Pacific Journal of Health

Volume 7 | Issue 1 Article 28

2024

Google Glass™ in Healthcare Education: A Scoping Review

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Recommended Citation

Gillette, David B. and Raja, Bhavana (2024) "Google Glass™ in Healthcare Education: A Scoping Review," *Pacific Journal of Health*: Vol. 7: Iss. 1, Article 28.
DOI: https://doi.org/10.56031/2576-215X.1057
Available at: https://scholarlycommons.pacific.edu/pjh/vol7/iss1/28

Google Glass™ in Healthcare Education: A Scoping Review

Abstract

Background: Google Glass™ (Glass), a wearable augmented reality device is gaining popularity in healthcare education due to its portability, affordability, and usefulness, including offering a different vantage point and potential for remote training. We conducted this scoping review to determine its applications, effectiveness, and limitations in healthcare education.

Methods: Seven electronic databases were searched for relevant studies and reports using specified search terms. Two reviewers independently screened studies for eligibility, retrieved data, and compared results.

Results: The search yielded 2,019 articles. After removing duplicates, 1,576 titles, 877 abstracts, and 408 articles were screened; 78 articles were included in this review. Most related to Medicine and Nursing, specifically, surgery, clinical skills, communication, and anatomy. Effectiveness was reported by measures, surveys, and open-ended questions/interviews. Technical problems included battery life, camera specifications, and connectivity.

Discussion: Glass has been used successfully in healthcare education across disciplines from classroom simulation to the operating room. Effectiveness varied depending on user experience, use case and preference. Some technical issues were reported. More studies are needed to test the application of Glass in healthcare education to increase proficiency in skills and improve behaviors. Future studies should include rigorous research designs examining all applications of Glass and standardized outcomes.

Keywords

smart glasses, augmented reality, clinical competence, communication, delivery of health care, education

The use of technology continues to grow in healthcare education. Extended Reality is a term that encompasses augmented reality (AR), virtual reality, and mixed reality. These are used in healthcare education and can be used to improve outcomes, but Logeswaran and colleagues note that there are limited reports for how these are being implemented with the learner in mind. [1]

AR is where digital augmentation is overlaid on or added to what is being seen in reality. [2] In healthcare education, AR may be used from teaching basic anatomy to training for surgical procedures. While there are multiple platforms and applications, there are generally two types of AR: handheld devices such as smartphones and tablets, and head-mounted devices that may be immersive such as Microsoft's HoloLens™ ($3,500), or smart glasses such as Google Glass™. [2] Google Glass™ and similar smart glasses can be unobtrusive as they are worn like eyeglasses and can be used to project in the wearer's field of view or to stream or record their field of view.

Having multiple AR devices, platforms, or applications may not be financially feasible or desirable for most educational institutions. While Google Glass™ was discontinued in 2023 and is now only available from resellers, it is relatively low cost, provides the ability to see from the user's view, and gives the possibility of working with a developer to create other uses. However, it is not clear from the literature or reports how Google Glass™ may be used for healthcare education. A scoping review was conducted to answer the following question: what is known from the existing literature about the application and effectiveness of Google Glass™ as a teaching tool for students in healthcare programs?

METHODS

A scoping review is a form of literature review that can be used to find gaps in the current literature, especially when the topic has yet to be reviewed extensively or the characteristics are diverse or complex and do not allow for a more precise systematic review.[3, 4] We conducted a scoping review using the five-stage framework for conducting a scoping study described by Arksey and O'Malley and Khalil *et al*. [3, 4] Informed consent and IRB approval were not required due to the nature of the study. A protocol was verbally agreed upon for the date and terms of the search, the inclusion/ exclusion criteria, study selection, and data extraction.

Eligibility criteria

Because this is a scoping review of the literature, it encompasses both grey literature including news reports, blog posts, and editorials, as well as peer-reviewed literature which included experimental designs, case reports, reviews, and perspectives. The search was limited to after April 2013 as Google Glass™ was released at that time, and studies were limited to English. Any use of Google Glass™ in healthcare education programs were included, including undergraduate and graduate students in health sciences disciplines, medical residents or fellows, and health care professionals undergoing further training. Studies that used Google Glass™ for treatment of patients, assistance of procedures (e.g., surgical checklists), documentation/ access of electronic medical records, or veterinary-related uses, or focused only on other head-mounted-device were excluded from the study.

Information sources

We systematically searched Medline, CINHAL, Pubmed, ERIC, HealthSource: Nursing/ Academic Edition, APA PsychINFO, and SCOPUS databases for literature published from Google Glass™ release in April 2013 until the search on September 30, 2021.[5] Data were downloaded into Microsoft Excel, results were compared, and duplicates were removed by the primary author.[6] In addition to the studies retrieved from primary database searches, we also checked references of each selected paper to ensure including all the relevant sources.

Search

To address our study objective “the application of Google Glass™ in healthcare education” and answer the study question: “What is known from the existing literature about the application and effectiveness of Glass as a teaching tool for students in healthcare programs?”, we carried out literature search on September 30, 2021 in each database using the following keywords: ("Google Glass" OR "Smart Glass" OR "Augmented reality") AND ("Medical education" OR "nursing education" OR "Healthcare education"). The search was limited to studies in English and those with human participants only.

Study selection

We used the PRISMA-ScR checklist to allow for transparent reporting of the literature findings based on conceptual and practical advances in the science of systematic reviews.[7] Two reviewers independently screened the titles and abstracts using the inclusion criteria. Articles chosen by both reviewers were automatically included. Any disagreements between the reviewers were arbitrated by consensus. When required, authors of studies were contacted to request missing or additional data. The full text of the remaining studies was then reviewed to ensure the studies meet the inclusion criteria. We included all levels of evidence including grey literature to help answer our question regarding the application and effectiveness of Glass as a teaching tool in healthcare education.

Data charting process

A data charting table was created in an excel spreadsheet, by the two reviewers after agreement was reached about what data to collect. Papers were examined and data extracted by both reviewers. Any disagreements between reviewers were arbitrated by consensus. The dataset is available in the authors' university library repository (https://scholarlycommons.pacific.edu/pt-data/3/).

Data extraction

The following data items were extracted from each paper.

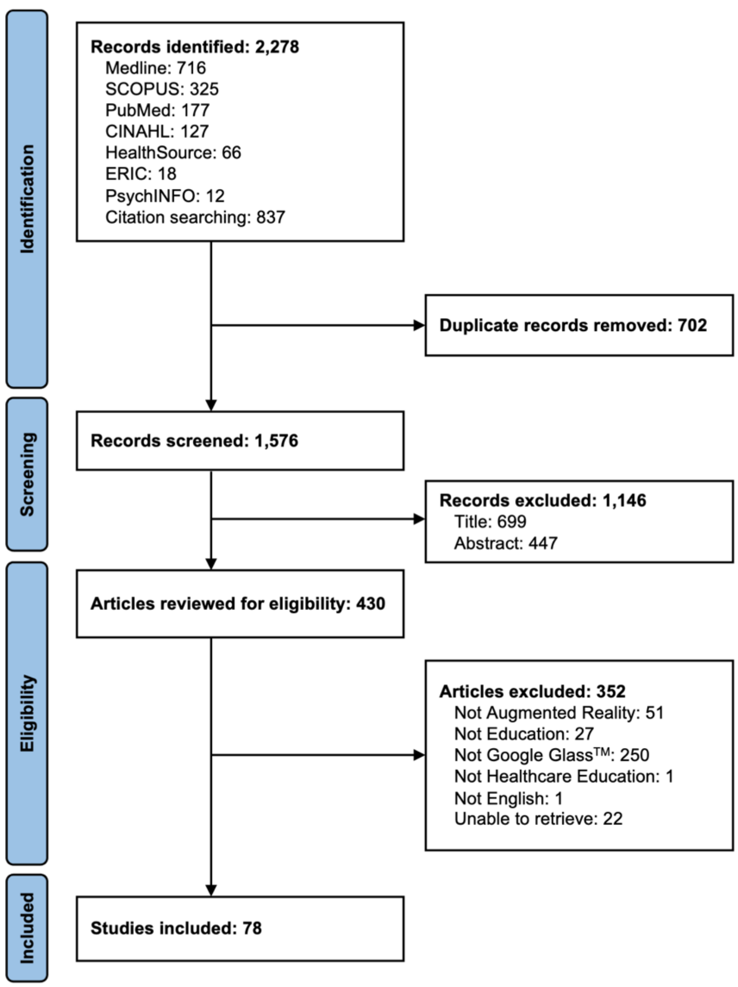
- *Study type and objective*: Type of study (observational, randomized control trial, systematic review, etc) and brief objective of study
- *Themes/ subthemes*: surgical skills, clinical skills, interpersonal skills. Simplifications were made for what was being taught, with subthemes for clarification.
- *Methods*:
    - *Setting used in*: where the study took place (classroom, hospital, etc)
    - *Population*: population studied, if an experimental study
    - *Who was wearing*: Who was wearing Glass
- *Use case description*: description of how study was conducted
- *How it is being used*: Communicating (two-way), recording (to device), or projecting (digital information from hard drive projected into eye piece)
- *Problems/challenges*: list of problems or challenges noted in paper
- *Version of Glass*: which edition (Explorer or Enterprise) and software version was used, if reported

