inconclusive, because of differences in course structure and organization and also in research quality (Azer and Azer 2016; Peterson and Mlynarczyk 2016). One of the main criticisms of these tools is that they do not encourage critical thinking but they expose students to a passive learning, where the information flow one-sidedly. Moreover, they encourage rote memorization of names and structures so reducing both students' interest in the content and the learning process (Huk 2006; Hopkins 2011; Luursema 2017).

Also, the 3D virtual models currently available are often inaccurate in representing relationships among organs, especially when considering abdominal structures. At this regard, it is no coincidence that, in our experience, most of the students have found useful these packages for the study of musculoskeletal system (Codd and Choudhury 2011; Battulga 2012).

Another critical point concerns medical imaging. Medical imaging, such as Computed Tomography (CT), Magnet Resonance Imaging (MRI) and Ultrasound (US), provide highly detailed two-dimensional images, so giving a better comprehension of the morphology of anatomical structures and their spatial relationship (Gunderman and Wilson 2005; Grignon 2016). Many Authors have enthusiastically proposed the integration of radiological imaging techniques into the anatomical curriculum (Rengier. 2009; Phillips. 2013; Murphy 2015).

When considering our results, radiological imaging had a lower score (Tables 3 and 4).

These data can be puzzling, especially if we consider that doctors interface with human anatomy mainly through radiological imaging, an everyday tool in clinical practice (Orsbon 2014; Torres 2016). How can we interpret this data?

In our experience, students were positive about integrating radiology into anatomy teaching. Nevertheless, students prefer traditional methods

like dissections and artificial models (both physical and virtual ones). These data are not contradictory. Undoubtedly, medical imaging inserted in the course of anatomy could lead to stimulate and support the understanding of gross anatomy by teaching the anatomy from two perspectives and by reinforcing the clinical relevance of anatomy, but it is, at least in part, an inadequate tool for the self-study (Chapman 2013; Choi-Lundberg 2016).

Medical image interpretation requires an overall vision of the human anatomy to become adept and accurate in interpreting radiographic images. Preclinical students are still in learning knowledge phase and they have not yet acquired the appropriate competences to understand the role of these specialties and the dynamics they are based on (Oancea 2007; Moloney 2017).

Moreover, the (critical) process of 3D reconstruction from a sequence of two-dimensional medical images requires a thorough understanding of both traditional gross anatomy and cross-sectional anatomy and it could undergo to the likelihood of failure to correctly interpret radiological images (Peterson 1999). Nevertheless, some Authors have shown that a Web-based cross-sectional learning tool (3D-X), when presented in addition to gross anatomy prosection, can improve students' ability to identify anatomical structures in CT images, as well as improving anatomical knowledge of the abdomen (Dorosh 2013).

In this context, we have started a pilot study with a selected group of second-year medical students, who passed the Anatomy exam. Students attended a four-hour course, where they learned how to create 3D visceral organ reconstruction alongside various CT cross-sectional slices of the neck, thorax and abdomen to describe patient specific anatomy. During this pilot study, the students: 1) apply their basic anatomy knowledge to identify anatomical structures in the radiological image; 2) learn to use open-source software for imaging elaboration (e.g. 3D slicer) and for the post-processing of virtual models (e.g. meshlab, meshmixer). Lastly, 3D scenes will be loaded on head-mounted displays (i.e., Samsung VR Gear and Samsung Galaxy 8 smartphone). About this, we are developing a prototype for an app that will be available on head-mounted displays Samsung VR Gear. As a next step, students will be introduced to use a 3D printer (Delta Wasp 20 40, capable of 250-300 mm/s), so as to have a complete vision of the whole process of 3D reconstruction and print from the beginning (interpretation of CT scans) to the final product. This protocol is a work in progress and actually we have implemented a small virtual anatomic laboratory class with 4 positions, each with Samsung VR Gear and Samsung Galaxy 8 smartphone.

In our opinion, this approach, by creating a 3D realistic scenario from radiological imaging datasets, might improve anatomical knowledge and understanding of medical imaging. Moreover, it might inspire or engage the medical students actively in learning anatomical studies, by introducing and strengthening the concept of patient specific anatomy, i.e. anatomic variability. Finally, it might, at least in part, obviate the absence of a human cadavers dissection lab.

