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iJET International Journal of Emerging Technologies in Learning

iJET | eISSN: 1863-0383 | Vol. 18 No. 23 (2023) | OPEN ACCESS

https://doi.org/10.3991/ijet.v18i23.44083

PAPER

Technology Adoption of Computer-Aided Instruction in Healthcare: A Structured Review

Queenie Kate Cabanilla[1], Frevy Teofilo-Orencia[2], Rentor Cafino[3], Armando T. Isla Jr.[4], Jehan Grace Maglaya[5], Xavier-Lewis Palmer[6], Lucas Potter[6], Dave E. Marcial[7], Lemuel Clark Velasco[1,8](✉)

[1]Mindanao State University-Iligan Institute of Technology, Iligan City, The Philippines

[2]Benguet State University, La Trinidad, Benguet, The Philippines

[3]Zamboanga City Medical Center, Zamboanga City, The Philippines

[4]Mercy Community Hospital, Iligan City, The Philippines

[5]University of the East-Ramon Magsaysay Memorial Medical Center, Quezon City, The Philippines

[6]Old Dominion University, Norfolk, Virginia, USA

[7]Silliman University, Dumaguete City, The Philippines

[8]Premiere Research Institute of Science and Mathematics – Center for Computational Analytics and Modelling, Iligan City, The Philippines

lemuelclark.velasco@g.msuiit.edu.ph

ABSTRACT

Computer-Aided Instruction (CAI) is one of the interactive teaching methods that electronically presents instructional resources and enhances learner performance. In health settings, using CAI is one of the important ways to improve learners' knowledge and usefulness in their healthcare specialization yet there is still a lack of research that offers a comprehensive synthesis of investigating into the adoption of CAI in healthcare. This research aims to provide a comprehensive review of related literatures on the enablers and barriers for technology adoption of CAI in healthcare. 31 journals were analyzed and revealed that several studies were utilizing the Unified Theory of Acceptance and Use of Technology (UTAUT). The researchers then conducted qualitative coding for thematic analysis and categorized the qualitative data to find themes and patterns. Enablers as well as barriers to CAI adoption in healthcare were then discussed along with the common conclusions, limitations and recommendations for future studies. Results shows that key enablers were perceived ease of use, ease of usefulness, performance expectancy, social influence, user experience, and effort expectancy while identified key barriers were government support, funding constraints, and interactivity. The majority of the research articles highlighted the benefits of CAI in healthcare education as an innovative method for boosting the effectiveness of both teaching and learning.

KEYWORDS

technology adoption, computer-aided instruction, computer-assisted instruction, CAI in healthcare, PRISMA

1 BACKGROUND OF THE STUDY

Computer technology has become an important educational resource and has dramatically changed the teaching and learning modality. Computer-Aided Instruction (CAI), sometimes referred to as computer-assisted instruction, is any software program that facilitates the abilities of the learners in understanding a certain topic [1]. [2], [3]. It is a specialized educational platform that can also be used to

Cabanilla, Q.K., Teofilo-Orencia, F., Cafino, R., Isla Jr., A.T., Maglaya, J.G., Palmer, X.-L., Potter, L., Marcial, D.E., Velasco, L.C. (2023). Technology Adoption of Computer-Aided Instruction in Healthcare: A Structured Review. *International Journal of Emerging Technologies in Learning (iJET)*, 18(23), pp. 160–181. https://doi.org/10.3991/ijet.v18i23.44083

Article submitted 2023-08-15. Revision uploaded 2023-09-14. Final acceptance 2023-09-20.

augment teaching and learning towards a learner-centered environment through interactive teaching methods that present instructional resources and enhance learner performance [1], [2], [3], [4], [5], [6]. CAI is known to be an effective resource in training, learning, and instruction in diverse disciplines of healthcare [1], [6], [7]. Numerous reports have been made on the utilization of CAI in providing supplementary materials, as well as practice tutorials to enhance skills and knowledge in medical and allied health education. The availability of CAI content databases provides easy access to healthcare educational materials that enhance the learner's ability to learn complex lessons. CAI usage is also reported in medicine and pharmacology due to its accessibility, ease of use, flexibility of discovery, high-quality medical imaging and the benefit of repeated practice to help in learning [5], [7]. CAI has expanded in medical education from simple applications to a number of computer formats specifically for the digital nature of ultrasound imaging and the video qualities of endoscopic surgery [9], [10]. CAI's computer imaging and simulation also bring considerable benefits to both professionals and patients as it provides more precision and accuracy in diagnosis and surgery [8], [7]. CAI also allows trainees to gain experience and develop their skills before they begin working on actual patients to practice surgical procedures in a safe and controlled environment without maximizing risks for the patients. In the health education setting, using computers with software programs has been deemed useful to increase learners' knowledge and improve clinical self-efficacy [11], [12], [13], [14]. By using CAI to facilitate learning, healthcare professionals can stay up-to-date with the latest advances in their field, adapt to new challenges and opportunities, and continually improve the quality of care they provide.

Technology adoption in healthcare entails acquiring and adequately employing the technology for its intended use. Among the most popular technology adoption models is the Technology Acceptance Model (TAM) which shows that there are two primary factors that affect adoption: (1) perceived usefulness and (2) perceived ease of use [15]. TAM explains the general determinants of computer acceptance that lead to an understanding of user behavior across a wide range of end-user computing technologies and user groups. Because of the limitations of TAM, it evolved with additional factors to include individual differences, system characteristics, social influence, and facilitating conditions [11], [15], [16]. With this, the Unified Theory of Acceptance and Use of Technology (UTAUT) was also employed by researchers to analyze technology adoption of CAI for healthcare applications [1], [4]. The use of mixed media in the teaching-learning process increases learners' level of comprehension in terms of visual and intellectual structures, which is improved greatly by the technology adoption of CAI when computers are used in the classroom [17]. Technology adoption of CAI may take into account factors such as how individuals view new learning technologies, subjective norms such as perceived social pressure to use or not utilize new technologies, and the ease of use of the CAI [12], [13].

The growing literature of techniques for evaluating the success of CAI in medical, nursing, and allied health care education has been studied but there is a lack of research conducted on instructional design principles and components of CAI in healthcare [4]. Moreover, it can also be observed that there is also a lack of research that offers a comprehensive synthesis on the adoption of CAI in healthcare. Thus, this research aims to provide a comprehensive review of the related literature in technology adoption of CAI in healthcare. Specifically, this paper presents determinants on the technology adoption of CAI with a particular focus on the factors that influence adoption. Lastly, this paper presents the gaps in related literature and gives recommendations for future research. The results of this research are intended to benefit healthcare educators, developers and technology providers, information systems researchers, and educational technology stakeholders. Furthermore, this study aims to contribute to CAI knowledge by analyzing the factors that influence technology adoption of CAI in healthcare settings. This knowledge can be used in designing future CAI systems which take into account enablers and barriers for technology adoption.

