

Exploring the Features of Mobile Application of Anatomy in Basic Medical Sciences: a qualitative study

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Abstract

Background The importance of mobile phones has become one of the new research topics in health professions education due to the ease of access and flexibility. Although novel approaches to health professions education recommend the use of educational technologies such as mobile applications, a limited number of studies have been conducted with regard to teaching anatomy through mobile applications. Considering the increasing needs of medical students for mobile technology to meet their educational needs, wants and desires, we decided to explore the features of an anatomy mobile application.

Methods This qualitative study was conducted in two stages of holding focus groups and an expert panel session. Students of basic Medical sciences, and faculty members of anatomy at Iran University of Medical Sciences formed the research participants. Semi-structured interviews and note-taking were used to collect the data. Brown and Clark methods were used for thematic analysis and feature extraction. Finally, four criteria presented by Lincoln and Guba for qualitative studies were used to ensure the credibility, confirmability, trustworthiness and transferability of the data.

Results Based on the data analysis, 37 codes that could be used to design anatomy mobile content for medical students were extracted. These features were categorized into the main themes of “visual richness”, “scientific comprehensiveness”, “audio richness”, “affordability”, “user-friendliness”, “self-assessment”, “interactive content” and “user support”.

Conclusion This study explored the features of an anatomy application that can be used by educational app developers. Anatomy departments of universities of medical sciences, policymakers, and planners in the field of medical education can also adopt the findings of the present study.

Background

The world has recently witnessed drastic changes in teaching methods which pose unavoidable challenges to traditional education systems. Information and communication technology, as a novel phenomenon in the world today, has deeply altered various aspects of education in general and teaching and learning process in particular (1, 2). In traditional education systems, the main approach to teaching was lectured-based teaching while currently, with the emergence of novel educational technologies, students can benefit from new approaches to learning (3). This is added to the new trend which shows that knowledge enhancement of students of medical sciences has received increasing attention over time (3). Nowadays, the use of mobile tools, and more specifically, cellphones which are easily accessible by everyone, provides a valuable opportunity for teachers to facilitate the teaching-learning process, deploy it for offering equal educational opportunities, and improve the teacher-learner communication(4). Due to ease of accessibility at anytime and anywhere, cellphone has become a major topic of education and research in medical education(5). There is a strong likelihood that cellphones are appropriate for enhancement of the quality of medical education, and this is the reason for the high popularity of

cellphones as an effective tool of learning(6). Reduction of the workload of in-person education system, availability of 24-hour education, facilitation of education, and reduction of educational costs are some of the advantages of using cell phones in education(3). It has also been reported that the use of cell phones improves patient care, promotes the accuracy of diagnosis, and saves time(7). The use of mobile apps in teaching improves students' learning experiences. Taking into account the pressure of modern trends on higher education, the use of mobile apps is an important and effective novel method which is compatible with the positive attitudes and perceptions of students who accept and use such tools for educational purposes(8).

Anatomy is a basic course for medical students and includes different sections, each with several components. The content focuses on the structure of and the relationship between different parts of the human body(9). The large volume of materials has made learning a highly demanding process for the students in this course; the topics are complicated with a large amount of details to learn and memorize. Therefore, many students try to employ tools other than print resources in order to pass their exams. These tools which are typically based on the use of modern educational technologies include pictures and text in smart phones. Students, as reported in their interview, mostly use Netter's Atlas of Human Anatomy which fails to meet all their needs and preferences. Accordingly, if a mobile app which meets local educational features is developed for the course of anatomy, it will increase students' interaction, and motivation to improve their learning, and engages them in the process of learning more effectively(10). The use of cell phone technology can provide new opportunities for the improvement of learning anatomy(11). The findings of a recent study suggest that learners who use cellphones for learning anatomy are more successful in achieving the specific objectives of learning, compared to those who had access to teachers and print sources in an anatomy course(11). However, to the best knowledge of the researchers there are a few studies on the features of a mobile application for learning anatomy.

As the current approach to medical education recommends the use of educational technologies, including mobiles(12), which are convenient and easily accessible, and with regard to the scarcity of studies focusing on teaching anatomy through mobile apps, the present study was proposed. The study was conducted to explore the features of a mobile app for teaching theoretical anatomy to undergraduate medical students by focusing on learners' expectations and teachers' perceived educational needs.