- *Outcomes and results: outcomes used in research studies, including objective data and survey results.*

RESULTS

The literature search resulted in a total of 1,576 potentially relevant articles. After the initial title, abstract, and full text screening, 78 articles met the eligibility requirements and were confirmed for inclusion in this review (Fig. 1). We created a table of our results from our charted data.

Figure 1: PRISMA Flow Diagram for Selection of Sources



Characteristics of included articles

Evidence retrieved comprised of 65 peer reviewed articles and 13 non-peer reviewed articles (Appendix 1). Articles were from the United States (n=52), Germany (n=6), Australia (n=5), the United Kingdom (n=5), Canada (n=3), France (n=2), and one each from Greece, Netherlands, Singapore, Spain, and Sweden.

The most common groups involved were surgery residents/surgeons (n=36), medical students/ residents/ physicians (n=23) and nursing students/nurses/nurse practitioners (n=11). Other healthcare practice-related populations included health science students (n=2), Emergency Medical Service (n=1), dental students (n=1) and physical therapy students (n=1). The non-peer reviewed articles were written in 2013-2014, with topics ranging from surgical education,[8–14] surgical mentoring,[15] medical school curriculum,[16–18] surgeon or cardiologist consultation,[19] and use with manikins.[20] We determined further assessment of these was not warranted as the areas of use were also in peer reviewed literature. Of the peer-reviewed articles, four were correspondence, perspectives, or viewpoints.[21–24] We determined that further assessment of these was not warranted as they did not add to where Glass was used or report on effectiveness beyond what was already reported. Experimental studies comprised 64.6% of the peer reviewed articles. Most of these were descriptive in design, including 24 cross-sectional studies, 8 randomized controlled trials, 4 case reports, and 3 case series. While all papers acknowledged the potential of Google Glass™ or other AR platforms to promote or assist learning, no experimental studies addressed learning theories or how theories may apply to this new tool.

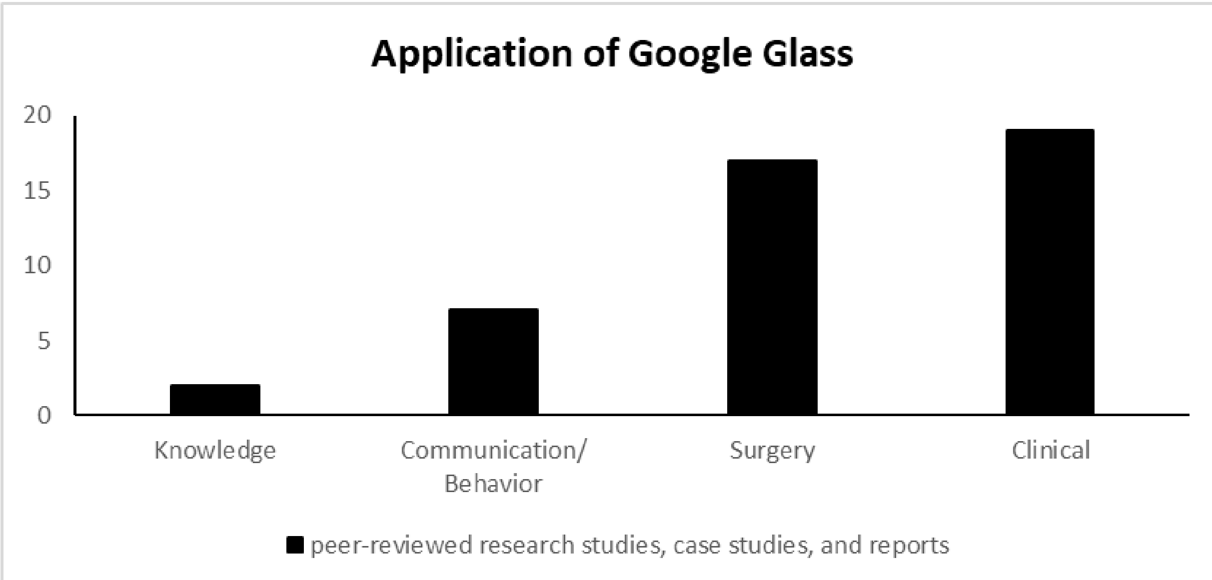
Applications of Google Glass™

Depending on the goal of the study or situation, Google Glass™ can be worn by the learner or by another person to give a first-person perspective to the learner. As noted in Appendix 1, Google Glass™ has been reported in a wide variety of healthcare education scenarios, including surgical settings, classrooms, emergency situations, and between institutions for knowledge sharing and transfer. Additionally, it has been used for communication (with audio/video), for recording, or for projecting a video into the screen depending on the purpose of its use (Appendix 1).

We categorized the peer reviewed studies included in the review into two themes based on the application of Google Glass™: to train physical skills (surgical or clinical), and to train behavior or communication. Reviews, narrative reviews, systematic reviews, and scoping reviews were excluded from this aspect of the review to reduce duplicate reporting.[2, 25–41]

Seventeen articles in this review addressed the training of surgical skills (Fig. 2). Articles were coded into this category if users were surgery students, surgery residents, fellows, or attendings and the focus of the article was on teaching surgical skills. Articles included creation of video catalogs,[42] determining if streaming would be feasible for education,[43] teaching skills to medical students,[44] remote training of residents,[45–48] remote tele-mentoring including overseas,[49–51] post-surgical review,[52–57] and a combination of remote consults, remote education, and post-surgery review.[58]

Figure 2: Frequency of Google Glass™ applications in healthcare education (may have been used in multiple ways in an article)



Nineteen articles were coded into the category of clinical skills (Fig. 2). These studies focused on clinical simulation for health care training related to cardiopulmonary resuscitation (CPR),[59–63] transfer training,[64, 65] diagnostic imaging,[66, 67] response to respiratory distress with a manikin,[68, 69] determining nursing student medication errors,[70] benign paroxysmal positional vertigo,[71] Emergency Management Services response,[72] emergency medicine clinical simulation scenarios,[73] advancing cardiology fellows education,[74] nursing student clinical decision-making,[75] dental students' head and neck examination,[76] and medical student performance in the emergency medicine clerkship.[77] Additionally, Google Glass™ was used for transfer of knowledge for anatomic pathology,[78] and static and dynamic stereo-structural anatomy.[79]

Seven articles were coded into the category of behavior and communication (Fig. 2). Google Glass™ was used to improve patient satisfaction and patient and otolaryngology resident communication,[80] provide medical students feedback on non-verbal communication with a Standardized Patient while giving terminal diagnosis news,[81] provide feedback to medical students after an Objective Structured Clinical Examination during a Family Medicine clerkship,[82] improve Nurse Practitioner student interview techniques and behaviors,[83] as a part of the curriculum to improve medical student empathy,[84] for self-assessment by dental students of communication skills during a head and neck examination with a standardized patient,[76] and to improve feedback of medical student communication in an emergency medicine clerkship.[77]

Effectiveness of Google Glass™

Google Glass™ has been used in different settings to deliver and/or assess academic and interpersonal aspects of healthcare education for a variety of healthcare professionals. Since it is a relatively new technological device, most of the peer-reviewed studies have been aimed at exploring its effectiveness in different settings. Forty-seven studies reported some information about its effectiveness in health care education.

