ORIGINAL RESEARCH

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AUGMENTED REALITY OF HEART IN TEACHING GROSS ANATOMY OF THE HEART: A LESSON LEARNED

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ABSTRACT

Background: Anatomy is a crucial science for medical students, the deep understanding on material would help students dealing with clinical context such give a better explanation to patients until having better performance in doing clinical procedure and dissecting ability as a surgeon. Nevertheless, having a deep understanding and memorizing anatomy would need abundant effort. Several strategies combined with fit learning media will give great advantages for the students. This study is aimed to explore innovation in teaching anatomy by using augmented reality (AR) within a case-based discussion.

Methods: A qualitative approach was used, in depth interview with teachers who facilitate the discussion and focus group discussion with the students. A thematic analysis was done in analyzing the data.

Results: Overall, the teachers and student were satisfied with the innovation. Several themes were identified from students' point of view such visualization, content, technical problem, and the need of teachers. The most important success factor of AR usage was its visualization i.e., orientation, and visual spatial ability.

Conclusion: Combination case-based discussion with AR give promising strategies in understanding anatomy of heart. Using AR should consider several limitations of AR regarding to its visualization. Also considering the perceived advantages from the students, the usage of AR will be limited as supplement, a supporting media for having deep understanding on anatomy.

Keywords: teaching anatomy, case-based discussion, augmented reality, evaluation

PRACTICE POINTS

- Teaching and learning in anatomy need innovative media which allows the best learning experiences, followed by evidence of its effectiveness.
- Teaching strategies also have meaningful impact in learning process, by adding more challenging situation will enhance students' motivation for seeking new expected information.
- The usage Augmented Reality (AR) technology allow the students have better orientation towards anatomical position enhanced from only 2D media like book.
- The AR modification towards its enhanced information regarding to certain anatomical points will ease the student having better and faster understanding on its orientation.

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INTRODUCTION

Anatomy is one of important science for medical students to understand how human works that determine future's students' clinical performance. Learning anatomy needs students' abundance of effort, as expected further cyclic learning on anatomy in clinical phase.[1] Furthermore, anatomy of the heart is a complex structure and understanding on how the structure could support its function needs a great effort. Therefore, understanding each anatomical position's function complexity would need advanced strategies.

Teaching strategies in understanding anatomy firstly used human cadaver, by dissecting technique. That technique not really help the students to memorize all the position.[2] Several strategies, like linkage the anatomical position with clinical importance, using anatomy books/interactive CD, introducing medical terminology, using advanced technology such virtual reality (visible human project), augmented virtual reality, 3D printing, or even hologram technology was expected to ease medical students learn and memorize anatomy better.[3] Nevertheless, those technology were mostly acknowledged as supportive material.[4] Nowadays, an innovative strategy that laid on students' centered learning strategy with or without distance learning such as team-based learning (TBL), case-based learning (CBL), and flipped classrooms.[5,6] Thus, bring advantages in making the students become more active and gain more memory retention[7]. Among those strategies, a case-based discussion is mostly used and combined into a blended learning strategy.

Blended learning was proven effective in help the students learn on anatomy in this Pandemic COVID 19 through online lecture, prerecorded laboratory dissection video and 3D anatomy application, with condensed offline cadaver dissection.[8] However, the student perceived the success of blended learning of anatomy laid on its visual, content, effective learning, their expectation, accessibility, their own motivation, students' perspective, and continuity.[9] There was also indicated that culture influences the effectiveness of anatomy course.[10]

Those strategies could embed with advanced learning media such simple power point, virtual reality, augmented virtual reality (AR), and 3D printing. Each learning media offers advantages with certain disadvantages. Based on a systematical review, it was proven that AR could enhance students' learning process by combined with a pedagogical approach and it is not questionable that it might be able to replace teachers as information source.[11] In addition, 3D shapes of anatomical structure help the students learn anatomy more.[12]

The success of the learning media would be also determined by the students' learning styles.[13] Their preference for media would influence their acceptance to the media. There are several types of learning styles regarding with the students' personal modalities in learning such VARK, and Kolb's technology usage styles.[14-17]

