



# A new model in medicine education: smart model education set

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## Abstract

**Purpose** Education set consisting of three-dimensional smart interactive models with audio, visual, and light features and an application program that allows learning branches of science such as anatomy and histology at the same time can bring innovation to medicine and health education. Our study aims to show contributions of this education set, which we have patented, to student academic success and medical education.

**Methods** The students participating in study consisted of three groups. Students were divided into Group 1 (classical education), Group 2 (smart model education set and theoretical expression), and Group 3 (smart model education set). Pre-test, post-test, and state anxiety scale applications were made to all groups before and after education. Trait anxiety scale was administered before education. Education set used in study includes hardware and software parts.

**Results** Post-education state anxiety scale in Group 1 mean was significantly higher than Group 2 and 3 mean; Group 2 mean was significantly higher than Group 3 mean. There was no significant difference between groups regarding trait anxiety levels. It was observed that there was a significant difference between the pre-test and post-test in all three groups. The increase in post-test achievement level of Group 2 and 3 was significantly higher than Group 1.

**Conclusions** Smart model education set integrates basic and clinical information. Mobile application will ensure continuity of theoretical and practical education at desired place and time. Invention will bring a new breath to basic medical education by preventing inequalities in medical and health sciences education.

**Keywords** Anatomy · Medical education · Histology · Smart model · Mobile learning · Patent

## Introduction

The main purpose of medical education is to educate physicians who protect and improve the health of the individual and society. Medical education includes pre-graduate, post-graduate, and continuing medical education periods [2]. The foundation of life-long medical education is laid in the pre-graduation period. The education given in this period should be determined meticulously and have attainable, measurable goals and objectives. To educate physicians under these conditions; it is recommended to ensure coordination between

medical education and health services, determine the content of education according to national requirements, integrate basic and clinical practices, and continuous medical education. The increase in the number of medical faculties and physicians reveals the importance of training qualified physicians [3].

The medical profession, which is in continuous development, necessitates changing the education system. This need in medical faculties is felt more especially in basic medical sciences [25]. Innovative education systems such as integrated education and problem-based learning are learner-centered methods that aim to integrate basic sciences and clinical sciences [14]. Developing new methods that integrate basic and clinical information by reconciling anatomy knowledge with clinical problems can be given as an example of innovative applications [30].

Anatomy education, one of the most important components of basic medical sciences, is included in the preclinical curriculum in medical faculties. One of the most important reasons for this is the low number of cadaveric donations

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[5]. Therefore, there is a need for new methods to support anatomy education. Today's techniques used as an alternative to cadaver-based education are technology and computer-assisted learning with three-dimensional models [32]. In addition, the use of many macroscopic anatomy mobile applications prepared for students and health professionals studying in health is becoming increasingly common [10].

One of the important building blocks of undergraduate medical education is histology education. In traditional histology education, light microscopy and laboratory courses accompanied by a faculty member are important. Today, in parallel with the developing technology, histology education materials have also changed, and traditional laboratory education has been revised. While previously, systems where images were transferred to computer monitors were used with digital cameras connected to microscopes; later, histology slides were scanned and converted into digital images and started to be used [9].

An education set consisting of smart interactive models and a software program that enables the learning of branches of science such as anatomy and histology with a multidisciplinary approach at the same time can bring innovation to medical education. Our study aims to show the contributions of the invention of the education set that we have patented [28] to the students' academic success and medical education.

## Materials and methods

The study was conducted by obtaining the ethics committee document dated 22.11.2021 and numbered 1598 from Siirt University Ethics Committee.

### Learning environment

The students participating in the study consisted of three groups. The gastric anatomy and histology course were completed in 2 h (one hour of theoretical, one hour of practical). Group 1 and Group 2, who participated in the research, attended one hour of theoretical lecture in the classroom. Group 3 followed the theoretical lesson through the mobile application. The institution's standard curriculum or didactic content for mobile learning was similar in both education methods. Group 1 was given the anatomy and histology book for theoretical lesson and the anatomy and histology atlas for the applied lesson [11, 33]. In addition, classical model and light microscope applications were shown to Group 1.