To clearly report the effectiveness of Google Glass™ in healthcare education, we categorized study outcomes into its effectiveness as a teaching tool for clinical skills and surgical skills (Appendix 2) or communication/ behavior skills (Appendix 3), and included all relevant reviews, narrative reviews, scoping reviews, and systematic reviews. For this study, the application was considered effective if a study reported qualitatively and/or quantitatively a positive trend or change in the group using Google Glass™. Additionally, we reported the learner's perception of the use of Google Glass™ in the same manner as teaching effectiveness, as the learner's perception of the technology may be different than effectiveness.

Surgical skills

Two systematic reviews specific to Google Glass™ in surgery indicate promise in assisting training (Appendix 2).[36, 39] Five studies reported that it enhanced surgical training by easing live-streaming of surgeries for trainees, was associated with reduction in error score, or improved overall educational experience.[45, 46, 49–51] Counter to those results, eight studies reported it did not result in any difference in the outcome of surgical training/education.[42–44, 52–55, 58] Additionally, three studies reported it was inferior to other platforms in terms of video quality and technical specifications.[47, 48, 56]

Ten studies reported learner's perception regarding the use of Google Glass™ via surveys/exit surveys, viewer feedback/comments or interviews. Participants in nine studies perceived it facilitated their learning,[43–46, 49, 50, 52, 56, 57] while participants in one study perceived it was less effective than other platforms.[55]

Clinical skills

One early review and two systematic reviews specific to Google Glass™ reported promise for use in graduate medical education or student training settings.[29, 35, 37] Twelve studies contained reports from feasible to positive in a variety of clinical skills (Appendix 2). Areas these studies covered included CPR,[59, 60, 62, 63] transfers,[64, 65] imaging,[66] respiratory distress simulation,[69] medication dosing errors,[70] anatomy lab examination scores,[79] vertigo,[71] and decision-making.[75] No studies reported it being inferior in teaching, but seven studies did not report an advantage in its use

Ten studies reported learner's feeling of the use of Google Glass™ as an effective tool for clinical skill learning, based on either survey analysis, or thematic analysis of interviews or open-ended questions (Appendix 2). Learners in nine studies perceived it enhanced their learning and overall experience, or was of satisfactory use.[63–65, 67–69, 72, 75, 79] Specifically, it was reported to be easy to use, and promoted self-confidence and learning through simulation of clinical scenarios. Survey analysis of another study reported video quality was considered unacceptable by most students.[71]

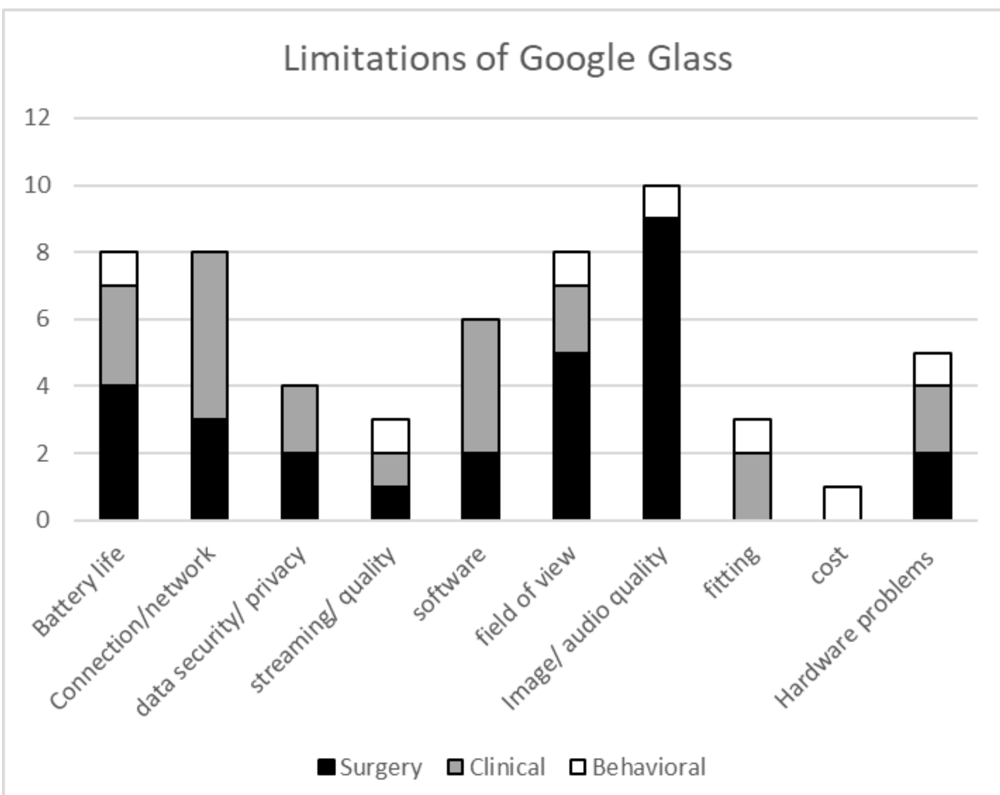
Behaviors

Four studies endorsed the use of Google Glass™ in clinical education to improve or self-reflect on targeted behaviors,[76, 80, 81, 83] and one study reported no significant change.[77] (Appendix 3) Data for behavioral changes were collected via student feedback after the session, surveys, and open-ended questions. Findings from the three studies revealed learner's perceived it was a useful tool for feedback, beneficial to improve interview skills, build self-confidence and improve communication skills.[81–83]

Limitations of Google Glass™

A total of 29 research studies or reports reported limitations associated with Google Glass™: 13 in surgical skills,[42, 44, 45, 47, 49–52, 54–58] 11 in clinical skills,[53, 59, 64, 65, 68–72, 74, 75] and 5 in communication/ behavior. (Fig. 3).[76, 80–83] Reviews, narrative reviews, systematic reviews, and scoping reviews were excluded from this aspect of the review to reduce duplicate reporting.[2, 25–41] Some of the commonly reported problems were short battery life (n = 8), and technical problems including connecting with wireless network (n = 8), data security and privacy concerns (n = 4), streaming quality (n = 3), and software compatibility (n = 6). In addition to software, studies reported issues with hardware, including the field of view (n = 8) and image resolution and audio quality (n = 10), both of which were more accounted for in surgery-related studies. The thirteen surgery-related studies accounted for 28 of the reported problems and occurred in all categories except fitting and cost. Most of these problems were field of view, image quality, and battery life. Interestingly, five of the behavioral/ communication-focused studies reported a total of seven distinct limitations.

Figure 3: Frequency of reported limitations of Google Glass™ in healthcare education (authors may have reported more than one limitation of Glass)



DISCUSSION

Google Glass™ has a low entry point in terms of cost in using AR for education, and gives the educator several options for use, from recording to streaming to playing video, and can be worn by the learner or another person. As this scoping review demonstrates, it is used in a variety of healthcare education settings for different outcomes.

We included 78 data sources regarding Google Glass™ in healthcare education published between April 2013 and September 30, 2021, consisting of grey literature and non-peer reviewed publications (n=13), textbook chapters (n=2), technical report (n=1), perspectives/ viewpoints/ correspondence (n=4), systematic reviews (n=6), scoping reviews (n=2), narrative reviews (n=1), reviews (n=7), and primary studies (n=42). Our scoping review suggests it is reported primarily in medical and nursing training and focused heavily on physical (surgical and clinical) skills, but it has also been examined for communication and behavioral skills, which may be an underutilized area of use as it can offer first-person perspective to the learner. Most primary studies indicated it was effective for the intended purpose.

While 34% of the research studies did not report limitations in the use of Google Glass™, there were consistent limitations noted in the literature, with battery life, connectivity, video quality, line of sight, and software compatibility being the most common challenges reported. Many of these were in surgical training, however this may be due to the technically demanding nature of surgery as compared to a broader visual field for communication and behaviors. It should be noted that of the 42 primary studies and 1 technical review, only 12 noted which version was used. Of these 43 papers, 34 were conducted, submitted, or published prior to the release of

Enterprise Edition, six prior to Enterprise Edition 2, and three after Enterprise Edition 2, so several of these problems may have been ameliorated or resolved entirely.