Our faculty used conventional way to teach anatomy, by using cadavers' dissection and books. The limitation of dissecting cadavers made the students' hard having the deep understanding on anatomy, and even in pandemic situation. In this study, we conducted an innovation in helping the students to understand the anatomy of heart and its' function by using the combination of Augmented Reality (AR) with case-based strategies. Augmented Reality (AR) offer us the alternative of teaching anatomy of the heart which allow them to explore the heart orientation even when they cannot be present at the laboratory. The aim of this study is to explore advantages and disadvantages of the usage of AR within case-based discussion strategy in order to make the heart anatomy more understandable and memorable.

METHODS

We conducted a qualitative with crossed controlled group technique to students and teachers who involved in our innovative development strategies in teaching gross heart. An in-depth interview with guideline were done with the teachers who facilitate the discussion and focus group discussion were done with the students.

We used simple clinical scenario in stimulate the discussion, using a heart attack - ischemic heart disease case for control group and stable angina case for the innovative group. The teacher uses the scenario to start the discussion, lead and guide the student to use the AR which attached within the module. A clear instruction already given within the module book, as shown in Figure 1.

The AR were designed in a QR code and picture code that could be accessed through the discussion, as printed QR code within the student's module. We had open recruitment for the students who willingly to join the "simple" course. In the end, we had 5-6 students for two divided groups, i.e., controlled (using books) and innovative (using

AR). Each group has one teachers and one researcher who monitor and gave hand for any trouble in using AR during the session. During the process, there was no major difficulties faced by the students. It was only small or minor difficulties which mainly caused by the internet connection or incorrect angle of camera in catching the picture.

The study was divided into two rounds, allowing the switch between control and innovation group. The first round, control group discussed the available scenario by using the books and the innovative group discussed the available scenario by using the AR. After first round, the group was switched in order to make all the student having the same experiences. We conducted Focus Group

Manual Penggunaan Aplikasi
AR Heart

AR Heart merupakan aplikasi anatomi jantung dengan menggunakan teknologi augmented reality. Aplikasi ini dikembangkan dengan harapan dapat membantu pembelajaran anatomi dengan memungkinkan pengguna mempelajari anatomi jantung secara 3D dengan mudah dan praktis.

Manual Installasi untuk android
1. Aplikasi dapat diunduh melalui tautan https://bit.ly/30N4i16 atau dengan men-scan QR code di bawah
2. Aktifkan "Allow installation from unknown source" pada smartphone.
3. Instal aplikasi
4. Setelah instalasi selesai, buka aplikasi AR Heart

Manual installasi untuk iOS
1. Pertama Unduh terlebih dahulu Aplikasi iFunbox pada link berikut : http://i-funbox.com
2. Siapkan file IPA, anda bisa mengunduh filenya pada tautan https://bit.ly/30RUpPN atau dengan men-scan QR code di bawah.
3. Kemudian **Hubungkan iPhone, iPad atau iPod Touch** anda ke PC/Mac
4. Jika sudah di kenali oleh komputer maka lanjutkan dengan **Install Apps** dan arahkan ke aplikasi IPA yang akan anda instal
5. Jika sudah berhadil akan di tandai dengan tulisan **Succees di iFunbox** jika aplikasi berhasil anda install
6. Namun jika tampil pesan error silahkan cari File IPA lainnya kemungkinan File tersebut rusak atau tidak Support pada Device anda.

Manual penggunaan
1. Setelah instalasi selesai, buka aplikasi AR Heart
2. Arahkan kamera *smartphone* ke key image AR Heart atau Kartu AR Heart
3. Apabila kamera dapat menangkap gambar tersebut, pada layar smartphone akan nampak 3D virtual gambar jantung utuh. Gerakkan smartphone/ kartu AR Heart untuk merubah sudat pandang model 3D.
4. Pilih "show/hide Anatomica Text" untuk memunculkan/menghilangkan nama struktur anatomi jantung.
5. Untuk melihat bagian dalam jantung, aktifkan "potongan belakang" atau "Potongan depan" sesuai kebutuhan.

