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Research Article

Anatomi Eğitiminde Mobil Öğrenmenin Öğrencilerin Öğrenme Becerileri ve Motivasyonuna Etkisi: Sistematik Derleme

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Öz

Anatomik yapıların anlaşılmasını kolaylaştıran teknolojiler, klasik yöntemlere kıyasla öğrenciler için avantajlıdır. Mobil öğrenme ve üç boyutlu (3D) görselleştirme yöntemlerinin öğrencilerin algı, memnuniyet ve kullanılabilirlikleri açısından oldukça faydalı olduğu bilinmektedir. Bu sistematik derlemenin genel amacı; anatomi eğitiminde mobil öğrenmenin etkilerini araştıran çalışmaları değerlendirmektir. Araştırmada Google Scholar, Medline, Pubmed ve Web of Science gibi elektronik veri tabanları kullanıldı. Anatomi eğitiminde mobil uygulama kullanımı 2013'den sonraki yayınlanan taramalar incelendi. "anatomy education" ve "mobile learning" anahtar kelimeler kullanılarak, anatomi eğitiminde kullanılan mobil uygulamalar hakkında bilgi içeren araştırma çalışmaları analiz edildi. Araştırmaya Ocak 2013 ve Mart 2022 tarihleri arasındaki veriler toplandı. Bu kapsamda elektronik taramalar sonucunda 12220 makaleye ulaşılmıştır. Araştırmada uygunluk açısından 779 bilimsel yayına ulaşılmış ve bu yayınlardan 30 tanesi, çalışmanın konusuyla ilişkili bulunmuş ve incelemeye alınmıştır. Sistematik inceleme kapsamında 20 (%66) çalışmada mobil öğrenmenin 3D öğrenimi kolaylaştırdığı, motive edici ve eğlenceli olduğu ifade edilmiştir. Çalışmanın 19 (%63) tanesinde anatomi eğitiminde tıp fakültesi öğrencilerinin mobil uygulamalar ile öğrenme etkinliği araştırılmış ve öğrencilerden olumlu dönüşler alınmıştır. Fakat 6 (%20) çalışmada öğrenciler kadavra eğitimi ile öğreniminin daha kolay olduğunu, okul dışında internet erişiminin sıkıntılı olduğunu, kişisel cihazlarına programları indirmede zorlandıklarını ve programların ücretli olmasından dolayı kullanamadıklarını dile getirmişlerdir. 30 çalışmanın 6 (%20) tanesini artırılmış gerçeklik (AR) ile yapılan uygulamalar oluşturmaktadır. Çalışmaların 8 (%26) tanesinde mobil uygulama ile anatomi öğrenen öğrencilerde final sınav sonuçlarının geleneksel yöntem ile öğrenen öğrencilere kıyasla daha yüksek puan aldığı görülmüştür. İncelenen makalelerde; sınıf içinde, laboratuvarda ve sınıf dışında anatomi eğitimi için kullanılan mobil öğrenme tekniklerinin, geleneksel öğrenme yöntemlerine göre başarıyı artırdığı ve daha motive edici olduğu göstermiştir. Mobil uygulamalardan en çok başarı AR programlarının sağladığı ve öğrenci başarısı üzerinde herhangi bir olumsuz etkisi olmadığı görülmüştür.

Anahtar Kelimeler: Anatomi Eğitimi, Artırılmış Gerçeklik, Mobil Öğrenme, Sistematik Derleme.

The Effect of Mobile Learning in Anatomy Education on Learning Skills and Motivation of Students: Systematic Review

Abstract

Technologies that facilitate the understanding of anatomical structures are advantageous for students compared to classical methods. It is known that mobile learning and three-dimensional (3D) visualization methods are very useful in terms of students' perception, satisfaction and usability. The general purpose of this systematic review is to evaluate the studies investigating the effects of mobile learning in anatomy education. Electronic databases such as Google Scholar, Medline, Pubmed and Web of Science were used in the research. The use of mobile applications in anatomy education scans published after 2013 was reviewed. Research studies containing information about mobile applications used in anatomy education were analyzed using the keywords "anatomy education" and "mobile learning". Data were collected for the study between January 2013 and March 2022. In this context, 12220 articles were reached due to electronic scans. In the research, 779 scientific publications were reached in terms of appropriateness and 30 were found to be related to the subject of the study and were considered. Within the scope of the systematic review, it was stated in 20 (66%) studies that mobile learning facilitates 3D learning, is motivating and fun. In 19 (63%) studies, the learning activity of medical faculty students in anatomy

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education with mobile applications was investigated and positive feedback was received from the students. However, in 6 (20%) studies, students stated that cadaveric education was easier, internet access outside the school was problematic, they had difficulty in downloading programs to their personal devices and they could not use the programs because they were paid. 6 (20%) of 30 studies are applications made with augmented reality (AR). In 8 (26%) of the studies, it was seen that the final exam results of the students who learned anatomy with mobile application got higher scores than the students who learned with the traditional method. Examined articles have shown that mobile learning techniques used for anatomy education in the classroom, in the laboratory, and outside the classroom increase success and are more motivating than traditional learning methods. It has been seen that AR programs provide the most success among mobile applications and do not negatively affect student success.

Keywords: Anatomy Education, Augmented Reality, Mobile Learning, Systematic Review.

1. Introduction

Anatomy is the basic course in all departments related to health sciences (Mansouri et al., 2020). Before studying clinical sciences, it teaches the structure and functioning of the human body. Inadequate anatomy training can potentially lead to misdiagnosis and incorrect practices. As a result, it is an indispensable part of quality medical education (A. Meyer, N. Stomski, S. Innes, & A. Armson, 2016).

Anatomy contains many details that need to be learned and memorized, so it is a rather difficult lesson for students. Many students need educational materials other than print resources to be successful. These materials are generally based on modern educational technologies (Mansouri et al., 2020). In particular, technologies that facilitate spatial visualization and understanding anatomical structures are advantageous for students compared to classical methods. It is known that 3D visualization methods are very useful for students' perception, satisfaction, and usability (Mendez-Lopez, Juan, Molla, & Fidalgo, 2022).