Lastly, to evaluate the impact of our design course and to attempt to identify measurable outcomes, rather than merely describing what we do in our institution, we have compared the results of the eight multiple choice tests submitted to two groups of students who followed the course of anatomy before (Group old) and after (Group new) the introduction of the new teaching approach (Table 5). Each multiple choice test was based on the same topics (see Table 5 for the explanation). We have noted a significant better performance of the students about the tests centered on gross and regional anatomy of neck, thoracic and abdominopelvic cavity (second module/second semester of the first academic year) and on neuroanatomy (third module/first semester of the second academic year). This is particularly intriguing, because the study of these topics requires a more critical approach, if compared to the study of muscular-skeletal system, which involves a more mnemonic approach. As previously stated, our dissection program is carried out in the second module. In our opinion, the better performance assessed in the Group new might reflect the fact that the direct switch from theory (lectures) to practice (dissection and also clinical reports on selected topics, videos) can both enable students to better understand the relevance of underlying scientific knowledge and represent a stimulus for learning. The same applies to neuroanatomy. The anatomical-functional approach to central nervous pathways and to the anatomic basis of the reflexes can enable students to reach their learning objectives in a more engaging context and not only to increase *per se* anatomical knowledge. Moreover, this approach might open the way to a linear continuum between structure, function and, for the future, clinical practice.

Conclusion

The rationale of our new design course, that includes also co-operation with other specialties (i.e., surgery and radiology), is that students go through a teacher-centered learning (i.e., lecture classes, exercitations with physical models) to an interactive and clinically relevant role (i.e., dissections, discussion about video presentation, elaboration of reports on selected topics). In the transition from volume-based to value-based teaching model, this approach could increase the collaboration among students, improve student's knowledge and performance in learning anatomy. The active involvement of the students could also encourage critical thinking as well as increase the effectiveness of their oral presentations, which is important during their clinical years and during practice.

Our study raises a few points: 1) the positive impact of integration of traditional methods and innovative solutions and activities on student's curriculum, also considering the breadth of topics covered in an anatomy course; 2) the need to improve the approach to radiologic imaging in the course of anatomy; 3) the need to emphasize the concept of patient specific anatomy, i.e., anatomical variability.

At this regard, our pilot 3D project, by creating an integrated framework, might reinforce the comprehension of radiologic imaging and the

concept of individual organ variability in preclinical students.

Tables

Table 1. Questionnaire on Anatomy Learning Evaluation submitted to Preclinical Students

STEP 1	
Rate your level of agreement with the following statements (answers are graded as follows: 1=Not at all; 2= No; 3= May be; 4= Yes; 5= Surely yes)	
1)	I Like anatomy
2)	I have enjoyed Anatomy Course
3)	In preparing the exam, I gave importance to the morphology of organs (shape, dimensions, weight, etc)
4)	In preparing the exam, I gave importance to the relations among organs
5)	In preparing the exam, I gave importance to the anatomical variations of the organs
STEP 2	
In preparing the exam, I used the following tools (answers are graded as follows: I didn't use this tool; from 1 to 5, 1-totally useless to 5-very useful)	
a.	Anatomical physical models
b.	Medical imaging (RX, TC, MRI scan)
c.	Anatomical dissections
d.	Videos and other multimedia resources
e.	Anatomical 3D virtual models
STEP 3	
I think the following tools should be recommended for the study of anatomy (answers are graded as follows: from 1 to 5, 1-least important to 5- very useful)	
a.	Anatomical physical models
b.	Medical imaging (RX, TC, MRI scan)
c.	Anatomical dissections
d.	Videos and other multimedia resources
e.	Anatomical 3D virtual models

Table 2: Description of Anatomy “appeal” and of the student’s approach to the study of anatomy. Values reported are number of subjects (%). Chi-Square Test analysis was statistically significant (p<.001) for each frequency related to each ordinal variable. Bolded values represent the higher scores for each group according to the different items.

	mean ± SD (median)*	Not at all	No	May be	Yes	Surely Yes
I like Anatomy	3.8 ± .72 (4)	-	-	59 (36.4%)	74 (45.7%)	29 (17.9%)
I have enjoyed Anatomy Course	3.5 ± .86 (4)	1 (0.6%)	18 (11.1%)	55 (34%)	69 (42.6%)	19 (11.7%)
Exam: Morphology of Organs	3.8 ± .99 (4)	3 (1.9%)	15 (9.3%)	35 (21.6%)	67 (41.4%)	42 (25.9%)
Exam: Relations among Organs	4.4 ± .73 (5)	-	3 (1.9%)	14 (8.6%)	57 (35.2%)	88 (54.3%)
Exam: Anatomical Variations of Organs	2.5 ± 1.1 (2)	29 (17.9%)	56 (34.6%)	49 (30.2%)	19 (11.7%)	9 (5.6%)

* this column represents the mean ± SD of the answers of the students for each item; median value is also reported in parentheses.