### Collection of data

Before starting the education, students were given a student introduction form and a knowledge exam (pre-test)

and asked to answer them. After answering, the students were divided into groups. All three groups were asked to fill out the State-Trait Anxiety Inventory (STAI). Group 3 was transferred to another class. They were told how to use the smart model and mobile application, and they were given two hours to study. Group 1 and Group 2 were given theoretical education at the same time. Group 1 was then taken to another classroom to study classical models, the light microscope, and textbooks for an hour together. After explaining the smart model and mobile application, group 2 was given one hour to work with the smart model education set. Afterward, the post-test and state anxiety scale was distributed to all groups, and they were asked to answer.

### Study participants

The research is a randomized controlled study and was conducted with nursing students who took anatomy and histology courses in the fall semester of 2021. Power analysis was performed using a statistical power analysis software, G\*Power, version 3.1.9.7 (Heinrich Heine University, Düsseldorf, Germany) to establish the research sample and determine the required number of students. The number of students in each group was determined as 45 to carry out a study at the  $p \leq 0.1$  level.

### Design of study and randomization

The study was devised as a randomized controlled trial. During the randomization of the research, using the website, students were divided into Group 1 (classical education group,  $n=46$ ), Group 2 (smart model education set and theoretical expression group,  $n=47$ ), and Group 3 (smart model education set group,  $n=45$ ) (Fig. 1).

### Data collection tools

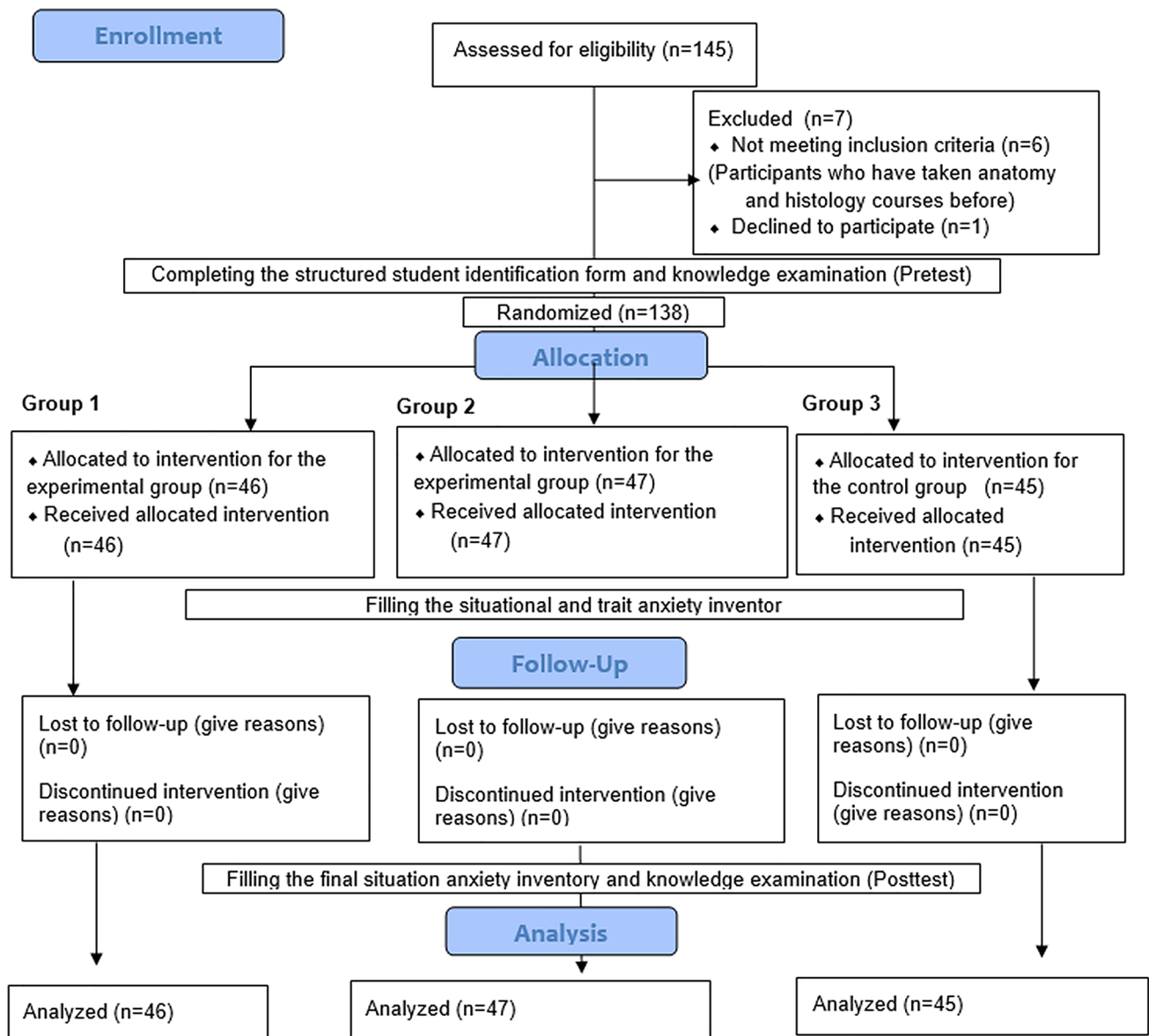
Data collection was made using the student introduction form, knowledge exam on gastric anatomy and histology, and STAI.