Methods

This qualitative study was conducted at school of medicine, Iran University of Medical Sciences (IUMS) in 2019. A purposive sampling was carried out from the population of undergraduate medical students, and the faculty members of the department of anatomy at the university. It was decided to have a FG (FG) and an Expert Panel (EP) session to extract the learners' expectations and educational needs, wants and desires on the basis of which to come up with the features of the mobile app. FG is typically performed because the participants have similar knowledge and ideas on a given topic. FG is believed to provide us with a richer information than individual interview due to its group dynamics and interaction between participants. It shows how participants feel about or behave toward a topic, and is recommended for

generating ideas. It could be used alone or accompanied by other techniques (13-15). In addition to FGs, it was decided to have an EP which is known to be appropriate for evaluation of some generated ideas. EP should discuss the topics, evaluate them, and come to a conclusion or recommendations(16, 17). In order to pinpoint the themes, we extracted from the FG meetings, and evaluate the decisions we made for the features, we decided to have an EP which consisted of the faculty members of Anatomy department at IUMS.

First, coordination was made with Student Research committee, and Student Medical Education committee to hold a FG through a face-to-face meeting. Participants' consent forms were collected prior to the FG sessions. Then, the first FG session was held with nine undergraduate medical students studying at the sixth semester. For the inclusion and exclusion criteria see Table 1. These students had all passed the anatomy course, had mastery over the topic, and were easier to access. In the first FG session, a list of their expectations was developed. However, to receive more information and to confirm some data, another FG session was held with eight undergraduate medical students. The prompts were mainly selected by literature review and were checked by the research team before holding the sessions. The session which took about 45 minutes was held at the office of Student Research Committee. Three members of the research team directed these sessions. One researcher (MM) who was a M.S. student of medical education at that time, served as the moderator. He gave a summary of the topic and relevant goals to the participants, and provided explanations on the nature of the session and, where necessary, asked probing questions such as "Could you explain this more?" or final questions such as "Do you have anything else to add?" to improve the discussion and the data collection process. Another researcher (MK) who was the first facilitator, was a PhD graduate of medical education. He had access to the framework of the questions, and monitored the accurate collection of data. The third researcher (SA) was a PhD student of medical education at that time and was responsible for taking notes. The discussions were recorded by a digital voice recorder, and then transcribed verbatim for analysis. In the first FG session, 12 participants were asked to participate, but three of them did not come due to busy schedule. In the second session of FG 10 participants accepted to attend the session but two of them did not attend because of having classes. The second which took about 55 minutes session was also held at the office of Student Research Committee. To ensure the data trustworthiness, four criteria proposed by Lincoln and Guba for qualitative research (credibility, confirmability, trustworthiness and transferability) were taken into account(18).

Table 1. Inclusion and Exclusion Criteria for the FGs

Inclusion Criteria	Being undergraduate medical students studying at Iran University of Medical Sciences
	Having passed the anatomy course
	Studying at the 6th or 7th semester of undergraduate medical program
Exclusion Criteria	Being guest or foreign student
	Having started clinical courses
	Currently being enrolled in the anatomy course

The data resulting from the FG sessions were analyzed by using thematic analysis as the most common technique for the analysis of FG data(15), based on the well-known six-step model proposed by Clarke and Braun 2006(19). Thematic analysis is an inductive technique moving from the parts to the whole, which requires reflection upon the data by using quotations. The comments made by the participants were divided into smaller parts, which finally led to the themes emerged. To become familiar with the data, on the basis of Clarke and Braun's model, the researchers read and re-read the data several times to find the preliminary ideas, and to be prepared for extracting the codes in the next steps. Afterwards, the codes were categorized, and for each category of codes, primary or secondary themes were specified. Ultimately, the final or major themes were extracted and defined. Thereafter, the final report was tabulated. For data analysis, several meetings were held with the research team, including the supervisor (AD), advisors (SB) and (ZS), mediator (MM), and one of the facilitators (SA). In each meeting, the problems were discussed, and resolved, the differences were reconciled, and decisions were made to assist accurate analysis. Since some points made by the participants were ambiguous, member check was performed; the participants were contacted individually through phone calls, social networks, or in person, until our intended meaning was clarified or some confusing points were explained. In the re-check part, the complementary and clear explanations of the participants on ambiguous points were provided.