Table 3: Exam Preparation and Tools. Values reported are number of subjects (%). Chi-Square Test analysis was statistically significant ($p < .001$) for each frequency related to each ordinal variable. Bolded values represent the higher scores for each group according to the different items.

	mean \pm SD (median)*	0	1	2	3	4	5
Anatomical Physical Models	4 \pm 1.1 (4)	5 (3,1%)	2 (1,2%)	9 (5,6%)	33 (20,4%)	41 (25,3%)	72 (44,4%)
Medical Imaging (Rx, CT/MRI scan)	2.6 \pm 1.1 (2)	49 (30,2%)	11 (6,8%)	48 (29,6%)	30 (18,5%)	19 (11,7%)	5 (3,1%)
Anatomical Dissections	4.1 \pm .93 (4)	40 (24,7%)	1 (0,6%)	2 (1,2%)	22 (13,6%)	52 (32,1%)	45 (27,8%)
Videos and Multimedia Resources	3.8 \pm .99 (4)	25 (15,4%)	-	11 (6,8%)	38 (23,5%)	48 (29,6%)	40 (24,7%)
Anatomical 3D Virtual Models	4.4 \pm .99 (5)	17 (10,5%)	2 (1,2%)	2 (1,2%)	16 (9,9%)	38 (23,5%)	87 (53,7%)

* this column represents the mean \pm SD of the answers of the students for each item; median value is also reported in parentheses; subjects who didn't use the considered tools (column numbered as 0) have been excluded

0: I didn't use this tool; from 1 to 5: totally useless 1 to very useful 5

Table 4: Study of Anatomy and Recommended Tools. Values reported are number of subjects (%). Chi-Square Test analysis was statistically significant ($p < .001$) for each frequency related to each ordinal variable. Bolded values represent the higher scores for each group of answers according to the different items.

	mean \pm SD (median)*	1	2	3	4	5
Anatomical Physical Models	3.5 \pm 1.4 (4)	15 (9,3%)	32 (19,8%)	27 (16,7%)	35 (21,6%)	53 (32,7%)
Videos and Multimedia	2.3 \pm 1.3 (2)	66 (40,7%)	35 (21,6%)	26 (16%)	23 (14,2%)	12 (7,4%)
Anatomical Dissections	3.6 \pm (4)	16 (9,9%)	10 (6,2%)	50 (30,9%)	22 (13,6%)	63 (38,9%)
Medical Imaging (Rx, CT/MRI scan)	2.4 \pm 1.1 (2)	60 (37%)	39 (24,1%)	28 (17,3%)	20 (12,4%)	15 (9,2%)
Anatomical 3D Virtual Models	3.7 \pm 1.3 (4)	6 (3,7%)	21 (13%)	45 (27,8%)	43 (26,5%)	47 (29%)

From 1 to 5: least important 1 to very useful 5

*this column represents the mean \pm SD of the answers of the students for each item; median value is also reported in parentheses.

Table 5. New: new design course; Old: previous design course. Pos: students with positive overall score; Neg: students with negative overall score. Values are reported as percentage of students. Chi-Square Test analysis was used; statistical significance was established at the $p < .05$ level.

		New	Old	Differences	p
I test	Positive	95.1	88	7.1	<.05
	Negative	4.9	12		
II test	Positive	61.8	59	2.8	NS
	Negative	38.2	41		
III test	Positive	69.4	72.5	3.1	NS
	Negative	30.6	27.5		
IV test	Positive	77.8	60.5	17.3	<.001
	Negative	32.2	39.5		
V test	Positive	90.7	83	7.7	<.05
	Negative	9.3	17		
VI test	Positive	94.4	88	6.4	NS
	Negative	5.6	12		
VII test	Positive	93.2	84	9.2	<.05
	Negative	6.8	16		
VIII test	Positive	96.3	84	12.3	<.001
	Negative	3.7	16		

I test: terminology (i.e., regions, positions, planes of the body, surface anatomy);

II test: skeletal system and joints; embryology (first and second week);

III test: muscular system; embryology (somites development);

IV test: respiratory system, digestive system (including liver, pancreas and major salivary glands); thymus; regional anatomy of oral and nasal cavities, of the neck and of thoracic cavity; embryology of the corresponding organs and cavities;

V test: male and female reproductive systems; renal system; spleen; regional anatomy of the abdominopelvic cavity; peritoneum; embryology of the corresponding organs and cavities;

VI test: cardiovascular and lymphatic systems; embryology of the heart and main vessels, assessment and recording of arterial pulses;

VII test: central nervous system: embryology of the nervous system;

VIII test: peripheral nervous system and sensory organs.