### Student introduction form

This form consists of data including socio-demographic characteristics of participants such as gender and age. The student introduction form consists of a total of five questions.

### State-trait anxiety inventory

The State-Trait Anxiety Inventory (STAI) was improved by Spielberger et al. [26]. It has two subscales measuring different types of anxiety: state anxiety (STAI-S subscale) and trait anxiety (STAI-T subscale) [21]. Each subscale is graded



**Fig. 1** Sample of the study flow chart based on CONSORT 2010 flow diagram

on a four-point Likert-type scale and comprise of 20 items. The response options in the four classes of the State Anxiety Inventory (STAI-S) are: (1) None, (2) A few, (3) A lot, and (4) Completely. The Trait Anxiety Inventory (STAI-T) has the following options: (1) Almost never, (2) Sometimes, (3) Often, and (4) Almost always. Scores from both subscales theoretically vary between 20 and 80 points. High scores demonstrate high anxiety levels. Low scores indicate low anxiety levels.

### Knowledge exam on gastric anatomy and histology

Gastric anatomy and histology questions were prepared according to the literature and consisted of 20

multiple-choice questions. Each question score was calculated as 0.5 points. The highest score that can be taken from the exam was identified as 10 points, and the lowest score was 0 points. Exams were given to all groups in the same format. The pre-test and post-test exams included the same questions. An equal number of questions were asked about stomach anatomy and histology.

### Development of the model

The education set, which consists of smart interactive models and software programs, consists of two main parts, including hardware and software parts. The hardware part consists of touch sensors that show models of organs or

tissues on a three-dimensional smart model with light and sound explanations. The software part was developed to reach detailed, up-to-date information about tissues or organs that represent the smart model. This information can be accessed by scanning the QR code on the model via any smart device in the presence of the internet.

## Hardware part

Both the outer surface and one half of the inner surface of the smart model, which is attached to each other with a hinge and can be opened and closed in twofold, have the appearance that reflects the macroscopic (anatomical) feature of the relevant organ or tissue. The other half of the inner surface of the same model has an appearance that reflects the microscopic (histological) feature of the relevant organ or tissue. The histological surface will be placed on the model by enlarging the microscopic image of the section of the tissue or organ it belongs to. There are touch sensors on the places corresponding to each formation on the smart model, and when these are pressed, audible information about that formation is given. Since the borders of the pressed area are shown on the model with light, the student can better understand which area they are working on (Fig. 2). In addition, when the name of any of the formations is spoken, this spoken word is detected by the microphone embedded in the system, and audio information about it is given through the built-in speaker. Thus, both macroscopic and microscopic visual education is integrated with theoretical information on the same model, and interactive education is provided.