Traditionally, anatomy education is theoretical and cadaveric dissection-based learning. However, there are problems such as high cost, excessive time requirement and limited cadaver availability in cadaver dissection. These problems have led to the emergence of modern computer technologies and the discovery of innovative, complementary tools for anatomy education. One of the applications that have become widespread of these technological developments is mobile applications. These applications are preferred in terms of ease of use and effective use of time. In addition, their low cost has caused them to be widely used by students studying in the health field and used in all fields. In this context, it can be foreseen that mobile applications related to anatomy education can be used more frequently in terms of convenient access to the desired information (Tirkeş, Gökpınar, Arıcı, & Bayralı, 2021).

Mobile learning is defined as any kind of learning or teaching activity carried out with mobile tools. It allows students and instructors to access learning systems over wireless networks using mobile devices. In a study, it is determined that mobile learning has the following characteristics: "visual richness, scientific comprehensiveness, auditory richness, affordability, user-centricity, self-assessment, interactive content, user support." In addition, it is known that it increases the motivation and academic success of the students, as it provides learning at the desired time and at the desired place. These features have brought significant innovations in educational technology by expanding the boundaries of traditional educational methods and have led to an increase in the use of mobile learning. (Bolatli & Kizil, 2022).

Mobile learning provides students with distinct advantages that can support the mobilized curriculum. It offers students multiple entry points and learning paths and allows differentiated learning. It makes it possible for students to have different learning tool that suits their needs and to access multiple modalities through mobile devices. Mobile games were preferred to make anatomy education easy, fluent, and motivating. Interaction, competition, entertainment, visual and instant feedback, accessibility, and easy winning aspects of mobile games effectively reinforced learning (Şahin & Çavus, 2019).

The Basıs Of Systematıc Revıew: With the advancement of technology in anatomy education, the number of innovative learning resources is increasing. These developments also provide an opportunity to conduct a systematic review and thus assess the impact of innovative learning resources. Although students generally use mobile learning tools well, more experimental research is needed to integrate these applications into the anatomy education curriculum (Golenhofen et al., 2020).

The general purpose of this systematic review is to evaluate the studies investigating the effects of mobile applications in anatomy education. To achieve this goal, the following research questions have been determine: 1) How comprehensively is the mobile application evaluated in anatomy education? 2) What is the contribution of the mobile application to anatomy education?

2. Material and Method

2.1. Design of the Research

This study is a systematic review.

2.2. The Strategy of the Research

Electronic databases such as Google Scholar, Medline, Pubmed, and Web of Science were used in the research. Since the use of mobile applications in anatomy education is a new phenomenon, scans published after 2013 were examined. Research studies containing information about mobile applications used in anatomy education were analyzed using the keywords “anatomy education” and “mobile learning”. Data were collected for the study between January 2013 and March 2022. The reference lists of other reviews, related review articles, and the files of the researchers were searched manually to determine the articles.

2.3. Inclusion and Exclusion Criteria in the Research

At the beginning of the research, all citation titles and abstracts were scanned. Articles deemed potentially appropriate were included as full text. If the inclusion of citations was found to be specific to anatomy education and included an assessment protocol detailing student learning, they were included in the study. There were no geographical restrictions, and only full texts in English were included in the study. Summary, letters to the

editor, compilations, systematic reviews, dissertations, textbooks, and congress proceedings were excluded. The full text of the articles included in the study was reviewed by two authors (E.E., G.B.), and the studies were discussed until a consensus was reached.

2.4. Data Extraction

Data in the study consists of sample type (students in medicine, dentistry, nursing, physiotherapy, and other health departments), length of study, type of study, year of publication and teaching environment (classroom, anatomy laboratory, and home), assessment methodology (pretest/posttest, evaluation question scores, and student satisfaction surveys) and teaching method (computer assisted learning tools, mobile devices, online learning methods, 3D application programs, virtual reality augmented images).

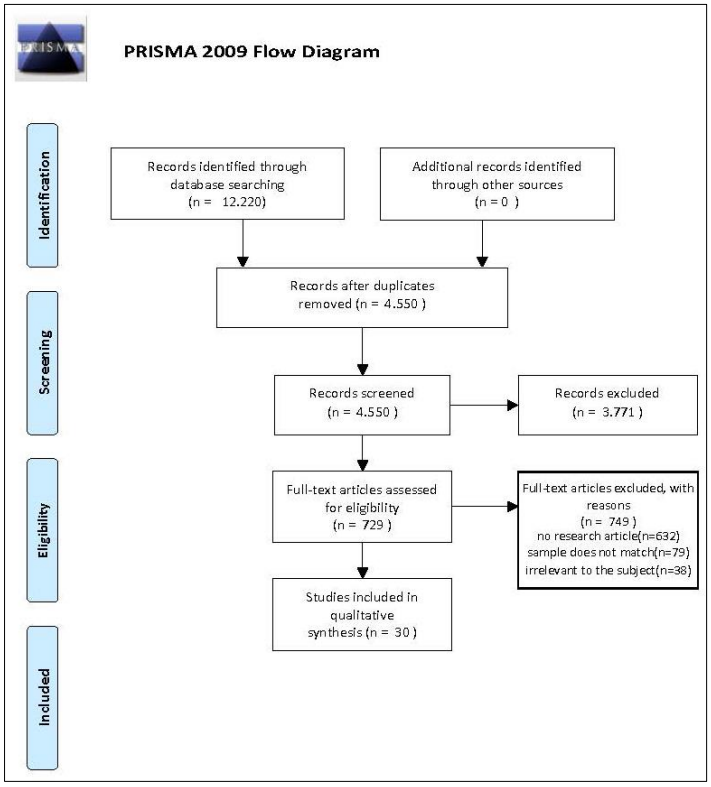
2.5. Data Analysis

The studies, which two independent researchers systematically compiled, were examined. A data summarization form was created by the researchers in order to form a consensus, and the studies were evaluated according to this form. In this form, eight titles have been determined as follows.

- ✓ Year of study,
- ✓ Authors of the study,
- ✓ The target audience of the study,
- ✓ Number of samples of the study,
- ✓ Mobile application type of the study,
- ✓ Student satisfaction with the study,
- ✓ Learning acquisition of the study and
- ✓ Content of the study.

In this context, using keywords, 12220 articles were reached due to electronic searches in Pubmed, Web of Science, and Google academic databases. In terms of relevance, 779 scientific publications were reached in the research, and 30 of these publications were found to be related to the subject of the study and were included in the review. "Preferred reporting items for systematic reviews and meta-analyses statement- PRISMA," which is a valid and reliable guide for systematic reviews, was used in summarizing the studies (Url-1, 2022) (Figure 1). The findings of this review are presented as follows, and a summary of each article included in the study is given in (Table 1).