2 METHODOLOGY

This structured review follows the 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. The review followed a systematic approach to identify, screen, and synthesize relevant literature related to technology adoption of CAI in healthcare. The methodology employed in this study involved six main steps: defining the scope of the review, identifying relevant literature, screening and selecting studies, extracting data, synthesizing the findings, and discussing the implications. To define the scope of the review, specific technologies and methods of CAI as well as the specific outcomes or impacts of interest were extracted from the selected studies. A comprehensive search of relevant journals was conducted to identify relevant literatures. The relevant literatures were then screened and selected based on predefined inclusion and exclusion criteria. Then the study design, sample size, type of technology model used, and outcomes measured were extracted from the selected studies. The data were then synthesized to draw conclusions about the technology adoption of CAI and identify any common themes or trends that emerge from the studies. Finally, the implications of the findings for future research were discussed.

2.1 Literature profiling

This section synthesized the studies by gathering, digesting and profiling relevant journal articles on technology adoption of CAI in health care. The literature synthesis was done after compiling the final sample size of the gathered journal articles stored in the literature bank and profiling the final sample size. Majority of the literatures provided the researchers with useful results for identifying possible research trends and essential research insights of medical or academic researchers interested in conducting further work as well as highlighting related questions that need to be answered for future investigations [17], [18], [19]. This study followed a systematic methodology in identifying the sample literature included in the content analysis and used the criteria for mining literature as depicted in Figure 1 which is based on the 2020 PRISMA [20], [21], [22]. To determine the relevant research articles, several keywords were used to search the literature which included "Computer-Aided Instruction" OR "CAI in Healthcare" OR "CAI in medical education" OR "CAI in education" OR "CAI in Surgeons" OR "CAI in Dental" OR "CAI in Anatomy education" OR "CAI in pharmacy" OR "Evaluating the CAI" [6], [16], [20], [21], [22], [23], [24], [25], [26]. As shown in Figure 1, the key terms were searched in Google Scholar resulting in a total of 204,610 published journal articles. It was then classified by English language and year published before 2022 which then resulted in 13,454 journal articles. To identify credibility, the journal articles were then screened by identifying if each journal articles had at least 2 or higher citations resulting to 7,745 journal articles. After excluding review literatures, the total number of journal articles were then reduced to 5,880. The articles were again screened by its relevance to title, abstract, and keywords, which resulted in 5,764 journal articles. Then the search phrase was modified to match the target article's title, abstract, and keywords, which resulted in 116 journal articles. The Journal Assessment Matrix (JAM) was utilized as a method to synthesize the research questions, research objectives, methodology, and results of the articles. A total of 60 journal articles was digested and recorded in the JAM. After searching each publisher name indexed in Scopus or Web of Science (WoS) databases for getting the credibility of each item, the sample size was finally reduced to 31 journal articles. This review does not claim to cover all publications primarily dealing with computer aided-instruction in general but only in CAI in healthcare to make all healthcare educational instructional materials accessible to learners in a way that improves their capacity to understand complex concepts.

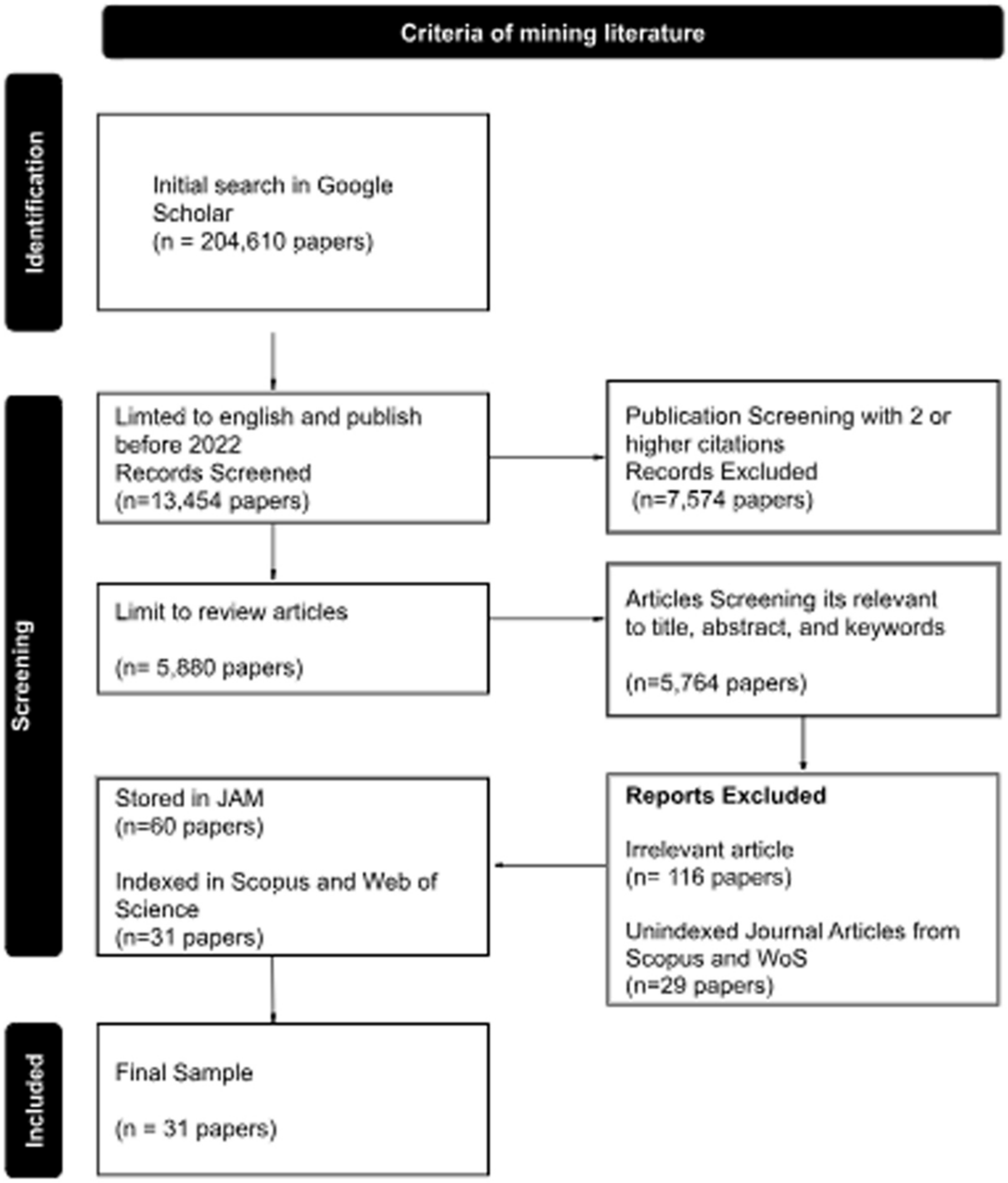

Fig. 1. PRISMA flowchart as used in this study

The final sample size of the study was then profiled using qualitative coding for the thematic analysis in order to find the themes and patterns. The researchers used the tallying method to list and theme the variables that are pertinent to the studies during the profiling process. The variables used in profiling the literature were the authors' background, educational degree, geographic location, methodology, subject area and related study category [1], [5]. The researchers then read each journal and listed all the variables needed to be collected. After identifying the year, the researchers identified the categories of the journal using the Scimago journals and country rank [27], [28], [29], [30]. To address these themes, the researchers analyzed the frequency of publication to see in what year the author's perspective was first studied. In order to ascertain which nation has the most publishers, the authors' geographic location was also listed, followed by their academic background and area of specialization.