Figure Legend

Figure 1: The Bar Graph shows the percentage related to the Step 2 of the questionnaire, i.e., exam preparation and tools. From 1 to 5: totally useless 1 to very useful 5.

Figure 2: The Bar Graph shows the percentage related to the Step 3 of the questionnaire, i.e., which tools should be recommended for the study of anatomy. From 1 to 5: least important 1 to very useful 5.

Figure 3: The Bar Graph shows the changed evaluation among the same subjects at the questions related (a) to the use of video/multimedia in preparing the exam and (b) to recommend this resource for the study of anatomy. Changing neg: subjects in whom (a) has a higher score than (b); Changing pos: subjects in whom (b) has a higher score than (a); No change: same score.

Figures

Figure 1

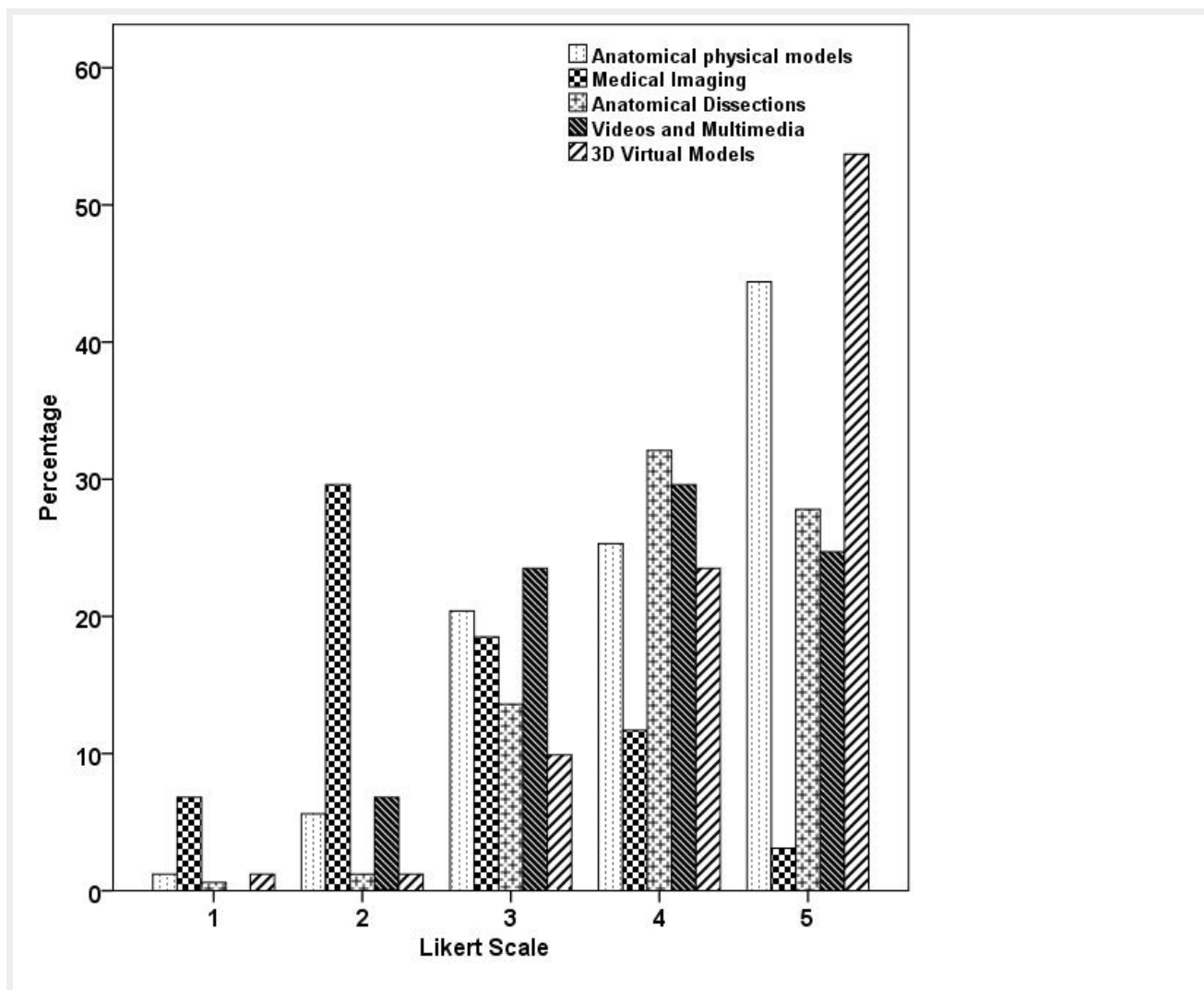


Figure 2

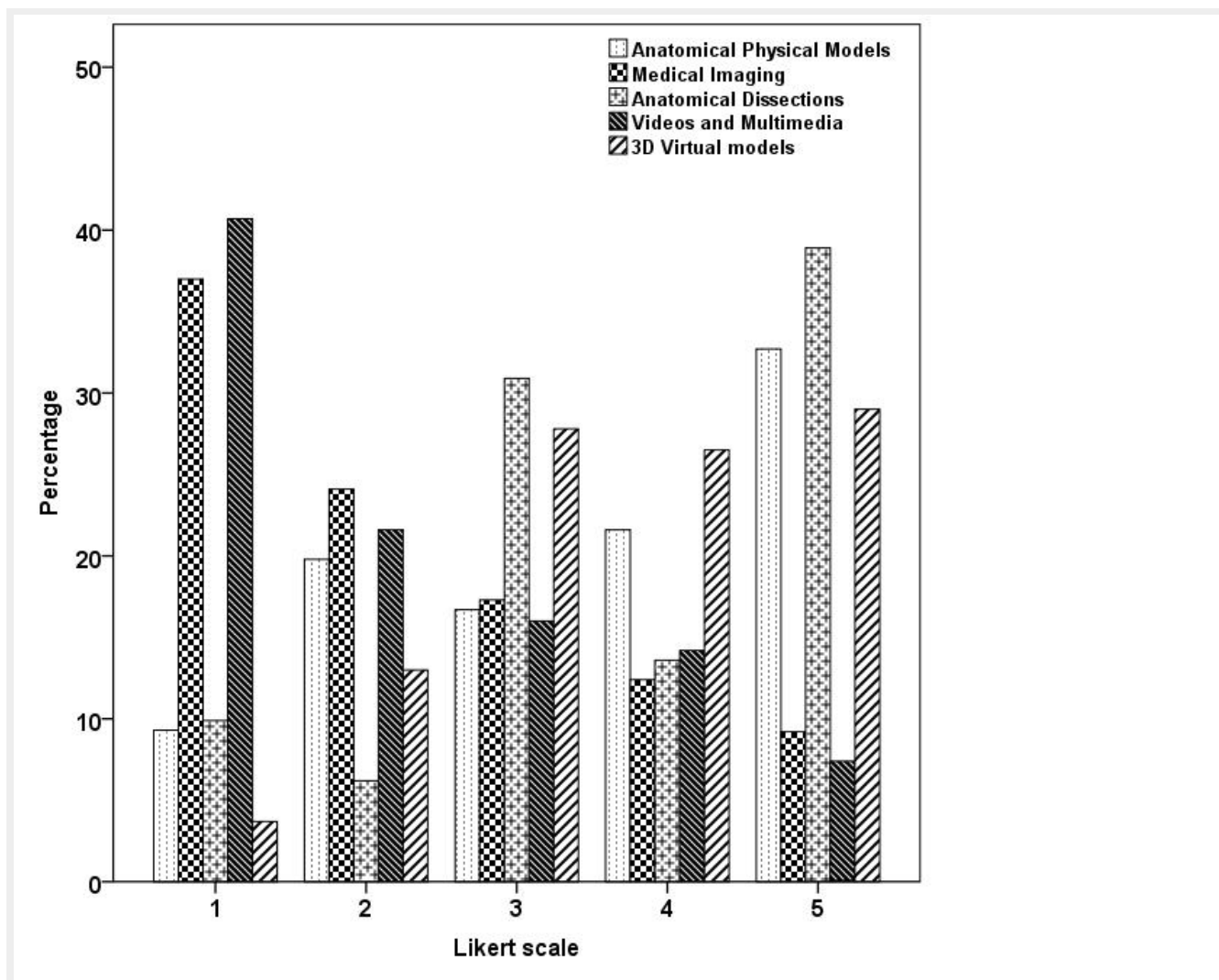
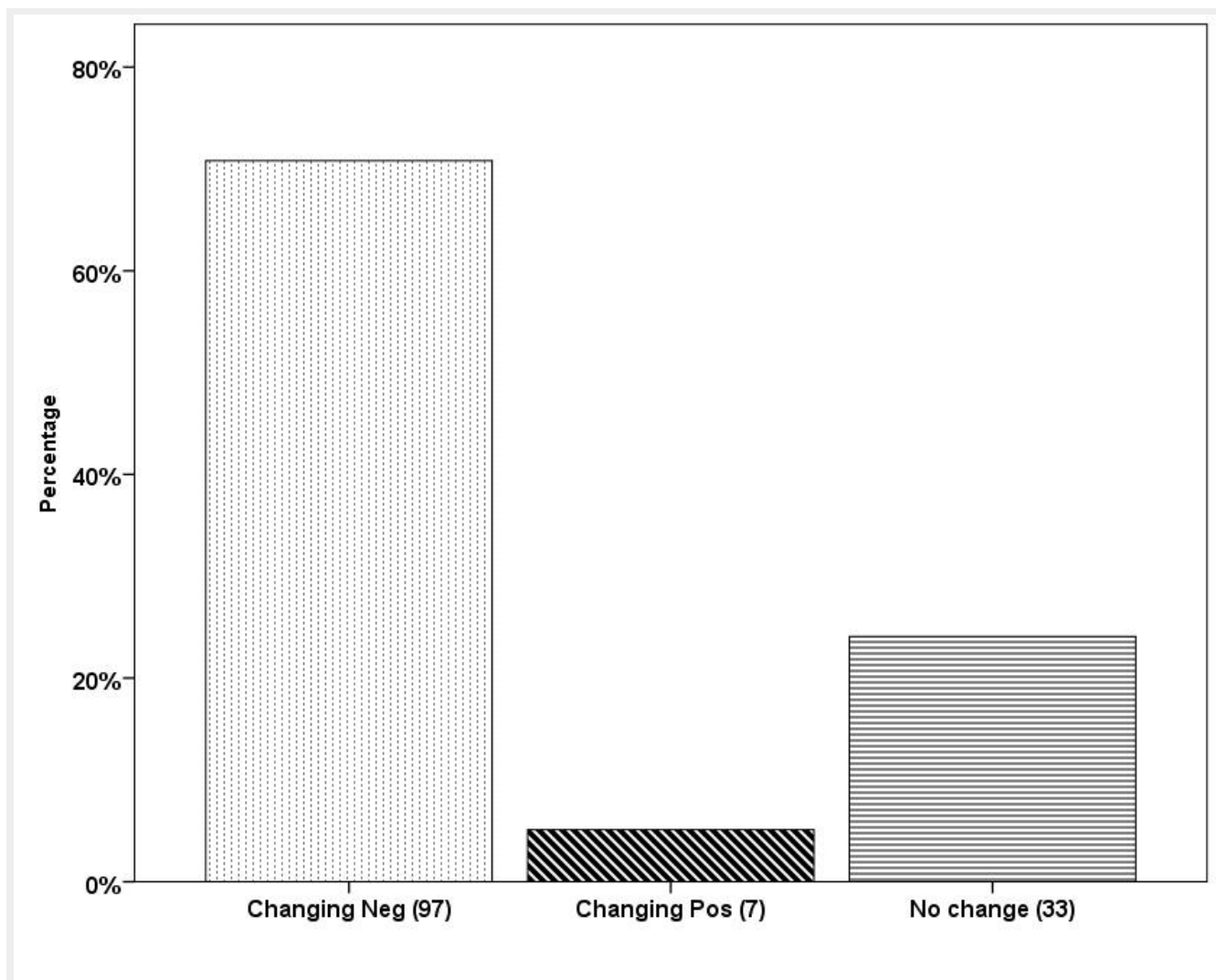


Figure 3



Take Home Messages

The rationale of our new design course is that students go through a teacher-centered learning (i.e., lecture classes, exercises with physical models) to an interactive and clinically relevant role (i.e., dissections, discussion about video presentation, elaboration of reports on selected topics).

Our study raises a few points:

- 1) the positive impact of integration of traditional methods and innovative solutions and activities on student's curriculum, also considering the breadth of topics covered in an anatomy course;
- 2) the need to improve the approach to radiologic imaging in the course of anatomy;
- 3) the need to emphasize the concept of patient specific anatomy, i.e., anatomical variability.

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Appendices

Declaration of Interest

The author has declared that there are no conflicts of interest.