There are two limitations of this scoping review. Our exclusion criteria limited papers to those in English, and Google is a worldwide company so it could be anticipated researchers in non-English speaking countries have conducted studies with Google Glass™. Second, we created our own definition of effectiveness in teaching. The information presented in the research papers may not be statistically significant, which may result in our over-estimation of the effectiveness of Google Glass™ as a teaching tool.

CONCLUSIONS

With 1st-person point-of view and the ability to record or stream video and project information to the wearer, Google Glass™ has great potential in healthcare education to teach clinical skills and behaviors and may improve cognitive, psychomotor, and affective abilities. Glass Explorer has notable limitations in the literature that appear to impact its potential in surgical training, and it is unknown if these have been addressed in the Enterprise Editions. Future studies should include rigorous research designs founded in learning theories, and standardized outcomes specific to the applications being examined.

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Appendix 1: Selected papers reporting the use of Google Glass™ in Healthcare Education

Author (Year), Country	Study a) type b) objective	Methods a) Setting used in b) Population c) Who was wearing it	Use case descriptions
(2013) Medical Teacher [8][a]	a) Column about teaching	a) Surgery b) students c) surgeon	Mentions Dr. Grossman having students observe feeding tube placement.
Abalkhani & Amanian (2020), Canada [42]	a) Case report b) implement Glass with surgeons for student library creation	a) hospital b) surgeons and students c) surgeons	Attempt to create video library of surgeries
Ahier (2014), United States [15] [a]	a) Blog b) Report on use of Glass in healthcare, including surgical resident education	a) hospital b) surgeon c) resident	General description of resident using Glass to contact attending for surgical mentoring
Aungst & Lewis (2015), United States [21]	a) Prospective b) covering initial research on Glass and possible uses in medical practice	NA	Possible 1st-person point-of-view for students, remote mentoring for students and residents, development of procedural skills, improving interactions with simulations
Barteit et al (2021), Germany [34]	a) Systematic review b) effectiveness of Augmented, Mixed, and Virtual Reality head-mounted displays for medical education, incorporating a global perspective comprising low and middle income countries.	b) research articles (n=27)	Mentions students learning suture skills, central line placement, Ultrasound-guided procedures
Bartlett-Bragg (2013), Australia [16] [a]	a) Article b) Present potential of Glass including learning design	a) Medical school	Mentions University of California - Irvine Medical School having medical students use Glass in curriculum
Benninger (2015), United States [79]	a) Cross-sectional study b) "to demonstrate the use of Glass coupled with a novel ultrasound finger probe to teach static and dynamic stereostructural anatomy as part of triple feedback."	a) Academic medical center b) medical students (n=106) c) student	Glass was paired with an ultrasound finger probe to identify structures
Berte & Perrenot (2020), France [26]	a) Review b) Surgical apprenticeship tools and how apprenticeship is done in the digital age	NA	NA
Brewer et al (2016), United States [45]	a) Cross-sectional study b) To determine if live video from Glass worn by a trainee and seen by an instructor would improve performance and efficacy of teaching	a) surgery b) surgical residents (n=11) c) both learner and trainer	Video from learner streamed to trainer, who directed learner to position needles in simulated operative area.

Byrne & Senk (2017), United States [75]	a) Cross sectional pilot study b) To assess if nursing students could retrieve information necessary for clinical decisions with a patient using Glass, then call a primary care provider to communicate an update using Glass; to determine perception of student as it related to Glass use in scenario.	a) College b) Nursing students (n=11), c) Students	Nursing student had simulated patient and had to access information for encounter with Glass, then complete a call to the provider.
Carrera et al (2019), United States [35]	a) Systematic review b) Review of available literature on "use of [Glass] in Graduate Medical Education in the clinical learning environment, its use for resident supervision and education, and its clinical utility and technical limitations"	b) Research articles (n=37)	Primarily used for training surgical skills; teleconferencing and photo or video capture.
Chaballout et al (2016), United States [69]	a) Cross-sectional feasibility study b) "assess feasibility and acceptability of using augmented reality via Google Glass during clinical simulation scenarios for training health science students"	a) Academic institution b) Health Science students (n=12) c) Student	Video of a simulated patient in respiratory distress projected in Glass while student worked with manikin
Chang (2013), United States [9] [a]	a) News report	a) hospital b) assistant professor and med students c) surgeon	Anterior Cruciate Ligament repair
Datta et al (2015), United States [49]	a) Prospective cohort feasibility study b) can international tele-proctoring using wearable technology improve surgical technique of local surgeons	a) surgery b) surgeons in Paraguay and Brazil (n=2) c) surgeon learners	Local surgeons performed four hernia repairs with tele-proctoring via Glass; assessment scale completed after each surgery
Davis & Rosenfield (2015), United States [36]	a) Systematic review b) "To identify and critique all medical and scientific literature associated with [Glass] and provide a balanced summary of its application within plastic surgery"	b) research articles (n=21)	Reported in several surgical training situations
Dhar et al (2021), Australia [33]	a) Narrative review b) Report on the use of Augmented Reality in medical education/ training, and the effect on student learning outcomes and experiences	NA	Mentions University of California - Irvine using it in anatomy classes and hospital rotations for med students to access content or patient information

Dickerson et al (2019), United States [52]	a) Partially-blinded randomized control trial b) Assess feasibility and effectiveness of using Glass to improve orthopedic resident surgical skills	a) orthopedic surgery b) residents (20 intervention, 22 control) c) resident	Resident performed simulated procedure while wearing Glass followed by coaching session; intervention group observed video in the session, control received verbal coaching only; task repeated immediately post-coaching and performance was scored.
Dickey et al (2016), United States [46]	a) Cross-sectional pilot study b) Examine the feasibility of using augmented reality with Glass that could be used for urologic surgery as a surgical assistant and as a training tool	a) surgery b) Urology residents/ fellows (n=20), faculty (n=10) c) trainee	Video footage of procedure steps projected in Glass; live operating room footage streamed to remote attending
Dong & Sharma (2015), Singapore [22]	a) Correspondence	NA	Glass is referenced as a "wearable teaching tool" for medical education
Dougherty & Badawy (2017), United States [37]	a) Systematic review b) To "evaluate the feasibility, usability, and acceptability of using [Glass] in nonsurgical medical settings and to determine the benefits, limitations, and future directions of its application"	b) patient-centered studies (n=21), and clinician-centered studies (n=30)	Used in training of multiple disciplines for skills and communication/ behaviors
Drummond et al (2017), France [59]	a) Randomized controlled study b) "determine whether real-time video communication between the first responder and a remote intensivist via Google Glass improves the management of a simulated in-hospital pediatric cardiopulmonary arrest before the arrival of the [Intensive Care Unit] team."	a) Hospital b) Pediatric residents (n=42) c) learner	Residents evaluated for two simulated pediatric cardiopulmonary arrests using a high fidelity manikin; in second evaluation residents randomized to Glass group could request help from remote intensivist; assessed no-flow and no-blow fractions and quality of chest compressions and insufflation.
Evans et al (2016), United States [53]	a) Cross-sectional study b) Assess "the feasibility of using first person (1P) video recording... to assess procedural skills, as compared with traditional third person (3P) video"	a) surgery b) surgical residents and faculty (n=10) c) learner	Participants wore Glass while performing a simulated central venous catheter placement, and observer wore head-mounted camera; videos assessed by 3 raters using a checklist and a scale.
Glauser (2013), Canada [17] [a]	a) News report	a) Medical schools b) Medical students	Mentions medical students observing surgeries, seeing themselves from patient's Point-of-View
Green & Hug (2021), United States [27]	a) Brief Review b) Present ways to assess skills of Emergency Medical Service trainees	b) Emergency Medical Service trainees	Mentions reference McCoy - intercontinental mass casualty incident simulation
Grossman (2013), United States [10] [a]	a) Blog b) Report on use of Glass in surgery for potential uses, including education	a) Surgery b) NA c) c) surgeon	streamed feeding tube placement to nearby iPad