2.2 Technology adoption factors of CAI in healthcare

This section identified the behavior of the user towards adopting CAI in healthcare. The synthesis of the journal article sample size discovered that some of the authors were interested in technology adoption of CAI in healthcare using the UTAUT as shown in Figure 2. The authors tallied the papers and found out that several studies are utilizing UTAUT [1], [4], [32], [33]. However, the studies were not yet synthesized to gain a comprehensive understanding of the factors that influence the adoption of CAI in healthcare through an inductive coding approach. Thus, the authors analyzed each thematic group from tallying their methodology followed by synthesizing their results and discussions. It was then confirmed that several studies were using UTAUT that identifies four key factors (i.e., performance expectancy, effort expectancy, social influence, and facilitating conditions) and four moderators (i.e., age, gender, experience, and voluntariness) related to predicting behavioral intention to use a technology and actual technology used primarily in organizational contexts [16].

The authors then divided the analysis of technology adoption of CAI in healthcare based on constructs of UTAUT into enablers and barriers. According to UTAUT, performance expectancy, effort expectancy, and social influence were theorized and found to influence behavioral intention to use a technology, while behavioral intention and facilitating conditions determine technology use [2], [3]. The behavioral intention and facilitating factors govern technology use whereas behavioral intention and effort expectancy were theorized and found to influence behavioral intention to use the CAI [4], [32]. Performance expectancy level refers to the phenomena in which an individual believes that using the CAI will assist him or her in improving job performance [2], [32]. The effort required to use the CAI, whether simple or complex, is also referred to as effort expectation [2], [3], [4], [29]. Social influence involves intentional and unintentional efforts to change another person's beliefs, attitudes, or behavior of the CAI [2], [4], [32]. Facilitating conditions is when an individual feels that an organizational and technological infrastructure exists to facilitate the use of the CAI [2], [32], [33]. The UTAUT also recognizes the demographic factors of the behavior intention of the user such as: sex, age, experience, and voluntariness of use.

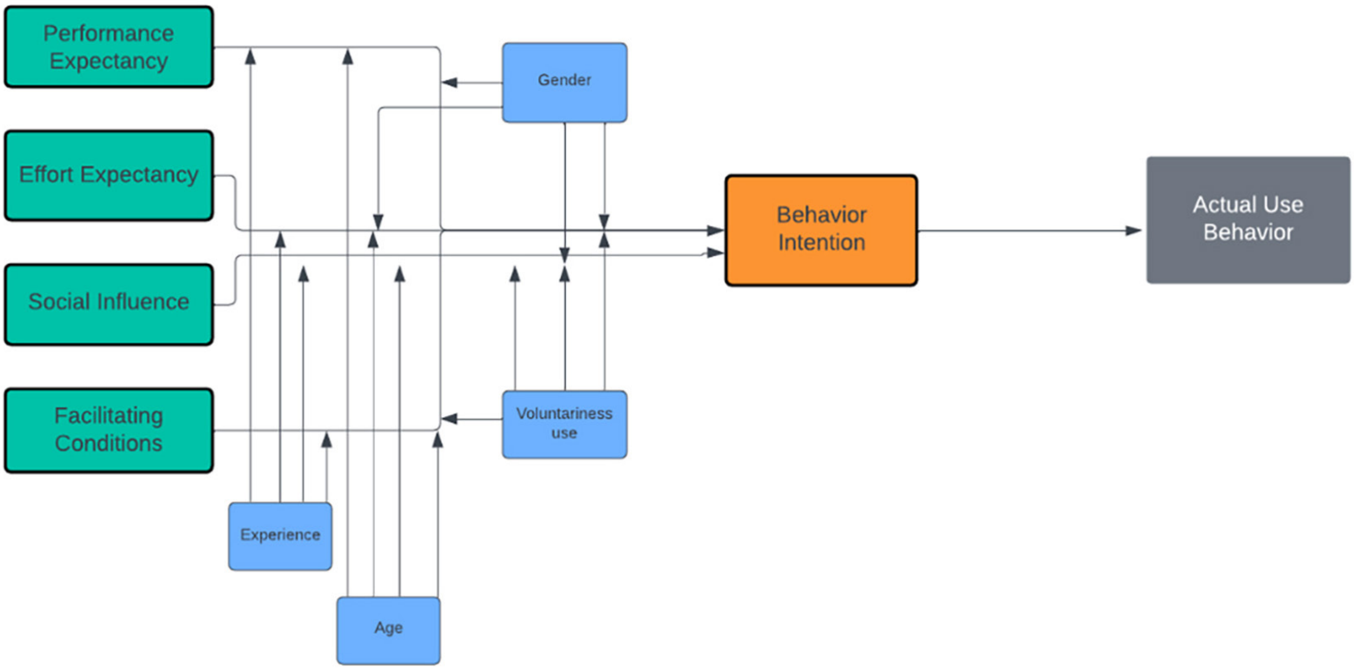

Fig. 2. Unified theory of acceptance and use technology model

Using a sample size of 31 journal articles to determine CAI adoption and acceptability, the UTAUT model was found to be realistic, comprehensive, and applicable in the context of CAI. By examining each paper's content and classifying the themes, the researchers looked at each determinant factors. In order to have a thorough grasp of how usage intention is influenced, the researchers categorized the components by identifying the enablers and barriers that affect the adoption of CAI and mapping out the determinant factors. The green boxes represent the primary class, then the blue boxes act as the subclasses of the primary class, and the red boxes are barriers. The green boxes served as moderators of the determinant factors. The enablers were identified and grouped under behavior intention as subclasses which are performance expectancy, effort efficacy, social influence, facilitating conditions, user experience, computer imaging, simulation, greater precision, accuracy, realistic, self-efficacy, self-explanatory, perceived ease of use and perceived ease of usefulness, accessibility, self-efficacy, high quality, freedom navigation, real-time and time-based, positive attitude, self-direct, and cognitive learning. The subclasses are the experience, gender, age, and voluntariness use. Within the 31 sample journal articles, the barriers were computer-self-efficacy, computer-owned, personal references, computer literacy, learning style, high quality performance, repeatable, response, interactive, government support, funding, training, stress, internet, and technical limitation.

2.3 Research gap analysis

In this section, the authors gathered and analyzed each conclusion, limitations and recommendations from the 31 journal articles. This procedure helped the authors in identifying the gaps for future research engagements. The authors used an inductive coding approach to analyze and synthesize the conclusions, limitations and recommendations for further studies [1], [2], [4], [28], [30], [42]. The use of mind mapping as a visual brainstorming tool was then used to help identify connections and relationships between the ideas of the identified research gaps on the applications of CAI in healthcare [27], [33]. This method synthesized the sample literature and served as the guide for the future researchers who would want to study CAI in healthcare and CAI in other fields.

3 RESULTS AND DISCUSSIONS

3.1 Literature profiling results

The researchers followed systematic approach for this structured review with Figure 3 showing the number of publications grouped according to the year of publication. The earliest research paper included in the literature sample size was published in 1980 with five studies published until 1999. Most of the included papers were published between 2000 and 2009 and five studies were published from 2010 to 2021. The majority of studies were done before 2010 when the potentials of CAI as a new tool for healthcare education was an emerging research interest. In this time frame, the convenience, functionality and ease of use of CAI was not yet fully recognized along with a lack of computers in the classrooms and a readily available dependable Internet connection. The results corroborated with research which concluded that weak leadership support, limited technical support, and limited access to information and technology (ICT) facilities were challenges that need to be addressed in the adoption of educational technologies [34].