Figure 1. PRISMA flowchart that shows the step-by-step process of the application of inclusion and exclusion criteria to generate a final number of studies for analysis in the systematic review.



3. Results and Discussion

3.1. Results

The authors of the articles included in the study presented many views on how anatomy education is used for learning and teaching in the classroom and virtual environment (Bolatli & Kizil, 2022; Fernández-Alemán, Lopez-Gonzalez, et al., 2016; A. J. Meyer, N. J. Stomski, S. I. Innes, & A. Armson, 2016; Wilkinson, Dafoulas, Garelick, & Huyck, 2020). Various mobile devices, mainly smartphones and tablets, were used in the studies,

and various research methodologies were used to examine the possibilities and limitations of mobile use.

Descriptive Analysis of the Included Studies

In the review, 12220 citations were provided to electronic databases, and after the duplication was removed, 4550 citations were identified, and 3771 of them were removed because they were deemed inappropriate. The remaining 779 citations were evaluated for a full review, of which 749 full-text articles were excluded from the research (632 without research articles, 79 without sample, 38 not relevant to the subject). The remaining 30 full-text articles included in the qualitative synthesis were evaluated.

The following headings were determined when the studies included in the research were examined.

The Effect of Anatomy Learning with a Mobile Application on Students

In the studies included in the research, it has been seen that mobile applications used in anatomy education have a positive effect on students. Within the scope of the systematic review, it was stated in 20 (66%) studies that mobile learning facilitates three-dimensional learning, is motivating and fun. They stated that they can access anatomy notes and images at any time of the day (Bolatli & Kizil, 2022; Bork et al., 2021; Fernández-Alemán, López-González, et al., 2016; Gnanasegaram, Leung, & Beyea, 2020; Golenhofen et al., 2020; Havens, Saulovich, & Saric, 2020; Jamali, Shiratuddin, Wong, Oskam, & Sciences, 2015; Kurniawan & Witjaksono, 2018; Küçük, Kapakin, & Göktaş, 2016; Lazarus, Sookrajh, & Satyapal, 2017; Mendez-Lopez et al., 2022; Mogali et al., 2019; Moro, Štromberga, Raikos, & Stirling, 2017; Morris, Lambe, Ciccone, & Swinnerton, 2016; Pickering, 2015; Stewart & Choudhury, 2015; Stirling & Birt, 2014; Traser, Hoffman, Seifert, & Wilson, 2015; Wilkinson & Barter, 2016; Wilkinson et al., 2020). In 19 (63%) studies, the learning effectiveness of medical school students in anatomy education with mobile applications was investigated, and positive feedback was received from the students. In addition, students said that learning is more permanent and takes place in a shorter time (Bork et al., 2021; Chandrasekaran et al., 2021; Fernández-Alemán, Lopez-Gonzalez, et al., 2016; Gnanasegaram et al., 2020; Golenhofen et al., 2020; Harmon, Burgoon, & Kalmar, 2022; Jamali et al., 2015; Kurniawan & Witjaksono, 2018; Küçük et al., 2016; Lazarus et al., 2017; Mayfield, Ohara, & O'Sullivan, 2013; Mogali et al., 2019; Morris et al., 2016; Pickering, 2015; Raney, 2016; Stewart & Choudhury, 2015; Stirling & Birt, 2014; Traser et al., 2015; Wilkinson et al., 2020). However, in 6 (20%) studies, students stated that cadaveric education was easier, internet access outside the school was problematic, they had difficulty in downloading programs to their personal devices and they could not use the programs because they were paid. It has also been observed that for students who do not have an iPad, mobile is a major obstacle to learning, but for students who use iPads, they improve their learning experience (Chakraborty & Cooperstein, 2018; Havens et al., 2020; Lazarus et al., 2017; Mansouri et al., 2020; A. J. Meyer, N. J. Stomski, S. I. Innes, et al., 2016; Pickering, 2015). In 2 (6%) studies included in the systematic article, in the mobile learning studies in anatomy education on psychology, physiotherapy, and biology students, a statistically positive return was achieved in the satisfaction of the students, and it was seen that learning was easier and permanent (Chakraborty & Cooperstein, 2018; Mendez-Lopez et al., 2022).

In a study on the iPad application, which consisted of nurses taking anatomy and physiology lessons and students studying in the physical education and biology departments; 63% of the students had an iPad, 48% of them were frequent users, and 30% were non-users, and the rest of them constitute the group of students who do not have an iPad. As a result of the survey, it was stated that the students who have an iPad and use it frequently have improved their learning experience and are satisfied compared to those who do not have an iPad and do not use it frequently (Chakraborty & Cooperstein, 2018).

Mayfield et al. (2013) determined in their study which they designed an iPad-based dissection guide, that the rate of students using textbooks and atlases decreased. The students needed fewer trainers, and the need for trainers was less despite spending time of the students on cadavers more.

Mobile Application Programs Used in Anatomy Education

The studies examined have explored various mobile devices, including personal digital-sourced devices, smartphones, and tablets. The mobile devices used in these studies used various research methods to examine their usage possibilities and limitations. Of the 30 studies reviewed, 1 was mobile games, 2 of them were intelligent Sistema De Respuesta Inmediata de la Audiencia in Spanish (i-SIDRA), 1 of them was an e-book, 2 of them were VARK, 2 of them were QR code applications, 1 of them was screencast, 6 of them were AR, 1 of them was AR and virtual reality (VR), 6 of them were iPad, and 8 of them were smartphones and other mobile applications.