In the next step, an EP was held with anatomy experts who were the faculty members of the anatomy department. For this session, seven faculty members who were accessible and accepted to participate in the study were invited, and a letter of invitation was sent to them by the supervisor of the project. However, five of them participated in the panel. The other did not attend the panel because of unexpected meetings. The supervisor (AD), advisors of the project (SB) and (ZS), a software engineer, the facilitators (SA) and (MK), and the mediator (MM) were present in the session. A summary of the topics was discussed and the goals were made clear to the participants, and explanations were offered on the process of the research, and the report of the FG recorded by the team. Each members of the EP was asked to discuss the themes identified, and comment on them. After discussion of each item a polling of agreement was performed by vote on approving or disapproving the items. The discussions were recorded by a voice recorder and then transcribed verbatim. There was also a facilitator (SA) to make notes. The other facilitator (MK) was present for polling the votes. The items were presented by the

mediator (MM). If there were any item which needed technical advice for approval, the softer engineer would help. The session, which took about 50 minutes, was held at the department of medical education in the medical school of IUMS.

Results

In the analysis of the FG data, 121 ideas or preliminary codes were initially obtained. Then, by eliminating similar, overlapping, or repeated codes, 30 codes were specified. The codes were compared and categorized on the basis of the similarities and differences, resulting in 11 sub-themes which were finally classified under 8 themes. These themes were then discussed in the EP. Analyzing the data of the FG, we were able to identify some codes denoting the same topic; the similar codes were then assigned to one sub-theme.

Visual feature of the app. was very important to participant; for example, Participant 7 said: "Being three-dimensional makes it great to see all the parts we want". Similar codes focusing on visual features were titled "appropriate visual design" as a relevant subtheme. There were other codes, belonging to another separate category, allocated to the sub-theme "educational clips". Eventually, upon further analysis of the codes and sub-themes, it was decided that these two sub-themes could be merged, forming a theme titled "visual richness".

The source of the scientific content, the extent to which the details are presented, and how comprehensive the functions are shown were the features important to the students. Participant 10 said "it should be based on presenting, organs, systems, and region, or if it is made for the students of a university, it will be based on the educational programs. It's much better if it's based on the topics and the lessons that are offered by the anatomy departments". Two codes, emerging from students' emphasis on curriculum, were assigned to the sub-theme "credible materials and curriculum". Some other related codes were assigned to the sub-theme "provision of comprehensive scientific content", as well. Then, it was found that the two sub-themes were similar and could be allocated to the same category; thus, these sub-themes were merged, forming the theme "scientific comprehensiveness". The students had different ideas about the auditory feature of the application. Some believed, "it should only be in the form of pronunciation, so that we can understand the correct pronunciation of units, such as nerves or muscles. (Participant 6). Or Participant 9 said "In general, if the pronunciation of the units is given it is excellent." Whereas participant 4 said, "If possible, the sounds are in the form of a link on a separate site so that someone can choose, especially sounds that have long descriptions." The codes related to the topic of sound were allocated to the sub-theme "optional audio feature". By reviewing the data and the sub-theme, the final theme called "richness of sounds" was formed.

Another code belonging to a separate category, was "reasonable price" which was put under the sub-theme economical. However, this was later changed to "affordability". The decision was based on the students' statement about the reasonable price of the application. For instance one of them said, "The price of the program is very important to be reasonable." (**Participant 1**).

There were other related codes which were categorized under the theme “user-friendliness”. Moreover, similar codes were categorized under the sub-theme “relevant tests”. Eventually, this category was assigned to the theme “self- assessment”. Some other codes which belonged to the same category were titled “interactive instructional design” which was then changed to the theme “interactive content”. There were two other related codes belonging to the same category, which was then called the sub-theme “having a support/guide option” for the theme “user support”. The results are shown in Table 2. The indicators or students’ quotations are available on request.