Figure 1. The manual instruction of The AR (in Bahasa)

Discussion (FGD) with each group discussion and in-depth interview with the teacher after the first and second round. In the end we had four records on in-depth interview, and four records on focus group discussion that were transcribed and analyzed the transcript by using close code (thematic analysis).

"I think I will use this AR as a supplement, not for my way of primary learning of anatomy of the heart…". (P1)

However, we also concerned on one students' comment,
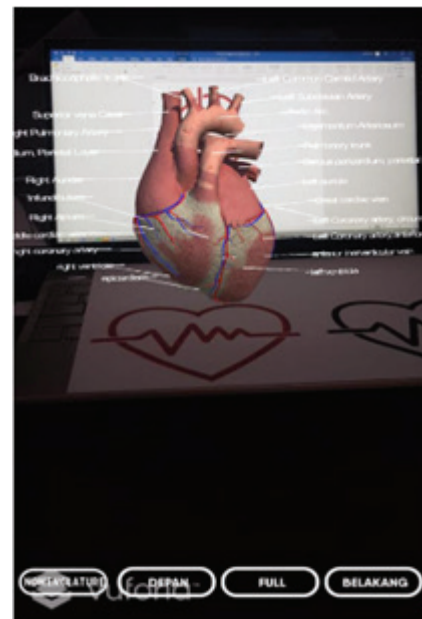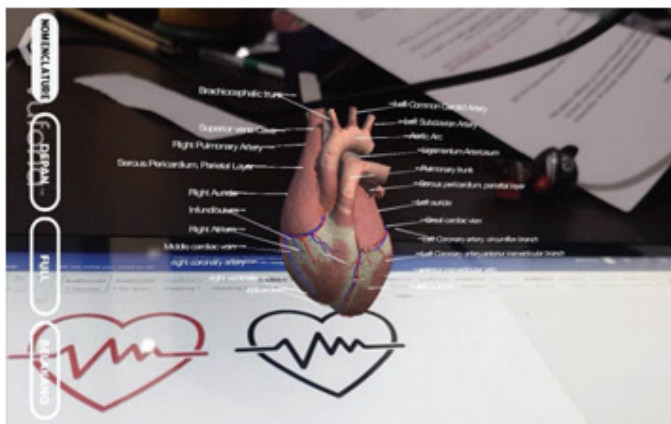
Figure 2. The AR - Anterior View

The study obtained ethical clearance from UGM's HREC No. KE/FK/0134/EC/2020.

RESULTS AND DISCUSSION

In this study, we gain perspectives from the teachers and also the students in AR usage in anatomical teaching and learning. Teaching and learning process will be gained from teachers' perspectives, including how the teachers handling the media through the teaching and learning process. Besides from teachers' point of view, how the AR advantaged the teaching and learning process will be gained from the students' point of view. The analysis was conducted with closed thematic based on description which are acknowledged from the previous study.[18,19]

Student's point of view

Overall, the students satisfied with media facilitated by the course as stated,

"I feel very futuristic somehow"; It is my first-time using AR, it is the new thing, it feels good. So, it is interesting and excited to see…".(P2)

Based on this study, from students' perspective, there were some themes regarding with the AR usages recognized by this study i.e., visualization (orientation, shape, spatial orientation), content, and technical problems as reported below.

Visualization

Grasping heart visualization was considered challenging for the students, especially the inner part of the heart. The shape and volume of the heart were perceived not really realistic, it was said too big. Furthermore, it was also hard for the student to recognize the rough and smooth part of the chamber. Besides, students also mentioned that they had difficulties in perceiving heart position

with another compartment within the thoracic cage. Although it does not have clinical importance, thus could influence on students' visualization on heart, especially effect on the students' visual spatial and orientation.