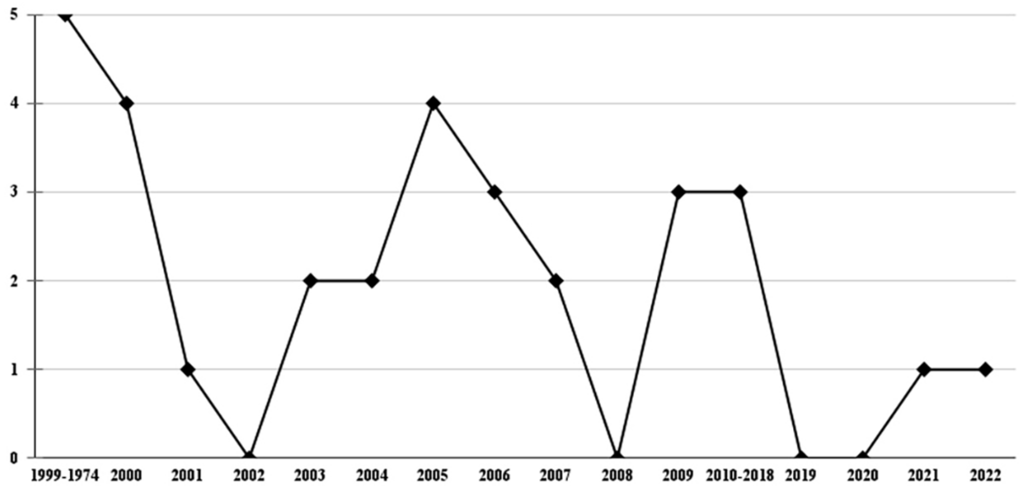

Fig. 3. Number of publications in each year

Table 1 shows how the researchers grouped the different journals into 8 themes. Evaluation of CAI in Healthcare had the highest total of journal articles (12) followed by CAI in Medical Education (10). The conducted thematic groupings highlights that most of the research articles were focused on the evaluation procedures of implemented CAI in the field of healthcare. The concern of evaluating the effectiveness along with the efficiency of employing CAI can imply the growing maturity of CAI adoption in healthcare in general and in medical education in particular.

Table 1. Thematic groups in JAM

Thematic Groups	Total
Evaluation of CAI in Healthcare	12
CAI in Medical Education	10
Instructional Materials	3
CAI in other Education	2
CAI in Anatomy Education	1
CAI in Science Education	1
CAI in Dental Education	1
CAI in Surgery	1

Table 2 shows that the research methods of the 31 journal articles were mostly quantitative and meta-analysis studies with 10 articles each with the rest of the studies were identified to be non-empirical, mixed method, descriptive and case studies. The studies were also found out to be distributed among 4 countries with majority of the authors who have contributed to the discourse on CAI to be originating from the United States of America. Additionally, results also show that the majority of the authors living in the USA currently hold education degrees, while others are still pursuing them. This suggests that the USA is a prominent player in the field of CAI research, and it may reflect the country's advanced technology and resources for research in this area. On the other hand, the low number of authors from other countries such as the United Kingdom, Egypt, and Czeck Republic implies that these countries may have limited interest in conducting research on CAI. However, it is important to note that the sample size of the study is relatively small, and may not represent the entire population of authors who publish about CAI.

Table 2. The research methods of the studies

Items	1974–1999	2000–2005	2006–2010	2011–2016	2017–2022
Methods					
Quantitative	3	3	3		1
Descriptive		1			
Mixed Method		1	2	1	
Non-empirical	2		3		
Review and Meta-analysis	2	4	2	1	1
Qualitative and Case Study		1			

The researchers also identified the subject areas and categories of the journals using the Scimago Journals and Country Rank. It was found that the majority of the journals' subject areas were covered by 19 publications in the medicine subject area, followed by 16 papers in the social science. The healthcare subject areas that publications in CAI were focusing on are biochemistry, genetics, molecular biology, and psychology. Different categories from the subject areas of the journals were also identified showing that education has the higher number of journals (16) followed by medicine (13). The categories show that CAI in healthcare mostly tackles issues surrounding anatomy, embryology, histology, surgery, physiology, biotechnology, biomedical engineering, health informatics, obstetrics and gynecology, radiology, nuclear medicine and imaging, occupational therapy, pharmacology, aging, geriatrics and gerontology, psychology, biochemistry, genetics, and molecular biology.

3.2 Technology adoption factors of CAI in healthcare results

The UTAUT model was used for the technology adoption analysis of CAI in healthcare on the 31 journal articles. As shown in Figure 4, the green boxes serve as the moderators of determinant factors, the blue boxes are the subclasses of the primary class of the determinant, the red one is the barrier to technology adoption, the orange is the behavior intention of users in CAI, and the gray boxes are the actual user behavior. Only the use of CAI technology in healthcare is the focus of the mapping for the determinants. The author tallied each enabler that influences learners' adoption of technology toward CAI and identified the common problems of the users during implementation of CAI. The author and considered it as the barrier on the behavior intention of the learners. Barriers to learning inhibit the efficiency of CAI technology deployment. Reduction is important, in addition to the investigation and implementation of enabling factors, as is economical and appropriate. Further, exploring how those factors impact actual use is essential.

Previous studies have emphasized the significance of perceived ease of use and perceived usefulness as crucial determinants of technology adoption [43], [44]. Additionally, authors have highlighted the importance of social influence and facilitating conditions in the context of technology adoption [45]. It becomes evident that addressing barriers, such as technical limitations and insufficient training is essential for efficient CAI deployment in healthcare education [46]. Simultaneously, leveraging enablers, including enhancing performance expectancy and effort expectancy, can contribute to the successful adoption of CAI in healthcare settings [47]. It is worth noting that healthcare institutions and educators must develop strategies to mitigate barriers and capitalize on enablers to facilitate the widespread adoption of CAI technology [46]. These strategies can have a profound impact on healthcare education and ultimately improve patient care outcomes [48].