Table 2 codes, sub-themes, and themes extracted from the FG

Codes	Sub-themes	Final theme
Being three-dimensional (3D)	Appropriate visual design	Visual richness
Containing real and appropriate images		
Having sufficient and appropriate graphics		
Having an appropriate visual design		
Having animation		
Having educational clips	Educational clip	
Being based on a credible sources	Accredited curriculum	Scientific comprehensiveness
Compatibility with accredited curriculums and syllabi		
Offering important contents such as diseases and their complications	Comprehensive content	
Containing features and details		
Being classified on the basis of regions and systems		
Showing functions		
Having comprehensive and reliable source		
Not having disturbing sound	optional audio feature	Richness of sound
Having a loud enough sound		
Offering the pronunciations of words		
Having a low price	Economical	Affordability
Having reasonable price		
Requiring low payment for subscription		
Having a reasonable file size	Appropriate content design	User-friendliness
Not being time-consuming		
Being easy to work with		
Not having unnecessary content		
Providing written explanation		
Having a note-taking feature and allowing to save certain items	Customization	
Containing tests for different levels	Relevant tests	Self-assessment

Having a zoom option	Interactive instructional design	Interactive content
Separating important parts and being responsive		
Having a search ability and being interactive		
Supporting the user in understanding the course content	Support and help option	User support
No support is required		

As for the EP, the recorded session was listened to, and reviewed several times to facilitate the transcription process and to have a good understanding of the content of the codes. After the transcription process, the data were compared with the notes taken during the interviews, and both were examined carefully. Although the EP initially discussed about some codes, they eventually confirmed all the codes extracted from the FG. However, they added some new codes (seven codes) to the previous ones (See Table 3). In this way, while assessing the learners' expectations, the EP helped us to make a better understanding about the features of a mobile anatomy app. These codes were discussed, reviewed and analyzed by the team of researchers.

One of the members of the panel, A, said that, "It must have an image or clip on cadaver, so the students could examine and study the parts on their own". C remarked that "there are a few number of cadavers which should be examined under the supervision of an instructor; but if the image is available on the application, they could examine it independently." On the basis of these indicators, a new code was formed, and we agreed it could be placed under the theme visual richness.

They also discussed about the content and topics which should be based on recent curriculum. Participant E said, "It is better to consider one block for each section because each block requires a large volume of content." Participant C believed that "It is much better to present parts from the surface to the depth."

As what they discussed and agreed on was based on the recent curriculum of medical school, we decided to categorize it under the theme of scientific comprehensiveness. They all agreed that an anatomy application should have labeling and language options which could be the same as user-friendliness.

On the rest of the codes we presented to them they all agreed with the students.

Table 3. Learners' codes and expert panel's new codes

Learners' codes**New codes added and codes confirmed
by the expert panel**

Being three-dimensional (3D)	
Containing real and appropriate images	"...using sample image of cadaver".
Having sufficient and appropriate graphics	
Having an appropriate visual design	
Having animation	
Having educational clip	Confirmed
Being based on a credible source	"...being based on a specified building blocks of anatomy"
Compatibility with the curriculum and syllabus	
Offering important points such as diseases and their complications	"...moving from surface to depth" and "displaying adjacencies"
Containing features and details	
Being classified based on regions and systems	
Showing functions	
Not having disturbing sound	Confirmed
Having a loud enough sound.	
Offering the pronunciations of words	
Having a low price	Confirmed
Having reasonable price	
Having a reasonable file size	
Not being time-consuming	"... having labeling option"
Being easy to work with	"... having language option"
Not having unnecessary content	"not looking cluttered"
Providing written explanation	
Having a note-taking feature	Confirmed
Allowing to save certain items	
Containing tests	Confirmed
Having tests for different levels	
Having a zoom option	Confirmed

Separating important parts

Having a search ability

Supporting the user in understanding the course content

Confirmed

No support is required

Evaluating the codes extracted from the FG sessions, the EP confirmed them all, and added seven new codes which were: “using sample image of cadaver”, “... being based on specified building blocks of anatomy”, “... moving from surface to depth”, “displaying adjacencies”, “... having labeling option”, “having language option”, and “not looking cluttered”. Upon specifying the highlighted, similar, and frequent features, based on the data of the FGs and EP, the features of a mobile app for teaching anatomy were extracted which are shown in Figure 2.