Fig. 2 Patent hardware part

## Software part

### Mobile application

Multimedia (multimedia) used in the teaching–learning process is educational designs that enable learners to become active by integrating video, animation, visual, diagram, sound, etc., types through information Technologies. The use of both verbal and visual features in instructional materials enables the two parts of memory to work together, making learning easier. Technology and multimedia products support students' learning and individual work. In order for these products to be successful, they must be developed with certain principles. “Mayer’s Multimedia Design Principles” were taken into consideration in the mobile application developed in this context [17] (Table 1).

The Anatomitas mobile application was improved using a Web 2.0 tool called mobiroller. The android package kit (APK) of the developed mobile application named “anatomitas.apk” was uploaded on two experimental group phones.

The developed Mobile Application consists of 8 sections. These sections are; lecture notes, lecture videos, pill information, screening test, notepad, favorites, contact, and about us.

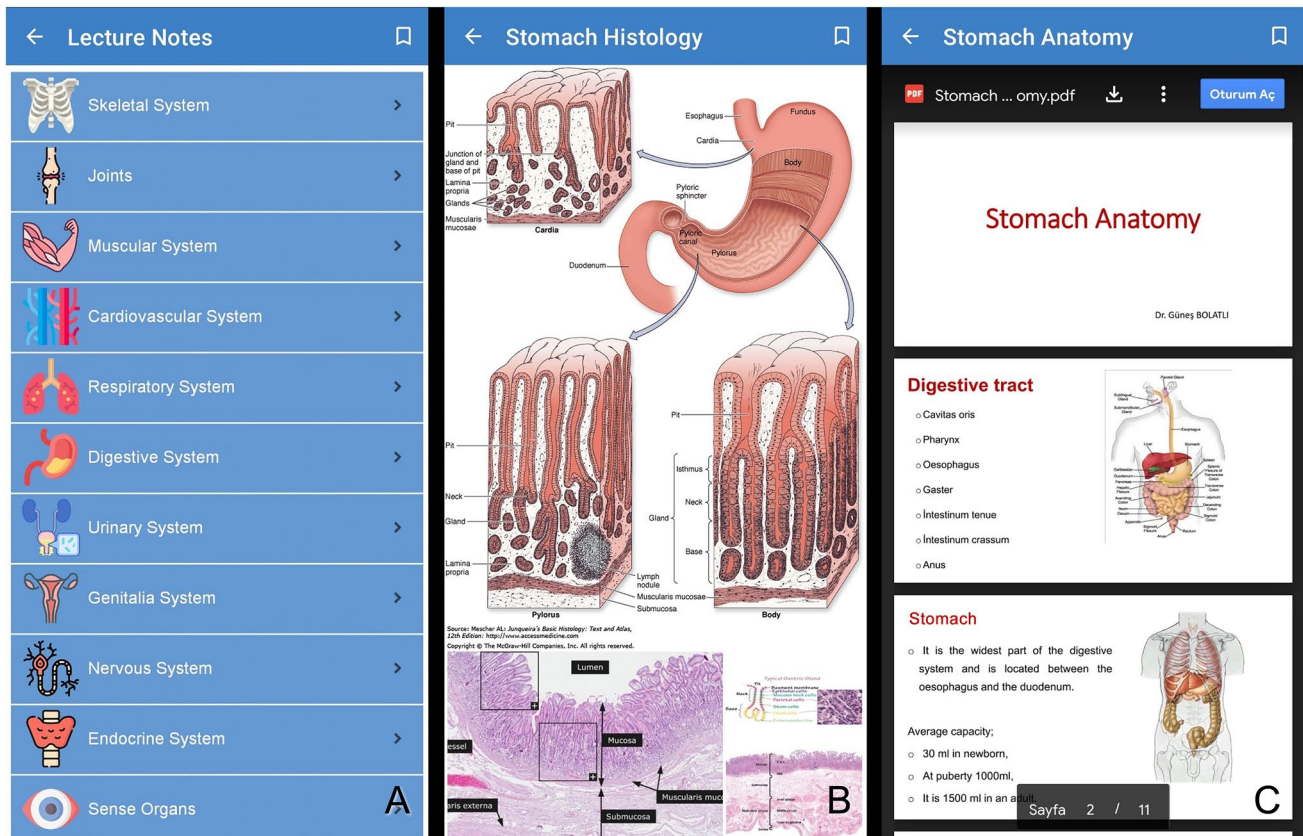
Lecture notes, videos, pill information, and screening test was divided into 11 systems (Fig. 3a). For the research, only the stomach structure of the digestive system was developed in the mobile application. Users were able to access the theoretical documents on stomach offline whenever they wanted (Fig. 3b). The videos were uploaded to the Youtube channel, and the students were able to watch the Youtube videos embedded in the mobile application (Fig. 3c). Other parts of the application consist of the note-taking section where they write the notes they want, the favorite section where they can save the pages they want, and the contact sections where they can contact the mobile application developer.