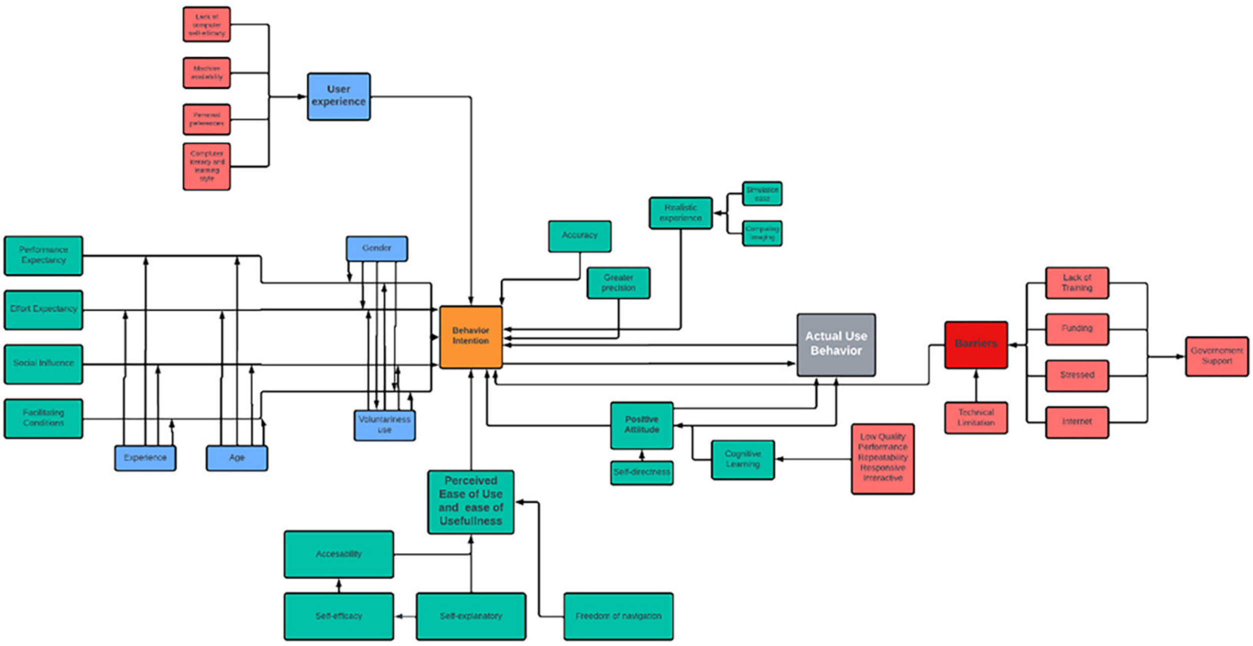

Fig. 4. Technology adoption analysis of CAI in healthcare

Enablers of CAI technology adoption. The term 'enablers' is being used to refer to the factors or components that facilitate the adoption and usage of CAI in healthcare. In this context, it is likely meant to convey the idea that these factors enable or facilitate the successful implementation and usage of CAI in healthcare. There are models used to understand the factors that enable or hinder the successful adoption and use of new technologies in various contexts. By identifying these enablers, the researcher can develop strategies to promote the adoption and use of new technologies and improve their overall success.

Results show that the fundamental components of UTAUT such as performance expectancy, effort expectancy, social influence, and facilitating conditions were the major determinant factors that influenced the acceptance of CAI in healthcare. These were identified as significant factors in the user's adoption. It was also revealed that the major components were influenced by demographic factors such as the user's age, gender, and career [4], [5], [30], [35]. The four key constructs of performance expectancy, effort expectancy, facilitation condition, and social influence all had a favorable impact on predicting user behavior toward the adoption of CAI in healthcare. Additionally, perceived usefulness is the potential user's subjective likelihood that using a specific system will improve his/her activity, whereas perceived ease of use refers to the degree to which the potential user expects the target system to be simple to use [5]. The users' mental assessments of the fit between the significant work goals and the consequences of doing job tasks using the CAI serve as the foundation for establishing impressions about CAI's effectiveness. This identified another factor determining the intention of the healthcare industry to utilize CAI. The CAI's accessibility, self-efficacy, high quality, and freedom of navigation are the factors of the ease of use and usefulness of CAI in healthcare and all of these aspects lead to increased motivation to acquire comprehensive medical knowledge and master clinical skills necessary for practicing evidence-based medicine of the users [10], [11], [19], [28]. It was also identified that the CAI must perform in a real-time and time-based mode to be of maximum benefit to the user because it will be associated with ever-increasing adoption of computer imaging and simulation in medicine, healthcare, and surgery [1]. Real-time imaging capabilities easily render ultrasound applications to a variety of computers and the realistic user visual recognition and memory enhances the users to recall and facilitate learner performance upon utilizing CAI. Additionally, another influential determinant factor that impacts the usage intention of CAI is that computer imaging and simulation can provide significant benefits for the professional and the patient. Greater precision and accuracy in the diagnosis and surgery can be obtained and these systems improve surgeon performance and are, in addition, risk free [8]. In the usage intention perspective, as a result of the CAI's perceived usefulness, it was analyzed that the more the user understands how effective the CAI is, the more they will use it. The user experience influences the usage intention of the user because CAI includes the user's perceptions of the system aspects such as utility, ease of use, and efficiency. Within the articles the authors discovered that as a recurring theme, positive attitude is another influential determinant of the CAI in healthcare as it impacts the user's actual behavior if the CAI is self-directed and has a high level of learning. This leads to adaptation and improvement in learning so that successful carry-over into new learning situations will occur. This seems to contribute to an increase in practical application skills, as well as an increase in cognitive learning, since repetition can imprint on the mind. It will be considered a high level of cognitive learning if the CAI incorporates high quality video, audio, hyperlinked text, and other interactive features, as then more users or learners will become more interested in using the CAI in healthcare [2], [11], [29]. These factors play a significant role in determining whether a CAI is worth developing and utilizing for healthcare.

Table 3 shows the identified 18 enablers of CAI adoption in healthcare. The perceived ease of use and ease of usefulness were identified as the most mentioned adoption enablers among the journal articles [2], [4], [6], [9], [19], [26], [27], [30], [35], [36], [37], [49]. Ease of use in this context was identified as the freedom from difficulty while ease of usefulness refers to the CAI usability. It was found that the usage intention in CAI increases because of the ease of use and usefulness of the system. The perceived ease of use is how CAI was able to achieve learners' goals through the system and the perceived usefulness is how CAI was able to improve the academic performance of the learners upon utilizing the system. The CAI is not difficult and useful in healthcare education. There are also enablers of perceived ease of use and usefulness such as: Accessibility, Self-efficacy, High-quality, Realtime-based time, and freedom of navigation [1], [2], [4], [5], [6], [26], [27], [28], [30], [32], [33], [39], [40]. Efficacy, quality, and real-time are already being discussed. Self-direction is the way a user directs or manages to learn by itself.

Table 3. Enablers of CAI adoption in healthcare

Enablers	Reference Number	Count
1. Perceived ease of use and ease of usefulness	[2], [4], [6], [9], [19], [26], [27], [30], [35], [36], [37], [49]	12
2. Performance expectancy	[1], [2], [3], [4], [6], [29], [32], [33], [37]	9
3. Social influence	[1], [2], [3], [4], [13], [29], [32], [37], [38]	9
4. User experience	[2], [4], [26], [28], [32], [37], [39], [51]	8
5. Effort expectancy	[1], [2], [3], [4], [13], [29], [37]	7
6. Self-efficacy	[2], [4], [5], [6], [27], [28]	6
7. Self-explanatory	[1], [4], [5], [28], [29], [30]	6
8. Positive attitude	[2], [3], [4], [26], [32], [38]	6
9. Computer imaging	[1], [6], [14], [19], [30], [40]	6
10. Accuracy	[1], [9], [21], [26], [28], [41]	6
11. Facilitating conditions	[1], [2], [32], [33], [37]	5
12. Simulation ease	[1], [9], [26], [28], [41]	5
13. Freedom of navigation	[27], [30], [32], [33]	4
14. Accessibility	[30], [33], [39], [40]	4
15. Greater precision	[9], [29], [30], [38]	4
16. Self-directness	[4], [28], [42], [51]	4
17. Cognitive learning	[4], [35], [28]	3
18. Realistic experience	[1], [26]	2