Discussion

The present study aimed to shed light on the features of a mobile app for teaching theoretical anatomy course of the undergraduate medical curriculum. The following themes were extracted for developing such an application: “visual richness”, “scientific comprehensiveness”, “auditory richness”, “affordability”, “user-friendliness”, “self-assessment”, “interactive content”, and a “support option”. Based on the results, visual richness is a major theme with two sub-themes of appropriate visual design and educational clip. Addressing the visual properties of the app, especially for the course of anatomy, will enhance its effectiveness because the content of this course is mostly visual. The studies on this topic have showed that the use of appropriate images and educational clips are essential for mobile learning (20-23). The importance of the visual features of apps has also been highlighted in the study by Crook et al. (2017) who had FG sessions (24).

Based on the results of the present study, scientific comprehensiveness is another important theme with two sub-themes of using credible content, accredited curriculum and syllabi, and presenting a comprehensive scientific content. This feature indicates that the educational content used in apps must be reliable, otherwise it is not appealing in the process of learning. Matheus et al. (2016) investigated the status of mobile apps in terms of health-related behaviors. In that study, the features of mobile apps were evaluated by using a well-known framework which affects the users’ behaviors and attitudes. Consistent with our results, features such as reliability and credibility of the content were extracted(25).

Another theme extracted in the present study was auditory richness. Considering this theme ensures that the app is rich in terms of sound features. This theme contained a sub-theme entitled having a sound option, with three components: having a loud enough sound, not having sound, and offering the pronunciations of words. This finding suggests that having sound, which can be turned on or off, can help the learners use the content of the app based on their own preferences. In line with our study, Liao et

al. (2017) who studied the essential and attractive functions used for promoting sports skills in mobile apps, showed that the features of such apps could influence the quality of the audience's perception. Similar to our finding, the analysis of questionnaires revealed that appropriate features for such apps include the use of speech for explaining practical activities(20).

In the present study, affordability was another main theme with the sub-theme of being economical, i.e., having an appropriate, low or reasonable price. This sub-theme indicates that the app must be affordable for the users so that it can be easily accessed by all or most of the learners, because students, who are the main user of this app, do not have an income. This finding is consistent with those reported by Nitsch et al. (2016) on mobile apps for individuals with eating disorders. In that study, which employed semi-structured interviews and questionnaires, the analysis of data revealed that affordability was an important feature of the apps (26).

Based on our findings, another theme is user-friendliness. Features belonging to the sub-themes of the user-friendly content design include: having a reasonable file size, not being time-consuming, ease of use, containing necessary content, providing written explanations, having a labeling option, having language options, and not looking cluttered. User-friendliness means that everything should be designed on the basis of the preferences of the users as the end users. This will result in an acceptable app and promote learning. Results of our study are in line with Zilverschoon et al. (2019) who compared the features of electronic apps for teaching 3D anatomy. In that study, following a systematic search, a comparison was performed among the features of apps in order to provide a guideline for the selection of appropriate apps. It was found that non-commercial apps were very promising in terms of ease of use(27).

In the present study, the next theme is self-assessment. When using this app, the users should be able to assess their own strong and weak points and improve their performance following every log in. A test or quiz can be provided at the end of each topic so that the learners can assess themselves and resolve their weak points. These results are consistent with the results reported by Chi Yan Hui et al. (2017) which examined the use of mobile apps for helping self-management in patients with asthma. The study was a systematic review conducted to identify the features related to clinical effectiveness. The data analysis revealed several features, including the feature of showing questions and feedback(28).

Another theme was having an interactive content. The zoomability, separating different parts, and searchability are the features belonging to this category. These findings are also emphasized in the study by Louise et al. (2014) who worked on complementing the teaching of anatomy by using an anatomy app. In that study, 27 apps in the mentioned domain were examined, and the results indicated that features such as having a zoomability on each anatomical structure and ease of separating a structure and explaining each part separately were positive features highlighted in some popular apps(23).