### QR code

There is a QR code system on the smart model that can be integrated with devices such as smartphones and tablets. Through this integration, when the person reads the QR

Table 1 Mayer’s principles for multimedia learning

Principles of reduction of irrelevant	Principles of managing basic processes	Producer process development principles
Consistency	Dividing into pieces	Multimedia
Attention	Preliminary exercise	Personification
Needlessness	Format	Sound
Spatial proximity		Picture
Temporal proximity		



**Fig. 3** a Lecture notes mobile page. b Stomach histology mobile page. c Stomach anatomy mobile page

code with his smart device, he can easily access all documents, videos, and relevant organ or tissue simulations. This system also allows up-to-date information to be added to the system at any time, thanks to its ability to be updated. The microprocessor card in the model hardware can also be updated when necessary with Wifi and USB input, as in the software. The model can be controlled via the application and can receive simultaneous commands.

### Statistical analysis

State and trait anxiety scales and the compatibility of the achievement levels before and after the education were examined with the Kolmogorov Smirnov test. It was seen that the data were in accordance with the normal distribution. Significant difference of data between groups was analyzed with one-way analysis of variance, and variation for the group was analyzed with *t*-test in dependent groups. Cohens' *d* statistics were calculated to determine the effect size. Analyzes were performed with SPSS 20.0 software at 95% confidence level.

### Results

One hundred thirty-eight students who took anatomy and histology courses in the 2021–2022 academic year participated in the study. The demographic characteristics of the participants were inspected. The mean age of the participants in the research was  $19 \pm 0.96$ . 81 (58.7%) of the participating students were female, and 57 (41.3%) were male.

### Quantitative results

All of the participants (100%) in the research demonstrated that the most used information tools are smartphones. One hundred twelve students (81.1%) thought that classical models and microscopes were insufficient to understand the subject. One hundred twenty-two of the students (88.4%) stated that they thought the mobile application would contribute to anatomy and histology education.

When the state anxiety scale average change according to the groups is examined, there was no significant

difference between the groups before the education ( $p > 0.05$ ), and there was a significant difference between the groups after the education ( $p < 0.05$ ). In the post-educational state anxiety scale, Group 1 mean was significantly higher than Group 2 and Group 3 mean, and Group 2 mean was significantly higher than Group 3 mean (Table 2).

When the trait anxiety scale average change according to the groups is examined, no significant difference was observed ( $p > 0.05$ ). In other words, trait anxiety levels of Group 1, Group 2, and Group 3 were at the same level.

When the variation of the achievement test within and between groups was examined, it was seen that there was a significant difference between the pre-test and post-test in all three groups ( $p < 0.05$ ). The post-test success level was significantly higher than the pre-test success level. When the variation of achievement tests between the groups was examined, there was no significant difference in the pre-test between groups, but a significant difference was observed between the groups in the post-test ( $p < 0.05$ ). According to the pairwise comparisons made to determine which group the difference originated from, the increase in the post-test achievement level of Group 2 and Group 3 was significantly higher than Group 1 (Table 3).

## Discussion

It has become inevitable for the developments in the current century to take their place in education. These improvements bring along new applications in the field of education. To improve the quality of medical education; There are different opinions on issues such as the person

giving the training, the use of interactive methods, and the adequacy of theoretical and practical course hours [4, 12]. It is stated that practical course hours should be increased to ensure efficiency in medical education [2, 12, 13]. In our study, the majority of the students (81.1%) understood the course topics and stated that the use of classical models and microscopes was insufficient, which supports this information in the literature.