Other important enablers to CAI adoption were also identified such as performance expectancy, effort expectancy, social influence, and facilitating conditions. Performance expectancy was defined as the judgment of one's capability to use CAI where judgment refers to the ability to apply computer skills. Individuals with high computer efficacy magnitude would consider themselves as possessing the capability of accomplishing CAI tasks [1], [2], [3], [4], [6], [29], [32], [33], [37]. Social influence involves intentional and unintentional efforts to change another person's beliefs, attitudes, or behavior which change upon utilizing CAI in order to adhere to existing social norms. It was found that CAI users believe that organizational resources and technical infrastructure should be available to support the effective use of CAI for new interactive learning materials[1], [2], [3], [4], [13], [29], [32], [37], [38]. Effort expectancy is the level of confidence one perceives in task accomplishment of CAI activities [1], [2], [3], [4], [13], [29], [37]. Other adoption enablers were also identified as user experience, self-efficacy, and being self-explanatory. User experience in this context refers to the feelings of CAI users when using the system and it was found that the users become more interested in CAI if the system was developed with good features [2], [4], [26], [28], [32], [37], [39], [51]. Self-efficacy is a user's belief in their capabilities to exercise control over their own functioning with studies referring to how CAI changes the person's belief that they can be successful when carrying out a particular task [2], [4], [5], [6], [27], [28]. Self-explanatory is when the user easily understands the CAI with studies exhibiting that if the CAI was provided with basic self-explanatory information, this will result in more user utilization [1], [4], [5], [28], [29], [30].

There are also other enablers that have been identified such as computer imaging, simulation, greater precision, accuracy, and realistic experience. Computer imaging in this context is the use of computers to produce, edit, and display graphical pictures, characters, and objects. The journal articles show that if the CAI was developed well to provide good computer images, this will result in higher usage interest [1], [6], [14], [19], [30], [40]. Simulation in this context is the act or process of simulating medical or surgical situations which allow the users to test CAI and to be able to answer difficult activity-based lessons [1], [9], [26], [28], [41]. Greater precision in this context refers to the capability of providing the same level of measurement precision over a long period of time implying that the users can trust the CAI to produce similar readings regardless of changing variable conditions [9], [29], [30], [38]. Accuracy in this context refers to how close a measurement is to an object's true measurement, implying that the user will utilize the CAI if the system produces accurate results. Self-direction is shown in the journal articles referring to instances where the CAI doesn't need facilitators to facilitate the utilization of the system [4], [28], [42], [51]. Realistic experience in this context imply that a user who recognizes what is real or possible in a particular medical or surgical situation through a more realistic image would result in higher usage interest since CAI is able to develop the user's skills resulting in fewer user mistakes in actual scenarios [1], [26].

The adoption of CAI in healthcare yields significant results with far-reaching implications for educational institutions, healthcare professionals, and technology developers. Notably, the pivotal factors that influence the adoption of CAI include ease of use, perceived usefulness, performance expectations, social influence, and user experience. These factors emerge as top priorities in the development of CAI content. Moreover, results suggest that essential training and support, instilling user confidence in CAI and fostering a positive orientation towards self-directed learning are priorities to augment the identified enablers. Notably, CAI systems should seamlessly integrate real-time and time-based elements, enriching practicality, precision, and the application of knowledge. Interactive CAI content emerges as a catalyst for cultivating critical thinking skills [52]. Meanwhile, the allocation of adequate resources emerges as a vital driver for successful CAI adoption, and tailoring strategies based on demographic considerations can enhance inclusivity in healthcare education.

Barriers to CAI technology adoption. As shown in Table 4, there were fifteen (15) most counted barriers to CAI adoption. Findings showed that government support plays a significant role for the users to utilize the CAI since this will help institutions in having resources for providing proper training to the teachers and learners in utilizing the CAI [4], [9], [19], [22], [30], [33], [35], [41], [49]. Government financial support will also help healthcare teaching institutions in acquiring funds to buy hardware, software and technical maintenance of the CAI system. It will also lessen the stress that the teachers will be facing because they will be given the chance to learn and be trained. Not a lot of medical schools receive proper funding and proper training for teachers to use the CAI in the classroom as a new learning technology. Interactivity challenges of the CAI were also identified as important barriers to using CAI for healthcare applications [2], [11], [29], [30], [32], [41]. CAI should also provide interactive connection between the teachers and the learners for CAI to be a useful education tool for student-learner collaboration.

Table 4. Barriers of CAI adoption in healthcare

Barriers	Reference Number	Count
1. Government support	[4], [9], [19], [22], [30], [33], [35], [41], [49]	9
2. Funding	[9], [30], [33], [35], [38], [41], [49]	7
3. Interactivity	[2], [11], [29], [30], [32], [41]	6
4. User experience	[6], [9], [30], [38], [39]	5
5. Machine availability	[6], [9], [33], [35], [38]	5
6. Technical limitation	[2], [4], [19], [33], [36]	5
7. Lack of training	[5], [22], [35], [38], [49]	5
8. High quality performance	[9], [11], [14], [19], [40]	5
9. Repeatability	[3], [4], [6], [29], [30]	5
10. Stress	[30], [38], [42], [49]	4
11. Lack of computer self-efficacy	[3], [5], [6], [39]	4
12. Computer literacy and learning style	[6], [30], [39]	3
13. Responsiveness	[4], [6], [29]	3
14. Internet connection	[27], [38]	2
15. Personal preferences	[2], [39]	2

It will also require additional funding as well resource for the CAI tutorial design and maintenance. Machine availability is considered a barrier to CAI adoption as available computers intended for CAI usage in a healthcare teaching facility will result to fewer opportunities for its usage [6], [9], [33], [35], [38]. The user's intention to use CAI for healthcare applications can be influenced by lack of training for CAI usage [5], [22], [35], [38], [49]. CAI users will also need high quality performance for it to be used properly and this was found to be important in meeting the expectations of its intended users [9], [11], [14], [19], [40]. Repeatability is considered an important feature since the CAI should help provide repeatable solving problems to the learners [3], [4], [6], [29], [30].

Some health care teachers are also stressed out in using the CAI due to lack of information about this new learning technology [30], [38], [42], [49]. Computer-efficacy represents an individual's perceptions of his or her ability to use computers in the accomplishment of a task rather than reflecting simple component skills of CAI. If the CAI is very difficult to use, the result will affect their behavior in using the CAI [3], [5], [6], [39]. Computer literacy and learning style of the user are also barriers to adopting CAI as this refers to the user's ability to use computers and related technologies effectively [6], [30], [39]. The studies show that some users, particularly teachers who are not well versed in computer usage in their teaching plan, have difficulty utilizing and implementing CAI. Responsiveness was also found to be a barrier in CAI adoption since immediate feedback to the user is considered an important feature [4], [6], [29]. The lack of immediate feedback with the CAI usage experience will result in lesser adoption. Another identified barrier is the personal preferences which are the conscious things the users choose for themselves when using CAI [2], [39]. Personal preferences influence utilization of specific CAI, which may explain some of the reports in the literature.