Table 1. Synopsis of Each Article Reviewed

AUTHORS	YEAR	TARGET GROUP	NUMBER OF SAMPLE	MOBILE APPLICATION TYPE	STUDENT SATISFACTION	LEARNING OUTCOME
L Lazarus,R Sookrajh, K S Satyapal	2017	Medical Students	179	Mobile Device	The students stated that tablet and mobile devices provide clear and clear images and 3D images provide real images in anatomy learning. The majority of the students stated that they could understand more easily on real cadavers and that there were interruptions in the use of the internet outside the school and that the university was lacking in terms of resources.	Survey
Derek J. Harmon,Jennifer M. Burgoon,Eileen L. Kalmar	2022	Medical Students	195	Mobile Device	They stated that the implementation should be extended to include all anatomy-related materials for each learning block at the authors' institution.	Survey
Joshua J. Gnanasegaram, Regina Leung , Jason A. Beyea	2020	Medical Students	29	Holographic and 3D Model	Holographic model was preferred the most in terms of student motivation.	Assessment Test
Kate Wilkinson, George Dafoulas, Hemda Garelick and Christian Huyck	2020	Medical Students	246	Mobile Quiz Based Games	They stated that it was a great privilege to have these applications and to be able to access the topics and see the answers to the questions at any time of the day and anywhere.	Assessment Test
Magdalena Mendez-Lopez, M. Carmen Juan, Ramon Molla, Camino Fidalgo	2022	Psychology Students	69	AR Application	They explained that learning in 3D was easier and they were satisfied.	Survey
Ramya Chandrasekaran, Shairah Radzi, Peh Zhen Kai, Preman Rajalingam, Jerome Rotgans, Sreenivasulu Reddy Mogali	2021	Medical Students	163	3D Models And Plastinate Models	Students were generally satisfied and stated that learning with 3D structures was valuable and motivating.	Survey
Kathryn L. Havens; Nicole A. Saulovich; Karin J. Saric	2020	Physical Therapy Students	46	Mobile Device	Students were satisfied with the practices and only They had difficulty because of the high number of software references in the program.	Survey
José Luis Fernández-Alemán, Laura López-González, Ofelia González- Sequeros, Chrisina Jayne, Juan José López-Jiménez, Juan Manuel Carrillo- de-Gea, Ambrosio Toval	2016	Pharmacy Faculty Students	108	i-SIDRA System	Students evaluated the practices positively at the end of the study.	Survey
Allan Stirling, James Birt	2014	Medical Students	71	e-Book	The students responded positively and were especially pleased to find the anatomy lecture notes.	Survey Pretest-Posttest
Marcella A. Raney	2016	Medical Students	166	VARK Learning	The students were pleased and found it useful to learn the location and orientation of anatomy structures through 3D structures and the app	Survey

					applications.	
Tandra R. Chakraborty, Deborah F. Cooperstein	2018	Nursing, Physical Education And Biology Students Taking Anatomy And Physiology Courses	324	IPad Application	It has been observed that for students who do not have an iPad, mobile is a major obstacle to learning, but for students who use iPads, they improve their learning experience.	Survey
Christian Moro , Zane Stromberga, Athanasios Raikos , Allan Stirling	2017	Medical Students, Students From Health Sciences, Biomedical And Other Faculties Taking Anatomy Courses	59	AR, VR and IPad	The students who participated in the study found it very useful and useful and stated that they could see the images from a wider angle and that they could see the structures more clearly and that it was really an excellent application.	Assessment Test
José Luis Fernández-Alemána, Laura López-Gonzálezb, Ofelia González- Sequerosb,Chrisina Jaynec, Juan José López-Jiméneza, Ambrosio Tovalaa	2016	Medical Students	200	i-SIDRA	Students' feedback on their understanding of anatomy concepts They said that it helped them to learn and most of them wanted to repeat the experience in another subject. They also reported that students who used i-SIDRA significantly improved their scores in the final exam.	Survey
Andria Kusuma Wahyudi,Joe Yuan Mambu, Andreuw Vandy Lengkong, Nurhadi,Zalfie Ardian	2019	University Students	32	AR And 3D Cuboid Tracker	Students stated that they got better insights with the 3D cuboid marker	System Usability Scale (SUS) Assessment Test
James D. Pickering*	2015	Medical Students	223	A Screencast	Students felt that they had a better student experience and a belief that their knowledge of the subject had improved. that their images were clear. Also, although the visual component was slightly lower than the auditory component although they said that both the audio and visual elements of the videos were of high quality. Questions were also asked about the accessibility of the resource and although students found it easy to view the resources directly through the Virtual Learning Environment (VLE), they found it difficult to download them to their personal devices.	System Usability Scale (SUS)
Kate Wilkinson & Phil Barter Journal of Pedagogic Development	2016	Students Of Sport And Exercise Undergraduate	251	IPad	They preferred mobile learning more than the traditional method.	Pretest-Posttest

		Program				
Michael H Kurniawana, Suharjitoa, Dianab, Gunawan Witjaksonoa Procedia Computer Science	2018	Medical Students	30	AR	They were satisfied with AR.	Survey
Courtney J. Traser,Leslie A. Hoffman,Mark F. Seifert,Adam B. Wilson Anatomical science educations	2015	Medical Students	194	QR Code Application	They found it useful and it facilitated their learning.	Survey Pretest-Posttest
Sevda Küçük,Samet Kapakin,Yüksel Göktaş	2016	Medical Students	70	AR	Students generally stated that although the subject was difficult, their success was high and the application increased their success. Students also stated that they learned more permanent that learning takes place in a shorter time	Pretest-Posttest Cognitive Load Scale
Stuart Stewart,Bipasha Choudhury	2015	Medical Students	36	IPad	Students increased their academic achievement and recommended the practice.	Survey Pretest-Posttest
N.P. Morris,J. Lambe,J. Ciccone,B. Swinnerton Journal of Computer Asisted learning	2016	Medical Students	177	IPad	They stated that mobile tools were fun and facilitated their learning	Survey Pretest-Posttest
Chandler H. Mayfield,Peter T. Ohara,Patricia S. O'Sullivan Anatomical science education	2013	Medical Students	148	IPad	Reviewing and using the iPad-based lab manual Students stated that it helped them in reaching their goals. They also stated that they prefer ipad to textbooks, atlases and hardcover books.	Perception Survey
Siti Salmi JamaliMohd Fairuz ShiratuddinKok Wai WongCharlotte L. Oskam Procedia - Social and	2015	Medical Students	30	AR	They stated that their motivation increased.	Survey Pretest-Posttest
Sreenivasulu Reddy Mogali,Ranganath Vallabhajosyula,Chee Hon Ng,Darren Lim,Eng Tat Ang,Peter Abrahams Anatomical science Education	2019	Medical Students	120	Accessing Course Materials With QR Code	They gave positive opinions that it increased their motivation	Survey
Felix Bork,Alexander Lehner,Ulrich Eck,Nassir Navab,Jens Waschke,Daniela Kugelmann Anatomical Science	2020	Medical Students	16	Mobil AR	They found it motivating and enjoyable	Survey Pretest-Posttest