It is known that students who use distinct learning tools (smartphone, tablet, etc.) increase their creative thinking and learning performance [7]. In addition, the use of technological tools in education is preferred by students because it increases academic success [9, 32]. As a matter of fact, in our study, all of the students reported that they used smartphones in cognitive activities. In addition, most of the students (88.4%) stated that mobile application programs to be installed on their smartphones would contribute to their academic success in anatomy and histology courses.

It is stated that QR Code technology can be used in education in two ways. The first is to be able to access online applications by being directed to the web-based education environment with the help of the QR code, and the second is to reach the desired information without the need for an internet connection. Today, when students want to access information, they both lose time and encounter information overload. However, the use of QR Code applications and educational materials allows the student to reach the desired comprehensive resources quickly [1]. In this context, we think that the QR code feature can bring innovation to the medical and health sciences education system by creating a bridge between smart models and web-based mobile education applications. As a matter of fact, the students participating in the study read the QR code on the education set with

**Table 2** Distribution of state anxiety scale according to groups

	Before training		After training		Cohen's <i>d</i>	<i>p</i> -value
	Mean ( $\pm$ SD)	Range	Mean ( $\pm$ SD)	Range		
Group 1	41.33 (9.72)	23–54	39.33 (8.28)	29–50	0.251	*0.461
Group 2	39.7 (6.80)	30–49	34.7 (9.84)	22–53	0.443	*0.042
Group 3	33.5 (6.65)	24–41	23.5 (1.85)	21–27	0.468	*0.005
<i>p</i> -value	0.12		*0.001			

*SD* standard deviation; \* $p < 0.05$

**Table 3** Comparison of knowledge test scores by groups

	Pre-test score	Range	Post-test score	Range	Cohen's <i>d</i>	<i>p</i> -value
	Mean ( $\pm$ SD)		Mean ( $\pm$ SD)			
Group 1	1.17 (0.56)	0.5–2.0	4.22 (1.33)	2.5–6.5	0.478	*0.00
Group 2	1.0 (0.67)	0.0–2.0	7.5 (1.49)	5.0–9.5	0.556	*0.00
Group 3	1.13 (0.52)	0.5–2.0	6.13 (1.64)	4.0–9.5	0.601	*0.00
<i>p</i>	0.816		*0.00			

*SD* standard deviation; \* $p < 0.05$

their smart devices and easily reached the target information without the need for an extra source.

The rapid developments in mobile device technology have made these devices an integral part of our lives. The ability of these devices to be used like computers and to be able to connect to the internet from anywhere increases their importance [8]. The increase in the number of users of mobile technologies has led to the emergence of concepts such as e-learning and mobile learning [13]. Mobile learning is accessing learning networks via mobile devices and wireless networks and supporting teaching and learning. Since mobile learning provides the opportunity to access information anytime and anywhere, it is also important in terms of providing equality of opportunity in education [6]. Therefore, as in our study, the presentation of smart models together with mobile applications and the high performance of the groups that received this education support this information.

In our study, the fact that the significance of the post-test success of Group 2 and Group 3 was higher than that of Group 1 should be considered in many ways. The first of these may be that the state anxiety scale was lower in these two groups than in Group 1. Because in both groups, there is an 'education set' option that allows students to learn individually as an alternative to the educator. Today, it is known that stress reduces the success of education and training [22]. Therefore, we think that the existence of an alternative and repeatable 'education set' to education will prevent poor performance due to stress factors. Moreover, the fact that the success rates were similar to Group 2 in Group 3, where the state anxiety scale was the lowest, can be explained by the knowledge that minimal stress increases success more [22]. Accordingly, groups with the least stress factor and only smart models and mobile applications can provide similar benefits with combined applications. To make these comments, the groups were also evaluated in terms of the trait anxiety scale, and trait anxiety values of all three groups were observed to be close to each other.