The result highlights that government support plays a crucial role in promoting the integration of CAI in healthcare education. Lack of government backing can hinder the allocation of essential resources and policy frameworks needed for successful CAI implementation. Funding represents a significant challenge, emphasizing the financial resources required for acquiring and maintaining CAI systems. Limited funding can impede effective CAI adoption in healthcare education, hindering investments in technology and training. On the other hand, the importance of interactivity underscores the need for CAI systems that facilitate engaging educational experiences. This includes features that encourage effective interaction between educators and students within the digital learning environment, fostering active learning and collaboration [53].

3.3 Research gap analysis results

As depicted in Table 5, the first common limitation is the CAI's effectiveness. Most of the journals are evaluating how CAI was proven to be an effective learning material that can make complex topics easier and CAI systems improve surgeon performance by lessening the risk [3], [5], [6], [19], [27], [30], [36], [41], [42]. Secondly, a well-designed CAI will make the user more interested and motivated in utilizing the CAI [2], [4], [9], [11], [30], [36], [40]. Easier, accessible, realistic, self-directed, and effective design will help the learners to improve their performance for healthcare education. Thirdly, studies show that ease of use is more important than computer literacy since common conclusions show that computer literacy will not be a hindrance for the user to utilize CAI as long as it provides ease of use [2], [22], [33], [36], [50]. Lastly, real-time based CAI helps the user to be associated with ever-increasing adoption of computer imaging and simulation in medicine and surgery [1], [9], [26].

Table 5. Common conclusion from the literature

Common Conclusions	Reference Number	Count
1. CAI effectiveness	[3], [5], [6], [19], [27], [30], [36], [41], [42]	9
2. Influence of well-designed CAI	[2], [4], [9], [11], [30], [36], [40]	7
3. CAI ease of use	[2], [22], [33], [36], [50]	5
4. Real-time feature of CAI	[1], [9], [26]	3

The authors also analyzed the common limitations of the literatures. As shown in Table 6, the first common limitation is the size of respondents. Some of the studies published about CAI have smaller sizes of respondents depending on the number of respondents in their target population [1], [2], [33], [38], [40]. In terms of the scope of the study, there are only a few publications about CAI in surgery, virtual surgical planning, and other healthcare topics [1], [22], [35], [37], [41]. Bias towards good CAI usage outcomes was also a common limitation [27], [33], [35], [50]. Most studies favor CAI usage and emphasize on its effectiveness over other challenges of its usage. The technological demand was also an identified limitation of CAI as it always needs maintenance and updation [2], [4], [38], [39]. Being unrealistic and real-time based limitations indicated that some of the findings of the studies showed that imaging capabilities can easily render ultrasound applications to a variety of computer formats [9], [26], [36], [39]. Lastly, the small sample size for the intervention groups would be problematic for significance testing of any single factor [11], [21]. Small sample sizes were identified as a challenge in evaluating the effectiveness of CAI as a learning technology in healthcare.

Table 6. Common limitations from the literature

Common Limitations	Reference Number	Counts
1. Size of respondents	[1], [2], [33], [38], [40]	5
2. Scope of the study	[1], [22], [35], [37], [41]	5
3. Bias towards good CAI usage outcomes	[27], [33], [35], [50]	4
4. Technological demands	[2], [4], [38], [39]	4
5. Not realistic and real-time based	[9], [26], [36], [39]	4
6. Sample size	[11], [21]	2

Table 7 shows the identified common recommendations based on the literatures. The first recommendation is to identify the factors that influence the technology adoption of CAI in healthcare [26], [29], [35], [37], [39], [41], [50]. It is then followed by the improvement of CAI to have a more effective web-based application for healthcare education [3], [5], [6], [21], [30], [38]. Technical limitations should also be addressed to avoid delays and errors in using CAI. Additionally, conducting further reviews to gain a deeper understanding of CAI features and its impacts was also recommended [9], [42], [50]. Furthermore, CAI should be self-directed, eliminating the need for an admin to facilitate its use [4], [5], [9]. The flexibility of CAI should be implemented in different courses, not just limited to healthcare education [3], [30].

Table 7. Common recommendations from the literature

Common Recommendations	Reference Number	Counts
1. Identification of adoption factors	[26], [29], [35], [37], [39], [41], [50]	7
2. CAI improvement	[3], [5], [6], [21], [30], [38]	6
3. Conduct different reviews	[9], [42], [50]	3
4. Self-direct CAI	[4], [5], [9]	3
5. Flexibility of CAI	[3], [30]	2

4 CONCLUSION AND RECOMMENDATIONS

The landscape of healthcare education has undergone a transformative shift in recent decades, driven by the rapid advancements in technology. These technological innovations have not only facilitated the delivery of extensive lectures but have also offered significant improvements in the realm of health education. However, the successful integration and adoption of CAI in healthcare necessitates a willingness to adapt and adjust to this evolving educational paradigm. This study synthesized insights from 31 journal articles, employing the UTAUT model to profile and map the technology adoption factors of CAI. Among the key enablers identified were perceived ease of use, ease of usefulness, performance expectancy, social influence, user experience, and effort expectancy, which underscored the pivotal role these factors play in driving CAI adoption in healthcare. Conversely, government support, funding constraints, and interactivity emerged as prominent barriers to CAI adoption, as evidenced by the comprehensive analysis of these 31 journal articles. Furthermore, the synthesis of these studies consistently underscored the effectiveness of CAI in healthcare, highlighting its potential to enhance motivation and foster the acquisition of comprehensive medical knowledge and clinical skills necessary for evidence-based healthcare practice.

The synthesis of research on CAI in healthcare education emphasizes its profound benefits as an innovative educational tool, bolstering both teaching and learning effectiveness. These benefits extend to greater motivation among learners, enabling them to access comprehensive medical information and cultivate essential skills for evidence-based healthcare practice. The application of the UTAUT model identified four key determinants—perceived ease of use and usefulness, performance expectancy, social influence, and user experience—as crucial factors shaping the acceptance and adoption of CAI in healthcare. Additionally, four moderators—age, gender, experience, and voluntariness—offer valuable insights into the technology adoption process, facilitating the prediction of behavioral intention towards CAI adoption. Moreover, the study underscores the value of self-directed CAI, promoting adaptability and enhanced learning outcomes across different educational contexts. Accessibility, self-efficacy, high-quality content, and navigational freedom further bolster motivation, driving the pursuit of comprehensive medical knowledge and clinical skills. Perceived usefulness and ease of use stand out as influential factors in shaping usage intention in healthcare education. The influence of government support in mitigating adoption barriers is a notable finding, emphasizing its role in facilitating the actual utilization of CAI among users.

This study unequivocally demonstrates CAI's efficacy as a potent learning tool, particularly in enhancing students' comprehension of complex concepts in healthcare education. To further enhance the field, it is recommended to expand sample sizes, offering more robust and revealing datasets for future research endeavors. Addressing the reliance on programmers and instructional design experts for CAI design and maintenance is crucial to expedite adoption and learning, ensuring timely modifications and corrections. Additionally, exploring alternative models beyond UTAUT could uncover additional determinant factors influencing CAI adoption. Broadening the scope of literature to encompass various medical specialties, such as internal medicine, surgery, otolaryngology, pediatrics, and other specific fields, could provide comprehensive insights into adoption patterns. A pivotal recommendation is the development of self-directed CAI systems, eliminating the need for facilitators, thereby enhancing usability and accessibility. Furthermore, this study aligns with previous reviews, highlighting the distinct learning advantages offered by CAI. Well-designed, computer-delivered programs yield multiple benefits, fostering positive attitudes and elevated expectations among learners.