Education						
Nikola Golenhofen,Felix Heindl,Claudia Grab-Kroll,David A.C. Messerer,Tobias M. Böckers,Anja Böckers Anatomical Science Education	2020	Medical Students	320	Mobile Device	¾ of the students liked the mobi application and participated in the study by using it.	Survey
Amanda J. Meyer,Norman J. Stomski,Stanley I. Innes,Anthony J. Armson Anatomical Science Education	2016	Medical Students	109	VARK	Of the 8 anatomy applications, 5 are paid and 3 are free applications. Of these, only 2 paid recommended the application to other students. Out of 8 applications, they did not recommend 3 free applications.	Survey
Amanda J. Meyer, Norman J. Stomski,corresponding author C. Dominique Losco, and Anthony J. Armson Chiropr Man Therap	2016	Chiropractic Students	57	IPad	-	Pretest-Posttest Self-directed Learning Readiness Scale (SDLRS)
Mahmoud Mansouri, Shoaleh Bigdeli, Afsaneh Dehnad, Zohreh Sohrabi, Somayeh Alizadeh & Mohammad Hasan Keshavarzi BMC Medical Education	2020	Medical Students	17	Mobile Phone	Students expressed that they would like more guidance on how to use the apps (training/acclimatization before the session) and even They preferred to work with an educator (instructor training for the group using the applications) rather than on their own. Students stated that they could not use the anatomy apps at home because they were paid and could not afford it. Students preferred to use the apps on tablets/computers rather than smartphones due to the larger screen size and increased image resolution. All the anatomy applications examined did not have enough detail for spinal cord tracts and lesions. In addition, students stated that the applications were too expensive to download and that they could not install the free applications on their phones even with the help of an educator.	Survey
Güneş Bolatli, Hamiyet Kizil	2022	Nursing Students	64	Mobil Phone	Students generally stated that mobile learning had positive effects on learning anatomy.	Pretest-Posttest

Table 1. Synopsis of Each Article Reviewed

AUTHORS	YEAR	TARGET GROUP	NUMBER OF SAMPLE	MOBILE APPLICATION TYPE	STUDENT SATISFACTION	LEARNING OUTCOME
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Derek J. Harmon,Jennifer M. Burgoon,Eileen L. Kalmar	2022	Medical Students	195	Mobile Device	They stated that the implementation should be extended to include all anatomy-related materials for each learning block at the authors' institution.	Survey
Joshua J. Gnanasegaram, Regina Leung , Jason A. Beyea	2020	Medical Students	29	Holographic and 3D Model	Holographic model was preferred the most in terms of student motivation.	Assessment Test
Kate Wilkinson, George Dafoulas, Hemda Garelick and Christian Huyck	2020	Medical Students	246	Mobile Quiz Based Games	They stated that it was a great privilege to have these applications and to be able to access the topics and see the answers to the questions at any time of the day and anywhere.	Assessment Test
Magdalena Mendez-Lopez, M. Carmen Juan, Ramon Molla, Camino Fidalgo	2022	Psychology Students	69	AR Application	They explained that learning in 3D was easier and they were satisfied.	Survey
Ramya Chandrasekaran, Shairah Radzi, Peh Zhen Kai, Preman Rajalingam, Jerome Rotgans, Sreenivasulu Reddy Mogali	2021	Medical Students	163	3D Models And Plastinate Models	Students were generally satisfied and stated that learning with 3D structures was valuable and motivating.	Survey
Kathryn L. Havens; Nicole A. Saulovich; Karin J. Saric	2020	Physical Therapy Students	46	Mobile Device	Students were satisfied with the practices and only They had difficulty because of the high number of software references in the program.	Survey
José Luis Fernández-Alemán, Laura López-González, Ofelia González-Sequeros, Chrisina Jayne, Juan José López-Jiménez, Juan Manuel Carrillo-de-Gea, Ambrosio Toval	2016	Pharmacy Faculty Students	108	i-SIDRA System	Students evaluated the practices positively at the end of the study.	Survey
Allan Stirling, James Birt	2014	Medical Students	71	e-Book	The students responded positively and were especially pleased to find the anatomy lecture notes.	Survey Pretest-Posttest
Marcella A. Raney	2016	Medical Students	166	VARK Learning	The students were pleased and found it useful to learn the location and orientation of anatomy structures through 3D structures and the app applications.	Survey

Tandra R. Chakraborty, Deborah F. Cooperstein	2018	Nursing, Physical Education And Biology Students Taking Anatomy And Physiology Courses	324	IPad Application	It has been observed that for students who do not have an iPad, mobile is a major obstacle to learning, but for students who use iPads, they improve their learning experience.	Survey
Christian Moro , Zane Stromberga, Athanasios Raikos , Allan Stirling	2017	Medical Students, Students From Health Sciences, Biomedical And Other Faculties Taking Anatomy Courses	59	AR, VR and IPad	The students who participated in the study found it very useful and useful and stated that they could see the images from a wider angle and that they could see the structures more clearly and that it was really an excellent application.	Assessment Test
José Luis Fernández-Alemána, Laura López-Gonzálezb, Ofelia González-Sequerosb,Chrisina Jaynec, Juan José López-Jiméneza, Ambrosio Tovalaa	2016	Medical Students	200	i-SIDRA	Students' feedback on their understanding of anatomy concepts They said that it helped them to learn and most of them wanted to repeat the experience in another subject. They also reported that students who used i-SIDRA significantly improved their scores in the final exam.	Survey
Andria Kusuma Wahyudi,Joe Yuan Mambu, Andreuw Vandy Lengkong, Nurhadi,Zalfie Ardian	2019	University Students	32	AR And 3D Cuboid Tracker	Students stated that they got better insights with the 3D cuboid marker	System Usability Scale (SUS) Assessment Test
James D. Pickering*	2015	Medical Students	223	A Screencast	Students felt that they had a better student experience and a belief that their knowledge of the subject had improved. that their images were clear. Also, although the visual component was slightly lower than the auditory component although they said that both the audio and visual elements of the videos were of high quality. Questions were also asked about the accessibility of the resource and although students found it easy to view the resources directly through the Virtual Learning Environment (VLE), they found it difficult to download them to their personal devices.	System Usability Scale (SUS)
Kate Wilkinson & Phil Barter Journal of Pedagogic Development	2016	Students Of Sport And Exercise Undergraduate Program	251	IPad	They preferred mobile learning more than the traditional method.	Pretest-Posttest