Based on the findings, user support is another theme with the sub-theme of having a support or help option. The existence of a support or guide in the app allows the users to resolve the problems they encounter while using the app. However, few students mentioned that it was not necessary to have such a support, because in case of an ambiguity, one can easily find the answer from the Internet. Similarly,

Crook et al. (2017) investigating interface of a mobile app for individuals with communication disorders, showed that the existence of ready messages for support is a major issue in apps, which merits attention(24).

Conclusions

The findings of the study revealed eight features including “visual richness”, “scientific comprehensiveness”, “auditory richness”, “affordability”, “user-centeredness”, “self-assessment”, “interactive content”, and a “user support”. These findings can assist educational mobile apps developers to design anatomy or similar apps in the domain of medicine. In addition, departments of anatomy can utilize the findings of this study for becoming aware of students’ needs and expectations in anatomy courses. The findings can also help policy-makers and curriculum developers in general, and policy-makers in the domain of e-learning and m-learning in particular, to become aware of the students’ expectations, and educational needs, wants and desires. Another study, in which participants from other universities are included, is suggested to increase the generalizability of the findings. It is also suggested that a survey study be conducted on the basis of the findings of this study.

Abbreviations

IUMS: Iran University of Medical Sciences

FG: Focus Group

EP: Expert panel

Declarations

Ethics approval, Consent to participate and Consent for publication: This study was a part of a Master’s thesis which was approved by Vice-chancellor for Research and by the ethics committee of Iran University of Medical Sciences with the number IR.IUMS.FMD.REC.1397.080. The participants filled out and signed a consent form for participating in the study, and publication of the relevant data in the form of an article.

Availability of data and material: The data and materials used in this study are available upon the request.

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Author's contribution: Mahmood Mansouri, male, M.S. students of medical education was the mediator of the focus groups and expert panel.

Shoaleh Bideli, female, was the advisor and performed the data analysis.

Afsaneh Dehnad, female, was the supervisor, performed the data analysis, and edited the paper.

Zohereh Sohrabi, female, was the advisor and performed the data analysis.

Somayeh Alizadeh, female, was the facilitator in the focus groups and expert panel session.

Mohammad Hasan Keshavarzi, male, was the facilitator in the focus groups sessions.