Gruenerbl et al (2018), Germany [60]	a) b)	Randomized study "Compare the effect of real-time wearable feedback with traditional training methods for cardiopulmonary resuscitation (CPR)"	a) University and Industry b) nursing students (n=23) and employees (n=27) c) learner	Group 1 received CPR lesson first, then train with either Glass or a smart watch; Group 2 trained with one of the devices and received a CPR lesson after.
Grünerbl et al (2015), Germany [61]	a) b)	Cross-sectional study "to verify the general viability of supporting teams of nurses in learning and performing emergency procedures by the means of near eye computing and on-body sensing"	a) education b) nurses (n=7) c) nurses	Used Glass to collect location information and a mobile phone to record posture and locomotion status, combined can provide information regarding cardiopulmonary resuscitation
Guze (2015), United States [25]	a) b)	Review How to face challenges in future medical education by creating infrastructure with technology	a) University b) Medical students	NA
Hashimoto et al (2016), United States [47]	a) b)	Cross-sectional study "to assess the feasibility of using Google Glass and its video quality in a telementoring session"	a) surgery b) attendings (n=34) c) chief resident	Chief resident completed surgery with attending guiding remotely via Glass; FaceTime used for comparison of quality of video, which were compared by 34 anonymous surgical attendings.
Herron (2016), United States [28]	a) b)	Review To demonstrate potential of augmented reality in medical education	NA	Interactions with manikins; live surgical feedback
Hoonpongsimanont et al (2018), United States [77]	a) b)	Cross-sectional study "to evaluate the effectiveness of first-person video recording... to enhance feedback quality"	a) Emergency Medicine b) fourth-year medical students (n=45) c) attendings or patients	Attendings and patients wore Glass to record interactions; students reviewed video with faculty who gave feedback. Students completed pre- and post-self-assessment forms and faculty completed standardized assessment forms.
Huang et al (2015), United States [48]	a) b)	Cohort study Evaluate effectiveness of tele-mentoring	a) Surgery b) Surgeons (n=9) c) Mentee (n=2)	Comparison a fixed hardwired Audio-Visual platform vs Glass: "Nine expert surgeons mentored two novice surgeons through a cadaveric laparoscopic right colectomy"
Ciomek et al (2015), United States [78]	a) b)	Cross-sectional assess Glass videos for educational purposes in anatomic pathology	a) pathology b) students c) pathologist	comparison of video and photo from Glass compared to hand-held digital photography
Iversen et al (2016), United States [71]	a) b)	Randomized control trial Determine if Glass was effective as a tool to teach treatment skills for adults with vestibular dysfunction in physical therapy students	a) University b) PT students (n=103; 52 with Glass) c) faculty member teaching the skills	Control group received normal instruction (readings, lecture, demonstration, practice); intervention group had the same except faculty wearing Glass during performance and practice of skills, projected in real-time on screen for students to observe. Skills check 7 days later.
NMC (2015), United States [18] [a]	a)	Overview	a) Medical Schools b) unknown c) unknown	Broadcast and record student training activities, including first-person perspective of faculty or patient.

Kamphuis et al (2014), Netherlands [2]	a) Review b) Describe a few uses of augmented reality training systems for medical learning to demonstrate potential for learning	a) Medical school	NA
Kassutto et al (2017), United States [63]	a) Cross-sectional feasibility pilot study b) To determine if Glass is feasible and reliable to record cardiac arrest and capture important resuscitation factors	a) Hospital b) responders to code c) physician code leader (n=11)	Simulated cardiac evens recorded by direct observation, stationary video camera, and Glass; videos analyzed by specialists for visibility and audibility, and quality of recording of predefined events and behaviors.
Klein et al (2015), Sweden [29]	a) Review (poster) b) Early application of Glass in healthcare	NA	Relevant application areas: remote instruction, instructional videos and simulation
Knight et al (2015), United Kingdom [43]	a) Case report b) To see how easy it would be to stream a surgery	a) surgery b) surgeon (n=1) c) surgeon	Surgeon wore Glass while implanting a device that was new to the hospital, and streamed it to a remote viewing area
Kopetz et al (2019), Germany [64]	a) Cross-sectional within-subjects design b) Determine the suitability of smart glasses support for skills training in nursing education	a) university/ school b) nursing students (n=29) c) student	Student performed repositioning bed > wheelchair without Glass, then with Glass which had a series of steps and video; self-assessment of performance after each. Number of errors and time recorded.
Kopetz et al (2018), Germany [65]	a) Technical report b) "the acceptance of smart glasses for this training, their effects, and how they can be integrated in the training"	a) university/ school b) nursing students (n=29) c) student	Technical report to use Glass as a tool to help nursing students learn practical skills with step-by-step instructions; students were surveyed on future use of Glass in education, and educators assessed error rates in those with and without glasses.
Kovoor et al (2021), Australia [38]	a) Systematic review b) Evaluate validity, effectiveness of AR in surgical education and compare with other training simulations	a) surgery b) research articles (n=24)	Urologic surgery
Lee (2014), United Kingdom [11] [a]	a) Perspective b) Report on use of Glass	a) surgery b) surgeon c) surgeon	Live stream of surgical procedure; plans for surgical procedure videos for students
Ljuhar et al (2020), Australia [30]	a) Review b) Review of wearable technologies in surgery and how they can promote learning	a) Surgery	Mentions formative feedback by simulated patient
Luce (2016), United States [23]	a) Perspective on current and future of surgery education	a) Surgery	NA
Marrocco et al (2019), United States [83]	a) Cross-sectional study b) Enhance student ability to effectively interview patients	a) nursing school b) nurse practitioner students (n=10) c) standardized patients	Standardized patient wore Glass during patient interview with student; afterward student completed survey, watched the video, completed the survey again, and was debriefed.
McCoy et al (2019), United States [72]	a) Cross-sectional feasibility study b) "to establish the process for successful delivery of educational content to learners overseas via telesimulation"	a) Academic medical center b) attendees of a Emergency Medical Services Mass Casualty Incident (MCI) course (n=32)	Live training of a simulated MCI applying what was covered in course content, then virtual simulation recording of another simulated MCI

		c) instructor	
McCullough et al (2018), United States [50]	a) Observational feasibility case study b) Determine feasibility of using Glass for tele-proctoring for surgery in low-resource country	a) hospital b) surgeon (n=1) c) field surgeon (n=1)	Remote tele-mentoring on novel or difficult plastic surgery cases
McKnight et al (2020), United States [31]	a) Review b) Virtual and augmented reality use in surgical training.	a) surgery	Total shoulder arthroplasty with remote assistance (reference); undescribed authors' experience
Moshtaghi et al (2015), United States [58]	a) Use case series b) To demonstrate use in otolaryngologic surgery, and assess if Glass could support education and improve team communication	a) Surgery b) otolaryngologic surgeons (n=3) c) surgeons (n=3)	1) communication for intraoperative consults, 2) streaming video of surgery for med students, 3) residents used for self-monitoring/ technical feedback and reviewed video with attending.
Munzer et al (2019), United States [40]	a) Scoping review b) To see what the current literature is regarding AR and emergency medicine practice or training	b) research articles (n=24)	Mentions pediatric life support training; simulated manikins with nursing
Nakhla et al (2017), United States [54]	a) Case series b) Assess the utility of Glass as a tool in neurosurgical education and improving on the efficiency of training residents.	a) surgery b) neurosurgeon attendings (n=3) c) attendings	1) recording attending performing preop positioning to incision in lumbar discectomy for later review by resident, 2) recording as attending observes/ assists resident in emergent craniotomy, 3) post-surgical follow-up on overseas medical mission for the surgical team that moved on
Nikouline et al (2016), Canada [55]	a) Cross-sectional feasibility study b) "evaluate the feasibility of Google Glass in scoring the technical skills component of the Fundamentals of Laparoscopic Surgery (FLS) exam	a) Surgery b) Operating Room nurse (n=1), med students (n=9), General surgery (GS) residents (n=13), GS fellows (n=2), general surgeons (n=3) c) Learner	Each participant completed a portion of the FLS exam using Glass and a Skype setup.
Nosta (2013), United States [19] [a]	a) Article b) Present 3 case uses of Glass	a) Academic medical center c) remote surgeon, surgeon, remote cardiologist	Physician Assistant consulting surgeon for procedure assistance; surgeon educating students on procedure; provider requesting cardiology consult
Pantelidis et al (2017), Greece [32]	a) Review b) History of Virtual and Augmented Reality in medicine, report of studies on these methods in medical training.	NA	Residents trained to place inflatable penile prosthesis