The future of healthcare is inseparably tied to technological progress, necessitating that both students and healthcare professionals remain abreast of the latest innovations. Technology's transformative potential has expanded CAI from conventional online and computer-based learning to fully immersive environments like virtual reality and augmented reality. Embracing technology adoption in healthcare education holds the promise of elevating medical knowledge, refining surgical skills, and enhancing patient care to unprecedented levels. For researchers seeking relevant CAI-related topics, employing associated keywords such as computer-aided instruction, CAI in healthcare, CAI in medical education, CAI in education, CAI in surgery, CAI in dentistry, CAI in anatomy education, CAI in pharmacy, and evaluating CAI can be an effective approach. These keywords offer a gateway to exploring the multifaceted dimensions of CAI adoption and its transformative impact on healthcare education and practice.

5 ACKNOWLEDGEMENTS

The authors would like to thank the support of the Mindanao State University-Iligan Institute of Technology (MSU-IIT) Office of the Vice Chancellor for Research and Extension for their assistance in this study. This work is supported by MSU-IIT as internally funded research under the College of Computer Studies-Department of Information Technology. The authors would also like to thank ILIGANiCE (Innovation thru Leveraging Industry, Government, Academe Networks and inclusive Community Engagements) for their assistance in this study.

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7 AUTHORS

Queenie Kate Cabanilla is a Bachelor of Science in Information Systems student from the College of Computer Studies of the Mindanao State University-Iligan Institute of Technology. She specializes on research engagements focused on the role of innovative learning technologies that can be used by healthcare professionals (E-mail: queeniekate.cabanilla@g.msuiit.edu.ph).

Frevy Teofilo-Orencia is an Associate Professor at Benguet State University, The Philippines. She is currently the Research and Extension Coordinator of the Department of Information Technology, College of Information Sciences. She is a member of the International Association of Engineers, Analytics Association of the Philippines and Philippine Society of Information Technology Educators, and Computing Society of the Philippines. She is a Certified Data Privacy Level II and a Certified Accreditor for Accrediting Agency of Chartered Colleges and Universities in the Philippines. She had served as a peer reviewer for International Journal of International Journal of Emerging Technologies in Learning, Philippine e-Learning Society (PeLS) journal, and Mountain Journal of Science and Interdisciplinary Research (MJSIR) of Benguet State University (E-mail: f.orencia@bsu.edu.ph).

Rentor Cafino, MD, DPBO-HNS is a graduate of the Otorhinolaryngology – Head and Neck Surgery training program and is among the pioneers of medical 3D printing in the Philippines. He is the unit head and founder of the Zamboanga City Medical Center Medical Makerspace and Prosthesis Laboratory (E-mail: rcafino@gmail.com).

Armando T. Isla Jr., MD, FPSO-HNS earned his medical degree from the University of the Philippines. He completed his residency training in Otolaryngology-Head and Neck Surgery at the Philippine General Hospital, where he honed his surgical skills and gained valuable clinical experience. Throughout his career, Dr. Isla has emerged as a leader in various medical societies, including serving in the Philippine Society of Otolaryngology – Head and Neck Surgery. His contributions to these organizations have been instrumental in fostering collaboration among healthcare professionals and driving advancements in the field. One of Dr. Isla's most notable areas of interest lies in influencing the future of medical practice, particularly in the community setting. He envisions a healthcare landscape where quality medical care is accessible to all, and he actively works towards making this vision a reality (E-mail: donisla.md@gmail.com).

Jehan Grace Maglaya, MD, FPSO-HNS strongly advocates education, innovation and research as the current chair of the Philippine Academy of Craniomaxillofacial Surgery (PACMFS), a recognized subspecialty group of the Philippine Society of Otolaryngology – Head and Neck Surgery, Inc. Dr. Maglaya has been in the academe since 2011 and is currently an Assistant Professor VI at the College of Medicine of the University of the East Ramon Magsaysay Memorial Medical Center Inc. Dr. Maglaya has been a Regional Faculty of the Asia-Pacific for AO (Arbeitsgemeinschaft fur Osteosynthesefragen) CMF since 2017 and has co-authored the PACMFS Clinical Practice Guidelines on Management of Isolated Mandibular Fracture in the Adult. Dr. Maglaya does volunteer work for surgical missions for AY Foundation (2008 up to 2017), World Surgical Foundation Philippines (since 2018), and is a Board of Trustee of the Maglaya Medical-Legal Missions, Foundation (E-mail: shahjehanmd@yahoo.com).

Xavier-Lewis Palmer, PhD earned his PhD in Engineering in 2022, from Old Dominion University. His other degrees include two master's degrees in Cybersecurity and Biotechnology and two bachelor's degrees in philosophy and biology. His experience covers research, device design, device fabrication, data curation, and analysis, in addition to a variety of tissue engineering and biotechnological assays. Some of his work combines this through technological intersections within biocybersecurity (E-mail: xpalm001@odu.edu).

Lucas Potter, PhD earned his BS in Biomedical Engineering in 2015 from Virginia Commonwealth University and a PhD in Biomedical Engineering at Old Dominion University. He has researched human factors for three federal organizations, biomedical engineering for three private companies and is an active contributor to the field of biocybersecurity (E-mail: lpott005@odu.edu).

Associate Professor Dr. Dave E. Marcial is the former dean of the College of Computer Studies, Silliman University, Philippines. He is a technical committee member for IT Education of the Philippine Commission on Higher Education, Executive Director of the Asian University Digital Resource Network, former President of the Philippine Society of IT Educators, Former Vice President Philippine eLearning Society. He is one of the Board Advisers of the Computing Society of the Philippines Special Interest Group on Information and Computing Education. Recipient of the 2nd Place Finalist of Philippine DigiBayani (Digital Hero) Award for Digital Literacy in 2015, Most Productive Faculty Award of Silliman University in 2016 and 2023, and the 2022 eLearning Forum Asia (eLFA) Award for Community Outreach. Among his research interests are educational technology, local knowledge computing, and digital trust where he has been recipient of some local and international research grants. As a United Board Fellow, he completed his Post-Doctoral Certificate on Leadership in Higher Education at Boston College, USA. Dr. Marcial is the Director for Silliman Online University Learning, Silliman University, Dumaguete City, Philippines.

Lemuel Clark Velasco is an associate professor of information systems from the Department of Information Technology at the Mindanao State University-Iligan Institute of Technology. He was the pioneering Director of FAB LAB Mindanao-Center of Innovation and Invention, co-founder of FAB LABs Philippines-the Philippine FAB LAB Network, and co-founder of Webforest Digital Solutions. He is a predictive analytics researcher at the Premiere Research Institute of Science and Mathematics – Center for Computational Analytics and Modelling (E-mail: lemuelclark.velasco@g.msuiit.edu.ph).