> "During the learning session with AR, our instructor said that the ratio of the ventricle is too big comparing it to the real one in the cadaver. Perhaps the proportion of the visualized heart in this AR hasn't been that realistic enough." (P1)

> "The structures in the chamber of the heart are not that clear between the rough surface one and the smooth one. So, it is hard for me to distinguish between the two because it is also too dark so it seems they are all the same." (P3)

> " …honestly, the exterior design of the heart is good enough, the problem is the visualization of the inside parts of the heart…" (P4)

> "…I wish to see the thoracic cage and the other organ or anatomical structure surrounding the heart to help my orientation (skeletopy). The dominant one and the clearest view is still highlighted on the heart, but we can see the heart's position in between all of them." (P3)

Content

The students mentioned that the AR give visualization that not too comprehensive. Some detail information was missed and then, the teachers take action to explain it further. Thus, could make the students miss important information of heart, if it was an important information that had clinical importance, it would frame the students' knowledge biased.

> "I think it is superficial. I do think like that since our instructor had to draw and explain some structures with whiteboard instead of using the AR…" (P1)

> "… I'm afraid that the content is not comprehensive." (P1)

> "I personally think it shouldn't be used for primary learning. Just for confirmation." (P2)

Technical Problems

The students realized several technical problems such the AR stability after retrieved from QR code and the phone got heated after several minute AR activation. Thus, implies that the AR design could have problem with the phone system.

> "… when I scan the QR code in the paper to get the visualization of the heart within my phone, it was a bit too shaky. After a while, my phone is heated." (P1)

> "Maybe it would be easier for us if on the QR code paper is featured with some numbers. So when the instructor taught us to pay attention for the structures in one point of view, he can instruct us to move the paper into number 1… and then rotate to number 2..." (P3)

Teachers' point of view

Two themes were emerged from in depth interview with the teachers i.e., strategy and teaching media. The teachers were appreciated the strategy that being used since the students were enthusiastic.

> "Uniform perspective is the obstacle, to make sure I asked several times if they see what I see, but there is no response, because of this the learning process becomes disintegrated … Some are enthusiastic because they're following and they got it, overall judging by the number of questions, they're enthusiastic." (S2)

While regarding with teaching media, the teachers point on two aspects like orientation, and content. The teachers appreciated for the teaching media since it brings advantages compare to cadavers.

> "… looking at cadavers can be confusing … as there are no pointers, the AR have pointers for the structures, so students can identify them …" (S1)

> "With AR … we can differentiate clearly between arteries, veins, and the yellow of the fat surrounding the heart, the coloring is detailed making it easy to differentiate between structures." (S2)

> "AR is good for orientation alone, because it is 3-D it is great to visualize it as if holding the heart itself " (S1)

Nevertheless, the teachers recognize the flaws of the AR such on content and visualization. The content perceived too superficial and some structures were not available.

> "In the Augmented Reality application, the structures are incomplete and do not meet the learning objective" (S1)

> "… from the inside of the atrium, the rough parts and the smooth parts of the auricles cannot be determined." (S2)

> "In a 0-10 scale, the atlas is superior to the AR in regards of structures and depth of material, there are more to explain so I give it an 8 …. For 30 the structures loaded in the AR I give it a 4, they lack in structure materials especially in the interior of the heart" (S2)

The teachers also mentioned that the AR have problems in heart's visualization such its' volume, shape, and projection.

> "The projection of the heart to the anterior thorax is a bit hard to explain, then the pericardium and skeleton cordis could not be pointed." (S2)

> "…normal heart resembles the shape of baby shoes, a bit trapezium, in the AR it looks oval like a heart shape…" (S1)

In the end, the teachers recommend the teaching media can only be used as supportive media for teaching heart. Using AR together with Atlas would enhance the students' knowledge on heart anatomy. Both will complement each other; the AR would improve the students' orientation - give the students sense the 3D shape of the heart.