Paro et al (2015), United States [56]	a) Cross-sectional study b) To evaluate the role of Glass and GoPro in video-based self-evaluation	a) surgery b) medical students, residents, faculty (n not provided) c) medical students, residents, faculty	Volunteers wore each during surgeries and compared features of devices; "proof-of-concept" was completed for using Glass to communicate remotely for flap check.
Peden et al (2016), United Kingdom [44]	a) Prospective randomized study b) Investigate if first-person view of suturing via Glass can improve skill learning and satisfaction compared to conventional teaching	a) medical school b) medical students (n=14) c) students in Glass group	Students randomized between conventional teaching (5), Glass- assisted teaching (4), and Glass self-learning (5). First two groups received tutoring prior and assistance as needed during task with Glass-assistance additionally having access to video of procedure; Glass self-learning did not receive any tutoring or assistance.
Peregrin (2014), United States [12] [a]	a) News report	a) Surgery	Reports on use of Glass by Grossman and other surgeons
Pérez Alonso et al (2017), Spain [62]	a) Randomized cross-sectional study b) To assess the effect of remote mentoring on cardiopulmonary resuscitation (CPR) compared to control of no assistance	a) Academic medical center b) nurses (n=72) and physicians (n=36) c) both (nurse only received audio)	Nurse volunteers randomized to Glass assistance from physician vs control and performed CPR on high-fidelity manikin; time and actions performed were recorded
Ponce et al (2014), United States [51]	a) Case report b) To assess useability and limitations in surgical setting	a) surgery b) orthopedic surgeon (n=1) c) surgeon	Surgeon interacted with remote surgeon via Glass during a shoulder replacement.
Ramsingh et al (2019), United States [67]	a) Prospective cross-sectional educational intervention study b) "to evaluate the ability of a POCUS [Point of Care Ultrasound]-trained physician to remotely guide nonmedical personal to perform an acute cardiac, pulmonary, and abdominal POCUS exam using consumer-available communication devices"	a) University b) untrained undergraduate students (n=21) c) student	Participants wore Glass while being guided remotely to perform three simulated ultrasound exams, and resulting images were compared to images from expert sonographer
Russell et al (2014), United States [66]	a) prospective, randomized, single-blinded study b) "determine feasibility of telementored instruction in bedside ultrasonography"	a) Medical school b) medical students (n=18) c) student	Group A received telementored education in obtaining cardiac imaging, B received bedside education, and C received no instruction. Blinded expert reviewed and graded images
Sahyouni et al (2017), United States [57]	a) Cross-sectional study b) "to assess Glass as a quality improvement tool and educational resource in neurosurgery"	a) Academic trauma center b) surgical residents (n=12) c) resident	Surgical resident wore Glass during surgery. Immediately afterward they were given a pre-questionnaire, followed by a debrief with the attending while reviewing the recording. The resident then completed the same questionnaire afterward.
Schneidereith (2015), United States [70]	a) Cross-sectional study b) Describe errors in medication administration	a) nursing school b) nursing students (n=10) c) student	Nursing student completed a medication administration while wearing Glass; videos were watched by faculty for possible causes of medication error

Shapiro et al (2019), United States [84]	a) Prospective cohort observational study b) Evaluate if curriculum increased empathy scores of medical students	a) Medical school b) medical students (n=208) c) Standardized Patient	A new curriculum to increase empathy was added to the first two years of medical school, including the use of Glass with a standardized patient, with a debrief watching the video with the Standardized patient, the physician mentor, and the group of classmates.
Silberthau et al (2020), United States [24]	a) Viewpoint b) Digital video technology for surgical training	a) surgery	Video recording for future viewing by trainee
Skiba (2014), United States [20] [a]	a) Column about technology	a) healthcare education b) nursing students c) educators and manikins	Mentions remote surgery education, use in simulations with manikins
Son et al (2017), United States [80]	a) Randomized trial b) To determine if using Glass is feasible and effective in improving patient satisfaction scores and patient–physician communication	a) clinic b) Otolaryngology residents (n=5) c) patients	Each resident interacted with 10 randomized patients wearing Glass, who were then surveyed re: satisfaction; videos were reviewed by external faculty and information provided. Each resident then interacted with 10 randomized patients wearing Glass and survey and review were repeated.
Tully et al (2015), United States [81]	a) Cross-sectional study b) To assess if recording from a Standardized Patient perspective would be useful for students to review their non-verbal behaviors	a) Medical school b) medical students (n=30) c) standardized patient	Students participating in an end-of-life module gave a terminal diagnosis to a Standardized Patient wearing Glass to record the 1st-person perspective with an additional camera recording the standard view; students then reviewed the videos and completed two surveys.
Vallurupalli et al (2013), United States [74]	a) Case series b) Explore possible uses in clinical practice to improve education of fellows	a) clinic b) trainee (n=1), fellow (n=2), manufacturer rep (n=1) c) same as b	1) trainee studies Electrocardiogram (EKG) with remote fellow, 2) jr fellow reviews ECG with remote senior fellow, 3) fellow consults device rep to interrogate Internal Cardiac Defibrillator, 4) fellow performs procedure with remote faculty observing skills
Vaughn et al (2016), United States [68]	a) Cross-sectional pilot study b) Assess addition of video via Glass for realism to a simulation for nursing training	a) nursing school b) nursing students (n=12) c) student	Video was projected into Glass while the student performed assessment and intervention on a manikin
Waxman (2014), Australia [13] [a]	a) Perspective b) Current overview of use of Glass and limitations	NA	Streaming surgeries to learners
Wei et al (2018), United States [39]	a) Systematic review b) Examining "on the feasibility and acceptability of using [Glass] in surgical settings and to assess the potential benefits and limitations of its application"	a) Surgery b) research articles (n=31)	Urology
Whitaker & Kuku (2014), United Kingdom [14] [a]	a) report on 2014 surgery using Glass	a) surgery b) learners c) surgeon	First surgery livestreamed over internet

Wu et al (2014), United States [73]	a) Prospective cohort pilot study b) Describe experience with wearable technology in simulation-based training and discuss feasibility of using wearable technology during simulation-based training scenarios for medical education	a) Academic teaching hospital b) residents (n=42) and med students (n=9) c) team captains	Patient simulation in Emergency Dept (15 scenarios), with 3 independent observers reviewing/ analyzing video after to provide feedback to participants for events, behaviors, and professionalism; participants surveyed on Glass use.
Wüller et al (2019), Germany [41]	a) Scoping review b) To see what research has been conducted with Augmented Reality in nursing	b) Research studies (n=23)	Information transfer, cardiopulmonary resuscitation, medication calculation errors
Youm & Wiechmann (2018), United States [82]	a) Cross-sectional study b) "to explore the possibility of providing formative feedback to students" from recording the first-person perspective using Glass	a) Medical school b) medical students (n=255) c) simulated patient	Medical students performed an objective structured clinical examination with a simulated patient wearing Glass; after reviewing the video they completed an online survey about Glass use as a feedback tool.
Zahl et al (2018), United States [76]	a) Cross-sectional study b) "to evaluate student perceptions of how SP interactions recorded by [Glass] compare to those recorded by a static camera"	a) Dental school b) students (n=7) c) simulated patients	Standardized Patient wore Glass, while traditional camera recorded overhead. Both videos were reviewed in small group sessions. Students (n=23) completed the Video Review Assessment Effectiveness Scale for both videos.