Michael H Kurniawana, Suharjitoa, Dianab, Gunawan Witjaksonoa Procedia Computer Science	2018	Medical Students	30	AR	They were satisfied with AR.	Survey
Courtney J. Traser,Leslie A. Hoffman,Mark F. Seifert,Adam B. Wilson Anatomical science educations	2015	Medical Students	194	QR Code Application	They found it useful and it facilitated their learning.	Survey Pretest-Posttest
Sevda Küçük,Samet Kapakin,Yüksel Göktaş	2016	Medical Students	70	AR	Students generally stated that although the subject was difficult, their success was high and the application increased their success. Students also stated that they learned more permanent that learning takes place in a shorter time	Pretest-Posttest Cognitive Load Scale
Stuart Stewart,Bipasha Choudhury	2015	Medical Students	36	IPad	Students increased their academic achievement and recommended the practice.	Survey Pretest-Posttest
N.P. Morris,J. Lambe,J. Ciccone,B. Swinnerton Journal of Computer Asisted learning	2016	Medical Students	177	IPad	They stated that mobile tools were fun and facilitated their learning	Survey Pretest-Posttest
Chandler H. Mayfield,Peter T. Ohara,Patricia S. O'Sullivan Anatomical science education	2013	Medical Students	148	IPad	Reviewing and using the iPad-based lab manual Students stated that it helped them in reaching their goals. They also stated that they prefer ipad to textbooks, atlases and hardcover books.	Perception Survey
Siti Salmi JamaliMohd Fairuz ShiratuddinKok Wai WongCharlotte L. Oskam Procedia - Social and	2015	Medical Students	30	AR	They stated that their motivation increased.	Survey Pretest-Posttest
Sreenivasulu Reddy Mogali,Ranganath Vallabhajosyula,Chee Hon Ng,Darren Lim,Eng Tat Ang,Peter Abrahams Anatomical science Education	2019	Medical Students	120	Accessing Course Materials With QR Code	They gave positive opinions that it increased their motivation	Survey
Felix Bork,Alexander Lehner,Ulrich Eck,Nassir Navab,Jens Waschke,Daniela Kugelmann Anatomical Science Education	2020	Medical Students	16	Mobil AR	They found it motivating and enjoyable	Survey Pretest-Posttest
Nikola Golenhofen,Felix Heindl,Claudia Grab-Kroll,David A.C. Messerer,Tobias M. Böckers,Anja Böckers Anatomical Science Education	2020	Medical Students	320	Mobile Device	¾ of the students liked the mobi application and participated in the study by using it.	Survey

Amanda J. Meyer,Norman J. Stomski,Stanley I. Innes,Anthony J. Armson Anatomical Science Education	2016	Medical Students	109	VARK	Of the 8 anatomy applications, 5 are paid and 3 are free applications. Of these, only 2 paid recommended the application to other students. Out of 8 applications, they did not recommend 3 free applications.	Survey
Amanda J. Meyer, Norman J. Stomski,corresponding author C. Dominique Losco, and Anthony J. Armson Chiropr Man Therap	2016	Chiropractic Students	57	IPad	-	Pretest-Posttest Self-directed Learning Readiness Scale (SDLRS)
Mahmoud Mansouri, Shoaleh Bigdeli, Afsaneh Dehnad, Zohreh Sohrabi, Somayeh Alizadeh & Mohammad Hasan Keshavarzi BMC Medical Education	2020	Medical Students	17	Mobile Phone	Students expressed that they would like more guidance on how to use the apps (training/acclimatization before the session) and even They preferred to work with an educator (instructor training for the group using the applications) rather than on their own. Students stated that they could not use the anatomy apps at home because they were paid and could not afford it. Students preferred to use the apps on tablets/computers rather than smartphones due to the larger screen size and increased image resolution. All the anatomy applications examined did not have enough detail for spinal cord tracts and lesions. In addition, students stated that the applications were too expensive to download and that they could not install the free applications on their phones even with the help of an educator.	Survey
Güneş Bolatli, Hamiyet Kizil	2022	Nursing Students	64	Mobil Phone	Students generally stated that mobile learning had positive effects on learning anatomy.	Pretest-Posttest

When the studies included in the research are examined, the most used application module in mobile learning is anatomy atlases and applications that transform images and photographs in books into 3D images via AR. 6 (20%) of 30 studies are applications made with AR. Questionnaires were conducted about their views on these practices and the aspects that need to be improved. It was seen that the application has advantages, facilitates learning, increases motivation, and they stated that the application should be more comprehensive and contain more visuals. According to the survey results, they received positive feedback from the students (Jamali et al., 2015; Kurniawan & Witjaksono, 2018; Küçük et al., 2016; Mendez-Lopez et al., 2022; Moro et al., 2017; Wahyudi, Mambu, Lengkong, & Ardian, 2019).

In 10 (3%) of the studies included in the research, they compared the traditional learning method and mobile application methods to investigate the effect of mobile learning. In 8 (26%) of the studies, it was observed that the final exam results of the students who learned anatomy with the mobile application were higher than the students who learned with the traditional method (Chakraborty & Cooperstein, 2018; Fernández-Alemán, López-González, et al., 2016; Fernández-Alemán, Lopez-Gonzalez, et al., 2016; Lazarus et al., 2017; Moro et al., 2017; Traser et al., 2015; Wilkinson & Barter, 2016; Wilkinson et al., 2020). In the other 2 (6%) studies, it was observed that the anatomy final exam results of the experimental groups were higher, but there was a decrease in their cognitive levels (Bork et al., 2021; Küçük et al., 2016).