> AR is hard to use for teaching, it is better for a self-study use for one's own understanding" (S1)

> "I do not recommend using AR alone, better to combine it with atlas, atlas for the structures and AR for the orientation … This is great as a first generation of UGM's AR try to implement it. Better to release it from the earliest generation, starting with using the AR for orientation, for the missing detailed structure, students should look on the atlas." (S2)

Virtual augmented reality is a common technology that is usually used with or without companion in certain teaching learning activities. Common pedagogical strategies in facilitating better understanding and memorization of gross anatomical of cardiac blood supply, such as case-based discussion, are used in order to understand the blood supply of the cardiac. By using clinical case, a discussion is triggered and leads the students having a deeper understanding of certain anatomical position. With discussion, the student will be more engage and having fun learning, in turn, it will lead to activation of students' self-directed learning to explore the anatomical position into more detail and having better memorization. An evidence also showed that collaborative learning through discussion process could enhance students' memory retention.[20,21] In this study, we also found that the strategy was felt pleasant by the student, it makes them more enthusiastic with the content. They were triggered by the case and enjoy the whole process. With AR, they much more easier to grasp the anatomical information regarding with the cardiac blood supply. Nevertheless, it would depend on the AR on how it will satisfy the students' discovery learning process through teachers guide.

From teachers' point of view, the teachers did not find any difficulties while facilitating the discussion, it was only felt difficult when guiding the students using the media. The teachers sometimes need to guide the students to discover certain anatomical position of cardiac blood supply and explain further since the students hard to follow the teachers' heart orientation. Nevertheless, the teacher also found that the AR was not equipped with detailed information for learned material.

During the discussion process, the students used the AR in order to have better understanding on anatomical position, especially on cardiac blood supply. The characteristic of its anatomical it selves is soft and has hard to perceived within real condition, especially with cadaver or even in anatomy textbook. AR offers so many advantages for the student having better perception for those anatomical structure, by enhanced visualization, and orientation. Nevertheless, in this study, we found that additional information was needed in order to help the students gain immediate information on certain anatomical position.

As well as also informed by previous study, in this study, it could be concluded that from the students and teachers perspective, AR should be used as supportive material not as a primary learning media.[12] The AR helps student getting the anatomical orientation, shape, and visualization but not the content. The AR could facilitate the student to understand the anatomical orientation and shape through its' 3D although it also depends on the system. Nevertheless, not all anatomical compartments could be facilitated through the AR which could make the AR's heart visualization too dense with all the information. A dot which could expand after click could be the solution but thus would also need the detailed shape of the heart visualization and AR visual systems' sensitivity.

A student mentioned that "*I feel very futuristic somehow*"; *It is my first-time using AR, it is the new thing, it feels good. So, it is interesting and excited to see…*". It shows that there is indication on students' engagement were determined by students' technological preference. How technology could help them to learn would be determined by the students' sensory modalities preferences. Students with great ability in multi-modal sensory would easily adapt and use the AR. It might be that the AR amused the students at the first time but might be not as his/her learning media that help them to learn better.

Although identifying students' learning style not really supported by body of evidence,[22-24] students' learning style would be the one factors that influence on how a learning media could help them to learn. The ultimate learning style related to the media is VARK models of learning style that determine the student into several type of learner such visual, kinesthetic, aural, social, solitary, verbal and logical.[16,17] While regarding with technology, Kolb also defines several types of learners as assimilator, accommodator, converter, and diverger.[15] Each type of learner's learning technological type has its own characteristic that could be identified and consciously used by the students in their learning process.[25,26] Thus identification of learning style could help the student recognizing their own ability in dealing with the media of learning, in order to enhance their understanding and memory.[27]

CONCLUSION

Using AR for learning gross heart anatomy would help the student in term of heart' orientation. This also need support in clear and detail visualization. Therefore, using AR heart could not be as primary learning media but would be great as a supportive media to learn heart anatomy.

RECOMMENDATION

We recommend using AR and another supportive technology to enhance students' understanding on anatomical position together with the 2D dimension such Anatomy book. Besides that, adding more clinical importance of anatomical position will help the student to memorize the anatomical position.

COMPETING INTERESTS

All authors declare no conflict of interest related to this publication.

AUTHORS' CONTRIBUTION

Hikmawati Nurokhmanti – as member of research team, who analyze the data and draft the manuscript

Dyah Samti Mayasari – as member of research team, who conducting, and collect the data.

Nisrina Nabila – as member of research team, who collect the data

Annisa Maulidina – member of research team, who collect the data

Putrika Gharini – as main researcher, who made the proposals and lead the research

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