[a] Not peer reviewed

DOI: 10.56031/2576-215X.1057

Appendix 2: Effectiveness of Google Glass™ in Teaching Skills

Author, Year, Country	Outcomes	Effectiveness as teaching tool	Student perception of Glass
Davis & Rosenfield (2015), United States [36]	Surgery: Studies using Glass in plastic surgery meeting inclusion/ exclusion criteria	[a] publications; Glass has "the potential to positively impact ….surgical training"	NA
Wei et al (2018), United States [39]	Surgery: Studies using Glass in surgical settings meeting inclusion/ exclusion criteria.	[a] 31 articles; "There are promising feasibility and usability data … with particular benefits for surgical education and training."	NA
Abalkhani & Amanian (2020), Canada [42]	Surgery: Obtain video recordings of surgeries from faculty surgeons	[b] Obstacles occurred, requiring development of a structured plan for next steps.	NA
Knight et al (2015), United Kingdom [43]	Surgery: Ability to set up Glass and screencast to a smartphone.	[b] Simple to set up	[a] Viewer reported seeing it remotely was helpful for training.
Peden et al (2016), United Kingdom [44]	Surgery: Graded practical assessment of suturing (1-10pt score); questionnaire re: confidence and satisfaction.	[b] Grades of suturing similar between the three groups.	[a] Glass-assisted group enjoyed learning more than the conventional group. Compared to conventional group, Glass self-learning was rated as more enjoyable but least useful.
Brewer et al (2016), United States [45]	Surgery: Composite Error Score (CES), Time to Task Completion (TTC), and an 8 item exit questionnaire using Likert scale	[a] CES improved from 18+/-5mm to 15+/-4 ($p<0.05$); TTC did not improve with Glass	[a] Exit survey included ease to operate (73%), useful for feedback (100%), useful for communication (73%).
Dickey et al (2016), United States [46]	Surgery: Augmented Reality Assisted Surgery Survey (4 questions on 10pt Likert scale, 4 yes/no, and one open-ended question)	[a] Educational usefulness: 8.6; Ease of Navigation 7.6, Likelihood to use 7.4; Distraction in operating room 4.9.	[a] 81% recommended implementing in program, 93% endorsed its role in operating room, 71% said they would consider using it in the future, and 53% reported it bettered their understanding of the procedure.
Hashimoto et al (2016), United States [47]	Surgery: Modified version of the Video Quality Expert Group (VQEG) video quality assessment and digital video quality assessment scale	[c] 50% rated Glass video fair, 50% bad to poor. 84% responded that video quality of Glass was not adequate for remote mentoring because of deficits in detail primarily.	NA
Huang et al (2015), United States [48]	Surgery: Interview and undescribed assessments	[c] Less effective than other platform	NA
Datta et al (2015), United States [49]	Surgery: Lichtenstein-Specific Operative Performance Rating Scale(OPRS); post-training questionnaire.	[a] 1st surgeon trainee: proficiency met in all areas for operations performed, with improvement noted in five areas. 2nd surgeon trainee: proficiency met in all areas for operations performed, with improvement noted in ten areas.	[a] 2nd surgeon trainee: reported great value of training which would change his practice and improved his confidence.

McCullough et al (2018), United States [50]	Surgery: Screen-capture, log of procedures performed, notes on interruptions, complications. 10-question survey for acceptability, functionality, and video quality, and narrative interview of both surgeons.	[a] 12 surgeries; no complications, all livestreamed.	[a] Survey indicated quality sufficient but image distortion a limitation. Both rated Glass helpful as a tool for teaching.
Ponce et al (2014), United States [51]	Surgery: Glass being able to be used in a surgical setting.	[a] Glass able to be integrated with University's Virtual Interactive Presence and Augmented Reality system (VIPAAR), allowing local and remote surgeons to interact with the surgical field, but limitations of current Glass platform makes it impractical for use in surgery at this time.	NA
Dickerson et al (2019), United States [52]	Surgery: Objective Structured Assessment of Technical Skills checklist, use of fluoroscopy, quality of reduction of fracture, Global Rating Scale; interview.	[b] No significant difference in improvement for any of the outcome measures between groups.	[a] Interview analysis revealed video coaching improved several aspects of learning for majority of subjects, and a desire for the use of video coaching for surgical education.
Evans et al (2016), United States [53]	Surgery: Videos were assessed by 3 expert raters using a task-specific checklist (CL), and an additive and a summative Global Rating Scale (GRS).	[b] The view from Glass had a significantly higher CL score; no significant difference in GRS scores. Interrater reliability for the three outcomes were similar for both views.	NA
Nakhla et al (2017), United States [54]	Surgery: Applicability of Glass including how easy it was to use, its effectiveness to record or document, to display needed information, and its use as a communication tool.	[b] Authors reported that Glass able to record video segments, responds to voice commands, and is a possible tool to create a video library for resident education	NA
Nikouline et al (2016), Canada [55]	Surgery: Times and errors of two tasks from the Fundamentals of Laparoscopic Surgery; survey of Glass experience.	[b] High interrater reliability, with no difference between Glass and Skype.	[c] Glass experience reported on average to be distracting, view obstructing, and limiting execution of tasks.
Paro et al (2015), United States [56]	Surgery: Comments on device features after use; specifications of hardware and software; trial of simulated flap check	[c] GoPro superior in technical specifications including recording speed, picture resolution, battery life. Glass able to be used in simulated flap check but detail of images lost.	[a] Glass more comfortable, easier to use, and did not require 2nd person to operate in the Operating Room.
Sahyouni et al (2017), United States [57]	Surgery: Pre-questionnaire after surgery; post-questionnaire (5-point Likert scale) after debrief assessing comfort level with procedure performed, quality of attending's education in debrief, comfort in repeating the procedure, and benefit of using video from Glass to debrief.	NA	[a] Average for questions 1-3 (utility, comfort, interest in using again) pre and post was 3.75 and 4.42. The average for question 4 (did debriefing with Glass video help improve understanding and training) was 4.63.
Moshtaghi et al (2015), United States [58]	Surgery: Beneficial for education, consultation.	[b] Able to remotely consult another surgeon (audio), stream video to medical students, and record video of resident surgery as way to observe themselves and receive feedback.	NA

Klein et al (2015), Sweden [29]	Review: Description of early uses of Glass in health-related contexts including medical education	[a] 6 situations of remote instruction, 2 situations for recording for instruction or simulation; "mostly promising results, but also caution" for some due to tech limitations	NA
Carrera et al (2019), United States [35]	Systematic review: studies using Glass in Graduate Medical Education (GME) meeting inclusion/ exclusion criteria	[a] 37 studies; "[Glass] shows some promise as a device capable of enhancing GME."	NA
Dougherty & Badawy (2017), United States [37]	Systematic review: Studies using Glass in nonsurgical medical settings meeting inclusion/ exclusion criteria	[a] 51 articles; "More promising results regarding the feasibility, usability, and acceptability of using [Glass] were seen in patient-centered studies and student training settings."	[a] 51 articles; "More promising results regarding the feasibility, usability, and acceptability of using [Glass] were seen in patient-centered studies and student training settings."
Drummond et al (2017), France [59]	Cardiopulmonary resuscitation: Main outcomes: no-blow and no-flow fractions. Secondary outcomes: (1) discrete, observable resuscitation-related actions, and (2) the times to first ventilation, first compression, and adrenaline prescription.	[a] No-blow and no-flow fractions similar between Glass and control; insufflations more effective; chest compression technique and rate better in Glass group.	NA
Gruenerbl et al (2018), Germany [60]	Cardiopulmonary resuscitation (CPR): % effective CPR % correct depth % correct Speed	[a] Neither device favored: Glass performed slightly more effective CPR and slightly better in speed of compressions but less in compression depth	NA
Grünerbl et al (2015), Germany [61]	Cardiopulmonary resuscitation: "Acceleration, gyroscope and earth magnetic field information"	[b] Able to determine motion and orientation of the head; data indicates whole body movement of cardiopulmonary resuscitation.	NA
Pérez Alonso et al (2017), Spain [62]	Cardiopulmonary resuscitation (CPR): completion	[a] Glass group more successful with defibrillation and completed CPR more quickly.	NA
Kassutto et al (2017), United States [63]	Cardiopulmonary resuscitation: Observation evaluation form including scores for average global visualization and average global audibility; Secondary outcomes: percentage of resuscitation factors visualized well or heard well, and percentage of observations where technical video problems prevented interpretation of overall resuscitation. Additionally, anonymous 17-question survey regarding Glass as a tool for resuscitation observation and feedback was given to code leaders.	[a] Glass had better average global visualization (3.95 vs 3.15) and average global audibility (4.77 vs 4.42). Overall interpretability limitations less with Glass (19% vs 35%).	[a] All survey respondents endorsed ease of Glass use; 20% reported it being distracting; 30% uncomfortable with its use in actual cardiopulmonary resuscitation.
Kopetz et al (2019), Germany [64]	Transfers: Questionnaire regarding their performance and about the app; expert rating on performance and errors; time for the task.	[a] Improvement in awareness/ self-evaluation of performance. 58.6% reported improvement in confidence in using app. Use of the app increased the time of completion by 11 seconds. Statistically significant improvement reported from no Glass to Glass by one rater but not the other.	[a] 51.7% neutral in comfort and 27.5% natural or very natural. 71.4% positive about the use of the app in training, but only 25.9% would want to use it in practice.