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Figures

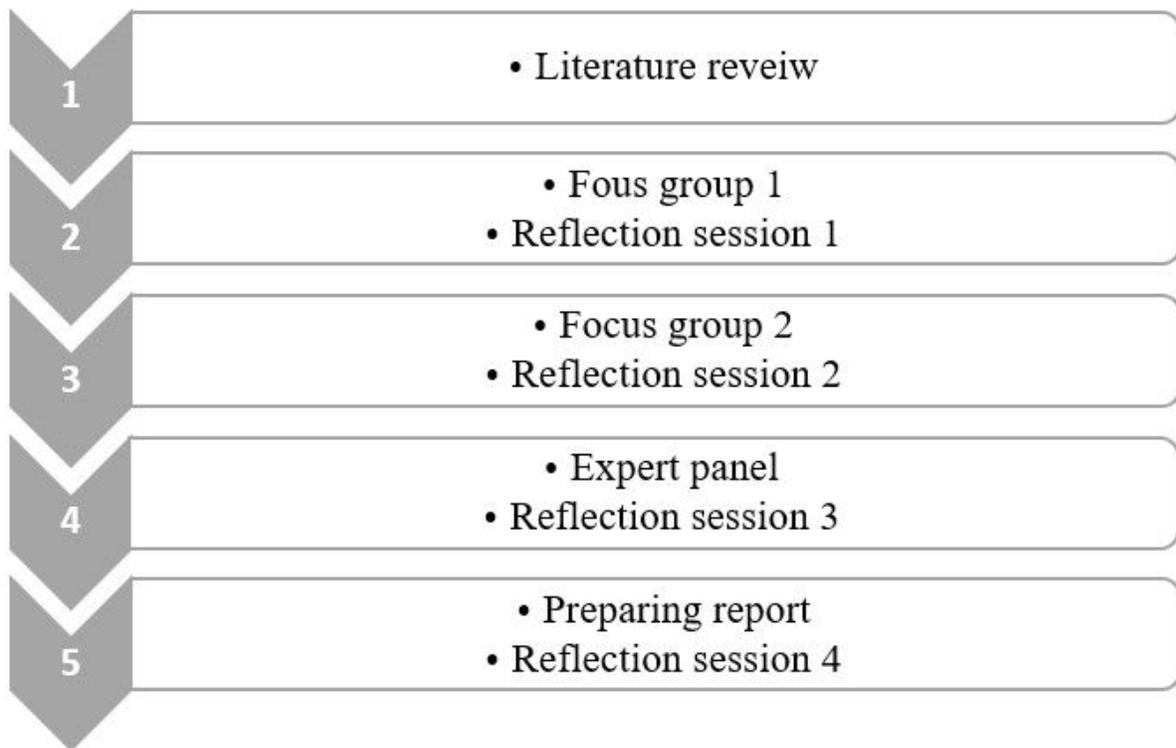


Figure 1

The process of conducting the research

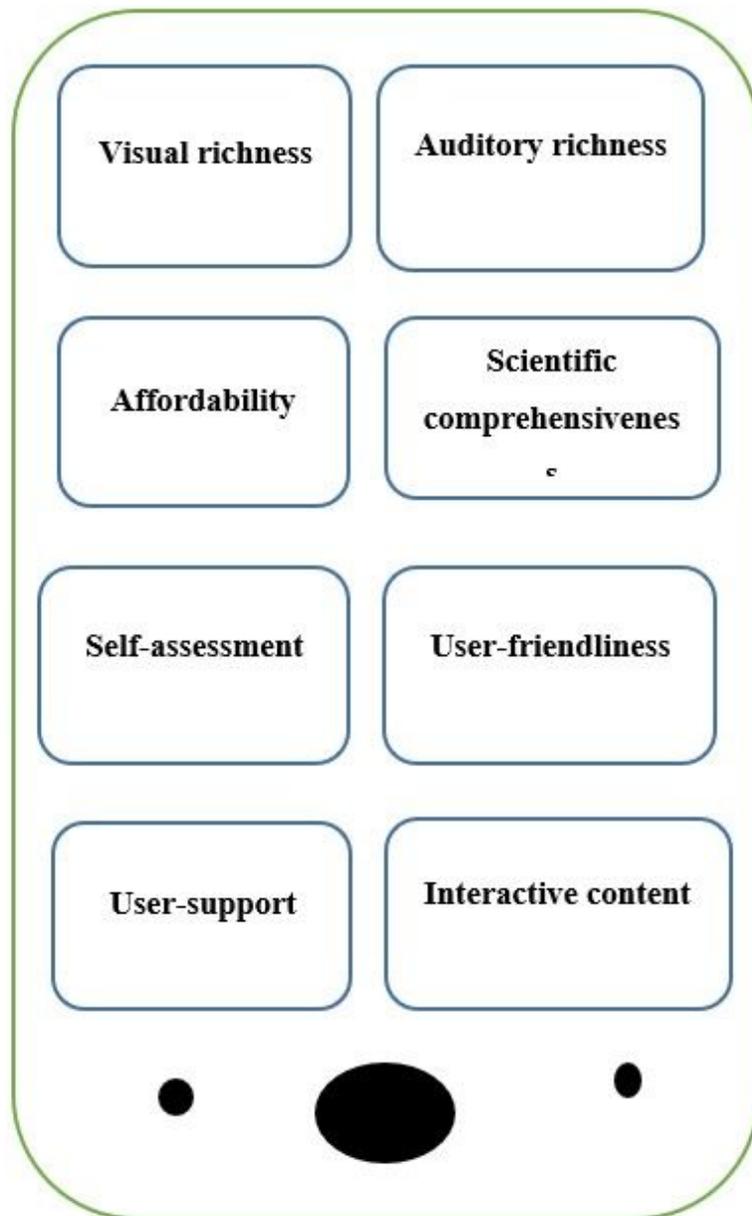


Figure 2

Major themes for developing a mobile application of anatomy

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [ISSMCOREQChecklist.pdf](#)