8 (26%) of the studies included in the research are exploratory and consist of articles that are not compared (Golenhofen et al., 2020; Harmon et al., 2022; Havens et al., 2020; Jamali et al., 2015; Kurniawan & Witjaksono, 2018; Pickering, 2015; Stewart & Choudhury, 2015). These articles have made no direct comparison between mobile learning and other learning experiences and methodologies. The aim of these studies is to document the mobile learning experience through descriptive quantitative and qualitative measurements. The research questions show that the focus is on the students' perspectives on technology, their participation, and their views on mobile learning. In several studies, multiple anatomy topics were examined simultaneously and researched on student engagement, flexible learning models, and the future usability of mobile tools with different mobile learning applications in the classroom (Harmon et al., 2022; Havens et al., 2020; Jamali et al., 2015; Pickering, 2015). These studies aim to document the potential and experience of mobile learning through qualitative and quantitative measurements. In these studies, there was no comparison made, and the measures used by the researchers, qualitative data such as observations and interviews, student scores, questionnaires, mobile usage, and participant satisfaction are included (Golenhofen et al., 2020; Harmon et al., 2022; Havens et al., 2020; Jamali et al., 2015; Kurniawan & Witjaksono, 2018; Pickering, 2015; Stewart & Choudhury, 2015).

Positive Results Of Mobile Learning

Wilkinson et al. (2020) have seen that with gameplay in mobile learning, the learning of anatomy is reinforced, the information is repeated, the success rate is increased, and it makes learning fun by taking the lesson away from boring. In 3 studies included in the systematic article, it was found that the exam results of the students who received anatomy education with mobile applications compared to traditional learning methods were statistically significantly higher ($p<0.001$) (Fernández-Alemán, López-González, et al., 2016; Stirling & Birt, 2014; Wilkinson & Barter, 2016). Morris et al. (2016) stated that using the iPad during the practical lesson was enjoyable and improved students (76.3%-82.4%) learning, and students (78.9%-85.9%) stated that it was easy to use the device.

Negative Consequences Of Mobile Learning

When we look at the studies researched in this systematic article, Gross anatomy mostly constitutes anatomy subjects in mobile learning. It examines the skeleton, muscle, joint, nervous system, all organ structures, and body parts as content (Bork et al., 2021; Chakraborty & Cooperstein, 2018; Chandrasekaran et al., 2021; Fernández-Alemán, López-González, et al., 2016; Fernández-Alemán, Lopez-Gonzalez, et al., 2016; Havens et al., 2020; Jamali et al., 2015; Kurniawan & Witjaksono, 2018; Lazarus et al., 2017; Mayfield et al., 2013; Mogali et al., 2019; Raney, 2016; Traser et al., 2015; Wilkinson & Barter, 2016; Wilkinson et al., 2020). Other studies also include neuroanatomy, microanatomy, and embryology (Golenhofen et al., 2020; Lazarus et al., 2017; Mogali et al., 2019; Wilkinson & Barter, 2016; Wilkinson et al., 2020). When the students were asked which anatomy subjects would be more useful to learn with mobile applications, 56% of them stated that it was the cardiovascular system and 29% of them stated that it was the musculoskeletal system (Chakraborty & Cooperstein, 2018). In the iPad-based anatomy laboratory session, it was observed that cadaver dissection was facilitated with three-dimensional images, but the presence of anatomical variations that could be seen affected the content and activity results (Küçük et al., 2016; Mayfield et al., 2013; Meyer, Stomski, Losco, Armson, & Therapies, 2016).

In the studies, mobile learning was mostly carried out in the classroom and anatomy laboratory environment. This situation has brought limitations to the studies. Because the reasons such as the lack of internet access for students outside of school, the lack of iPad tools for some students, and the fact that the applications are paid and cannot be downloaded to their phones have imposed limitations on the studies (Bolatli & Kizil, 2022; Lazarus et al., 2017; Morris et al., 2016).

Evaluation Of Learning Achievements In Anatomy Education

In 30 studies included in the study, questionnaires, pretest-posttest, and evaluation tests were used to evaluate the learning outcomes of anatomy education. Of the 30 studies included in this systematic review, 16 were made with only a questionnaire, 6 were both pretest-posttest and questionnaire, 1 of them was both pretest-posttest and self-directed learning readiness scale (SDLRS), respectively 3 of them were only pretest-posttest, and 4 of them were evaluation tests (Bork et al., 2021; Chakraborty & Cooperstein, 2018; Fernández-Alemán, López-González, et al., 2016; Harmon et al., 2022; Havens et al., 2020; Jamali et al., 2015; Kurniawan & Witjaksono, 2018; Lazarus et al., 2017; Mansouri et al., 2020; Mayfield et al., 2013; Mendez-Lopez et al., 2022; A. J. Meyer, N. J. Stomski, S. I. Innes, et al., 2016; Mogali et al., 2019; Morris et al., 2016; Pickering, 2015; Raney, 2016; Stewart & Choudhury, 2015; Stirling & Birt, 2014; Traser et al., 2015; Wahyudi et al., 2019). In the surveys conducted in 16 studies, the highest number of participants was 324, and 82% of this number were female students, and 18% were male students (Chakraborty & Cooperstein, 2018). In the three studies using pretest and posttest, the maximum number of participants is 251, and the studies using the evaluation test have a maximum of 246 participations (Wilkinson & Barter, 2016; Wilkinson et al., 2020).

3.2. Discussion

With the use of technology in education, the use of mobile phones and educational applications is increasing. It is possible to access applications anytime and anywhere via mobile phones over the Internet. Mobile learning, which is included in educational applications, is an educational tool whose use is increasing (Liu et al., 2014)

In classical anatomy education, there are problems such as using the laboratory in limited time and not being able to access information outside the classroom. Anatomy books are boring for many students, and it becomes difficult to memorize and keep in memory since they contain too many details. Students also generally expressed that visual learning remains easier in memory (Co et al., 2021). The main purpose of teaching cadavers, which is one of the important teaching methods in anatomy education, is to enable students to examine the anatomical structures they see in the textbooks in three dimensions and to see the relationship between these structures concretely. Although this method provides many advantages, finding and preserving cadavers can cause many ethical and health problems (Küçük et al., 2016). While most anatomists and surgeons argue that clinical anatomy learning is based on cadaver dissection, some argue that there should be technology-based education. Problems with cadaveric education have increased the need for alternative education means (Rosario, 2021).

Mobile learning is defined as learning using mobile technologies such as mobile phones, smartphones, e-readers, and tablets. It is argued that these devices offer unique access to communication and information. Mobile technology is more affordable, more functional than other technologies, and seems to better support learning in the classroom and at home in new ways. Mobile learning is an application that gives students the flexibility to study whenever and wherever they want. The allowed flexibility supports students to learn at their own pace and style (Liu et al., 2014). Mobile learning also has a positive impact on the academic success of students. Mobile augmented reality (AR) integrates digital data into the real environment, providing users with a comprehensive sensory experience (Küçük et al., 2016). For this reason, mobile learning can be offered as an alternative, especially in departments without a laboratory or where the number of cadavers is insufficient (Korf et al., 2008; Nicholson, Chalk, Funnell, & Daniel, 2006; Parker, 2002).