Kopetz et al (2018), Germany [65]	Transfers: Acceptance by group using system; improvement in training of skill	[a] Error rate slightly less with Glass setup.	[a] Majority endorsed imagining using this for skills training and agreed it improved their training and self-confidence.
Russell et al (2014), United States [66]	Imaging: Adequacy of image for E-point Septal Separation (EPSS), image quality on 0-10 scale.	[a] Adequacy of image 100% for Group A and B; Group C 17%. Image quality (median): Group A 7.5, Group B 8, Group C 0.	NA
Ramsingh et al (2019), United States [67]	Imaging: "the frequency of obtaining adequate image quality" on the three components of the imaging exam. Secondary: exam time; survey on use of system and process for all participants; model experience survey.	[b] 87-95% of images obtained were of adequate quality, with 100% agreement of interpretation between live expert and blinded reviewer. Total exam time: 8.5min.	[b] Survey on user satisfaction: audio quality 3/5; comfort for obtaining views 4-5/5, ease of following instructions 5/5. Model comfort: 5/5 for all exams.
Vaughn et al (2016), United States [68]	Simulation: Simulation Design Scale (SDS), Self-Confidence in Learning Scale (SCLS); open ended questions regarding experience, if Glass added to learning, and if barriers were encountered	NA	[a] SDS indicated simulation design viewed favorably (mean scores 4.81 to 4.83). SCLS results indicated the addition of Glass to the simulation was viewed positively for learning (4.65 ± 0.65).
Chaballout et al (2016), United States [69]	Simulation: Feasibility (set-up, play video, address technical problems); Acceptability: Student Satisfaction and Self-Confidence in Learning Scale (13 items), the Simulation Design Scale (20 items), recommendation to continue use of Glass in simulations, and open ended question regarding participant experience.	[a] Feasibility: video played for all simulations, but some challenges with connecting due to security measures, learning curve for students, coordinating starting video and simulation, short battery life, overheating with longer usage.	[a] Acceptability: simulation design, promotion of learning with simulation, and self-confidence showed high scores. 80% recommended continued use; open-ended questions showed variety of opinions.
Schneidereith (2015), United States [70]	Medication: identifying reasons for dosing errors	[a] Incorrect dosing equations noted	NA
Iversen et al (2016), United States [71]	Vertigo: Pre-test questionnaire for baseline level of self-reported skill; competency assessment; evaluation of teaching.	[a] No differences between groups for changes on questionnaire regarding self-efficacy; Glass group had a statistically significant difference in assessment of skill. 77% of Glass group were competent vs 59% of control group.	[c] Video quality deemed to be unacceptable to most students.
McCoy et al (2019), United States [72]	Emergency Medical Services: Anonymous post-course survey regarding taking the course via tele-simulation; feasibility assessed by collecting triage data for diagnostic accuracy.	[b] Triage data was able to be collected.	[a] Positive responses to all survey questions.
Wu et al (2014), United States [73]	Simulation: Google Glass recording of simulations and analysis of variables to enhance feedback and debriefing sessions.	[b] Able to record and use video analysis results for feedback of team members.	NA
Vallurupalli et al (2013), United States [74]	Cardiology: ability to stream video/ audio and mentor	[b] Able to stream video/ audio and mentor in four simulations.	NA

Byrne & Senk (2017), United States [75]	Nursing: Ability to use Glass to access information and to communicate with a provider; researcher-developed survey (9 questions with 4pt scale, two open-ended questions)	[a] 100% completion of both tasks.	[a] Survey results: device easy to use, way to improve communication, allowed access to information to help make decision about care. Themes of communication and safety noted in open-ended questions.
Hoonpongsimanont et al (2018), United States [77]	Standardized medical school evaluation form completed by the student (pre and post review session), and standardized faculty assessment form.	[b] No significant change in scores after review session; 9 students did change scores toward faculty scores on clinical skills after review	NA
Ciomek et al (2015), United States [78]	Anatomic pathology: Image evaluations	[b] Image quality comparable to digital photography; Glass convenient, efficient compared to traditional photography. Videos of more educational use than photography or reviews of tissues.	NA
Benninger (2015), United States [79]	Anatomy: Lab examinations to identify anatomical structures and perform minor procedures; two-item questionnaire using 5-point Likert scale to assess enjoyment of this learning method and preference for future use.	[a] Lab examination score improved from 81% to 97%.	[a] Enjoyment of method 4.6, and preference for future use was 4.8

[a] Positive report
[b] No change/ NA/ only about feasibility
[c] Negative report

Appendix 3: Effectiveness of Google Glass™ in Teaching Communication and Behaviors

Author, Year, Country	Outcomes	Effectiveness as teaching tool	Student perception of Glass
Zahl et al (2018), United States [76]	Video Review Assessment Effectiveness Scale (VRAES) with 5 subscales for both videos; additional survey re: using Glass and static video for self and peer assessment	[a] Statistically significant differences towards Glass for Verbal Communication and Paraverbal Communication subscale, and towards static camera for Non-verbal Communication.	[b] Themes for open-text responses included 1st-person perspective, non-verbal communication assessment, experience with audiovisual aspects including video, head movements, and line-of-site, and operation of Glass.
Hoonpongsimanont et al (2018), United States [77]	Standardized medical school evaluation form completed by the student (pre and post review session), and standardized faculty assessment form.	[b] No significant change in scores after review session; 9 students did change scores toward faculty scores on clinical skills after review	NA
Son et al (2017), United States [80]	Patients completed a survey regarding their interactions (6 questions from the Consumer Assessment of Healthcare Providers and Systems (CAHPS) survey); faculty reviewers completed a 14-item survey regarding those 6 items plus 4 other topic areas.	[a] Patient scores significantly decreased on one item, and decreased on others but not significantly. Faculty scores significantly improved for 11 questions.	NA
Tully et al (2015), United States [81]	Self-evaluation immediately after experience, with Glass group having additional questions regarding possibly using Glass in future scenarios; written reflections after watching their videos, with Glass group watching standard video and Glass video, and also completing an additional 10-question survey.	[a] After viewing videos, 77% of Glass group participated in survey; 70% endorsed that Glass helped to identify actions or behaviors they did not see in the other video.	[a] In Glass group, 60% viewed experience as positive; 77% found it distracting to at least some extent.
Youm & Wiechmann (2018), United States [82]	Survey on the use of Google Glass in a family medicine clerkship Objective Structured Clinical Examination	NA	[a] 89% endorsed receiving helpful feedback from Glass; 82% thought it was a new opportunity for feedback; 89% saw value for the device in their education. 84% agreed they were comfortable with the standardized patient wearing Glass; 79% denied it impacted communication. 15% believed it resulted in a decrease in their performance.
Marrocco et al (2019), United States [83]	Four-question open-ended survey given after interview and again after watching the video, about "perceptions of the interview, the process, strengths and limitations of the interview, and areas seen as needing improvement;" 1:1 debrief with faculty regarding perceptions and use of Glass.	[a] After the video students added reflections not mentioned previously in relation to their performance or technique.	[a] Students also reported the use of Glass to be beneficial to improve interview skills.

[a] Positive report
[b] No change/ NA/ only about feasibility
[c] Negative report