The quality and standards of anatomy education have been discussed for many years. Students stated that learning anatomy is a boring lesson depend on rote learning [19]. They also had difficulty to consider in three dimensions during the training. At the same time, they stated that more emphasis should be placed on visual education [20]. A three-dimensional understanding of the human body is the basic of clinical anatomy, and mastering human anatomy makes it easier for a medical practitioner [27].

Difficulties experienced in anatomy education have led to the need for alternative education tools. The use of cadavers and plastic models in education makes it possible to use technology in this course. In recent years, technology-based education has been applied as an alternative to face-to-face education [29]. We think that the three-dimensional

interactive smart models with touch sensors that we have developed will provide solutions to existing problems. Because with this education set, students will be able to meet their educational needs even without cadavers or educators.

In our study, in both groups (Group 2 and Group 3) in which smart models were used, it was observed that the success increased significantly compared to Group 1. In fact, the fact that the significance in Group 3, where only the smart model was applied, was close to Group 2 suggests that models based on this education set may be an alternative option to face-to-face training in cases such as the COVID-19 pandemic [15]. In addition, the need to continue laboratory education outside the faculty will also be met with this education set. In this way, students have the opportunity to continue their education without interruption and continuously. On the other hand, it is known that mobile learning is more beneficial when combined with face-to-face learning [16] and increases the motivation of learners [16] and academic achievement [31]. Although significant improvements were detected in the post-tests of all groups participating in the study, the highest performance was observed in Group 2. Therefore, it can be said that the education set we used in the study is more beneficial when used not alone but integrated with face-to-face learning.

Students often describe histology courses as difficult to understand and abstract subjects. The main reason for this is that theoretical courses and practical applications cannot be given with a holistic approach [23]. The smart model education set we used in our study allowed the students to observe the tissue or organ they examined both macroscopically and microscopically. This gave the students holistic thinking skills and prevented the lesson from remaining abstract. In addition, by pressing the touch sensors on the model, the students could learn all the formations on the structure they were working on without the need for any other source. Thus, the student could simultaneously evaluate the tissue or organ he was working on, both auditory and visually. The study results in the histology section are similar to the results in the anatomy section, which makes this education set more important.

The current coronavirus (COVID-19) epidemic has negatively affected the education system as well as human health and forced people to apply alternative education models [15]. It is important to find alternatives to support this education, especially in faculties where laboratory education is important, such as medicine and health sciences. Education with multimedia ensures that information stays in memory for a longer time than traditional education [24]. It is also known that interactive environments increase success in medical education [18]. In this context, the invention can guide solving the problems experienced in medicine and health education, both with its technological content and increasing the level of success.

## Limitations

This study was conducted on 138 students studying at Siirt University, Faculty of Health Sciences, Department of Nursing. Therefore, the study's originality can be further improved by increasing the number of students participating in the study. Secondly, new studies can be planned by ensuring the participation of students from different fields such as medicine, veterinary medicine, and dentistry within the student population participating in the study. Thirdly, the study was carried out on smart stomach models and by preparing basic medicine courses (anatomy, histology). Similar studies can be done on different tissues and organs in future studies by adding other basic and clinical lessons. Uploading three-dimensional simulative images of the relevant tissue or organ to the mobile application for new studies can make the education set even more efficient.

## Conclusion

It can be said that a smart model education set provides advantages such as integration of basic and clinical information, learning the lessons holistically and in a short time under a single educational material, and making macroscopic and microscopic approaches together. In addition to these, it is possible with this education set to give lessons outside the laboratory without any educator or extra resources. Each department will be able to convey the minimum knowledge it wants to give to the students during the education period through this education set. Perhaps the most important feature of the education set is bringing of together basic medical courses such as anatomy and histology with technology and can meet the expectations of today's students. As a result, we think that the invention will bring a new breath to basic medical education by preventing possible deficiencies and inequalities in medical and health sciences education.

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**Data availability** The datasets used during the current study are available from the corresponding author on reasonable request.

## Declarations

**Competing interests** The authors declare no competing interests.

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the Declaration of Helsinki. The study was conducted by obtaining the ethics committee document dated 22.11.2021 and numbered 1598 from Siirt University Ethics Committee.

**Consent for publication** The participants have consented to the submission of the original article to the journal.

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