Studies conducted on mobile learning in anatomy education stated that student satisfaction is higher than traditional learning methods and that difficult subjects can become more permanent in a shorter time. It has also been seen that mobile learning increases the motivation of students (Havens et al., 2020; Küçük et al., 2016; Mayfield et al., 2013; Wilkinson & Barter, 2016). With mobile learning, it is possible to access high-quality education and information wherever and whenever you want. Therefore, it has been stated that the mobile application can bring a new breath to anatomy education (Bolatli & Kizil, 2022).

Students now have access to a wide variety of electronic learning resources, such as online websites, software packages, and “applications” available on their mobile phones. Augmented reality is a technology that offers a new educational approach that helps students develop critical capacity and understand scientific research concepts more deeply. In addition, AR allows examining difficult-to-understand abstract concepts such as three-dimensional shapes and geometric objects through textbooks (Sural, 2017). According to the studies included in the systematic article, it was found that AR-related students increased their course success, and the AR encouraged students. In literature studies, it has been seen that programs that transform anatomy atlas or images in books into 3D images through AR have improved students' learning potential and that learning with three-dimensional images is easier and more effective and, at the same time, increases the motivation of students (Bork et al., 2021; Jamali et al., 2015; Kurniawan & Witjaksono, 2018; Küçük et al., 2016; Mendez-Lopez et al., 2022; Moro et al., 2017; Wahyudi et al., 2019). On the other hand, applications for obtaining high-quality images are expensive, and many of them have been criticized by anatomists for failing to convey a realistic anatomical representation. Although the e-learning packages available on the market claim to show 3D anatomy, there are studies stating that the representations on a screen are not actually three-dimensional compared to the actual cadaveric anatomy (Demirtaş, Onay, & Günerigök, 2019).

Stirling and Birt (2014) stated that mobile e-book applications in anatomy learning increased by 13% compared to the traditional application method. 4 (13%) of the articles included in the research with iPad-based mobile learning and 8 (26%) of them with smartphones stated that mobile learning increased student satisfaction, motivation, course success, and permanent learning (Bolatli & Kizil, 2022; Chakraborty & Cooperstein, 2018; Golenhofen et al., 2020; Harmon et al., 2022; Havens et al., 2020; Lazarus et al., 2017; Mayfield et al., 2013; A. J. Meyer, N. J. Stomski, C. D. Losco, et al., 2016; Morris et al., 2016; Stewart & Choudhury, 2015; Wilkinson & Barter, 2016; Wilkinson et al., 2020). In addition, students noted that using mobile devices in a practical classroom is valuable and useful for learning (Morris et al., 2016).

In previous studies on mobile learning, it was observed that students' interest in the course increased and there was a reasonable level of academic learning and motivation (Chen, Kao, & Sheu, 2003; Kumar et al., 2010; Liaw, Hatala, & Huang, 2010).

Among the studies included in the research, Traser et al. (2015) stated that in their study on QR code applications, students were allowed to evaluate their knowledge with instant feedback. Mogali et al. (2019) found in their study that learning becomes easier, access to course content is easy, and it provides independent learning. However, it has been emphasized that more research is needed to see the effect of QR codes on students' anatomy education. In addition, using QR codes did not significantly contribute to practical exam performance.

It is known that mobile games, which are popular in many areas, are also effective, especially in education (Hamari, Koivisto, & Sarsa, 2014). Studies conducted in education and learning have shown that mobile games increase participation, motivation, and learning tasks in learning outcomes and make the learning process more enjoyable. However, some negative aspects have also been highlighted in studies that require attention, such as increased competition, difficulties in task evaluation, and design features. When a comparison is made between the control and experimental groups consisting of 246 students, Wilkinson and Barter (2016) found that the success rate of the students in the experimental group was statistically higher.

In studies conducted in other fields, it has been seen that mobile learning is effective in medicine and science, helps students use grammar, and brings a new perspective and solutions for their learning (Seisto et al., 2011).

Limitations of the Study

In the systematic review, studies containing valid results for the research may not be available because there is a threat of inadequacy to search the literature, and it is tried to reach the literature within the possibilities available in the research. Since the number of samples is insufficient in some of the studies examined, there are limitations related to the data analysis. Failure to identify appropriate studies will likely be limited when we consider the given range of keywords used to select studies, the time chosen to collect appropriate studies, relevant and comprehensive databases, and manual search among known journals. In this review, the number of studies on the subject is growing rapidly, and we encourage other researchers to continue where we finished the literature review for this important topic.

4. Conclusions and Recommendations

This systematic review was done by considering the effectiveness of mobile applications used in anatomy education and student feedback. It has been found that mobile learning techniques used for anatomy education in the classroom, in the laboratory, and outside the classroom increase success and are more motivating than traditional learning methods. It has been seen that AR programs provide the most success among mobile applications and do not negatively affect student success.

The use of AR and other mobile programs has been shown to have a very positive effect on students' spatial understanding and three-dimensional understanding of anatomical structures. We think that these innovative applications can be conveniently downloaded to all students' mobile devices anywhere, and the high image quality of the free applications can further increase the success rate. However, insufficient research has been done in this study, and academic programs need to integrate more innovative techniques to evaluate three-dimensional anatomy learning properly.

It is important that the applications used in mobile learning are suitable for the needs of the students and the technological infrastructure. While planning the process, the orientation process for the students regarding the environment and technology to be used should be included. Thus, we think that the problems that may arise from the features of the developed applications will be minimized and a suitable learning environment will be provided for the students.

In the study, the mobile learning approach focused more on the students' individual learning. Since the application offers a flexible and individual learning environment to students, it can be thought that it may be useful to integrate such applications with distance education textbooks. When the results obtained by the pre-test-post-test and the feedback of the students are considered, it is thought that the continuity of the study can be ensured.

Overall, based on the findings of the study, mobile learning in anatomy education seems to provide a learning environment for students and educators where they can potentially access the learning system at any time of the day and anywhere. It can be concluded that mobile learning is an alternative learning technique suitable for traditional teaching practices in the new age where new technology is developing.

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