Review Article

**Applicability and validation of educational technologies for teaching in health courses with an emphasis on mobile applications: A review**

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**ABSTRACT**

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| This review aimed to gather current evidence on the applicability of educational technologies in the health field, with an emphasis on mobile applications, as well as the methods used for their validation. The advancement of digital technologies has positively impacted the training of health students and professionals by facilitating access to information and promoting the development of clinical competencies. Mobile applications (m-Health) stand out as complementary tools in education, supporting active learning and evidence-based decision-making. However, the rapid expansion of these resources poses important challenges, such as the need for regulation, usage safety, and scientific validation. This review sought to answer the following questions: (1) What are the main applications of mobile educational technologies in health education? and (2) What methods have been used to validate these tools? To address these questions, the review identified validation methodologies such as the Delphi method, expert panel analysis, and the Content Validity Index (CVI), considered effective strategies to ensure the reliability and effectiveness of the applications. The integration between active teaching methodologies and mobile technologies is also emphasized as essential for a more interactive educational experience, aligned with the current generation of students. The review includes studies conducted in different countries, giving the work a global scope. Nevertheless, barriers related to accessibility and content adaptation persist. It is concluded that mobile applications in health education must undergo rigorous validation processes to ensure pedagogical effectiveness and contribute to the training of professionals better prepared for the challenges of clinical practice. |

*Keywords: Educational Technology, Mobile Applications, Health Sciences*

**1. INTRODUCTION**

Health care has increasingly relied on digital tools, driven by the advance of health technologies. These technologies have taken on many different aspects, including health promotion, prevention, treatment, maintenance and teaching. Technological tools stand out by overcoming various barriers to health care, especially geographical and time constraints.[1]

The World Health Organization (WHO) calls technological innovations with applications in the health area e-Health, m-Health, also known as mobile health, is part of e-Health, as it encompasses mobile applications aimed at improving health.[2] It is a fact that mobile applications are growing technological innovations with the potential to provide access to information and transform it into knowledge.[3]

The WHO emphasizes the potential of mobile applications as tools to support health, recognizing them as “complementary strategies for strengthening healthcare.” In this sense, the importance of the user knowing how to discern when to use a technological tool as a support is emphasized, while at the same time promoting the continuous deepening of clinical knowledge through other validated scientific materials.[4]

It is estimated that there are more than 4.8 million mobile applications available in the App Store and Google Play stores, of which more than 350,000 are aimed at the health area [5], a much higher figure when compared to 2015, when there were approximately 165,000 m-Health applications, according to the Institute for Healthcare Informatics. Over the last decade, more than half of cell phone users have downloaded a health-related mobile app, underscoring the growing demand for these applications.[6]

This perspective also encompasses the potential use of mobile apps in teaching, particularly in the education of professionals and undergraduates in the health sciences.[7] The changes in university curricula aimed at overcoming traditional methods in favor of active and interactive methodologies highlight the role of the student, as opposed to the view that the teacher is the central holder of knowledge.[8]

Furthermore, it is essential to consider the profile of the majority of today's university students, belonging to the so-called “Generation Z”, made up of individuals born in the 1990s and strongly influenced by technological immersion, with ample access to the internet, television, mobile devices, and various other digital resources. In a way, this generation has driven the transformation of educational dynamics, since it has a growing expectation for the daily incorporation of digital technologies into the teaching-learning process.[9]

Teachers of health courses have adopted various technologies to expand knowledge and improve students' skills.[7] It should be considered that nowadays, with the decrease in the value of smartphones, many individuals already own a mobile device, favoring students' access to educational technologies. These devices enable students to clarify their doubts in real-time, eliminating the need to wait for answers from teachers or classmates.[10]

The integration of active methodologies with technological tools makes the teaching process more attractive to students. This practice makes classes more dynamic, enhances the discussion of specific topics, and can drastically contribute to advances in teaching practices by arousing students' curiosity.[11]

Mobile applications designed to educate healthcare students have made a positive contribution to the development of clinical practice, particularly in fostering critical thinking. Their use in practice has been correlated with greater satisfaction, progress, and self-confidence, as well as being associated with a reduction in the anxiety levels of professionals when faced with doubts and gaps that arise daily. Evidence even indicates significant improvements in professionals' skills when compared to traditional teaching.[12]

Despite the significant growth in m-Health teaching applications, many are still of poor quality and lack security, given that they are often developed by people with no training in the health field, have no solid foundation, have not been validated with reliable instruments, and have not been published in peer-reviewed scientific journals.[1] Given the growing diffusion of educational technologies, especially mobile applications, and considering the need for structured, evidence-based validation, this review sought to gather current evidence on the applicability of educational health technologies, with an emphasis on mobile applications, as well as the methods for validating these tools.

**Technological innovations in health (e-Health) and mobile health applications (m-Health)**

The e-Health concept is broad and encompasses the use of technologies to provide health resources, services and information. Today, health technologies have become an essential part of health systems, contributing to the optimization of clinical practice, reduction of errors and improvement in the provision of services, making them more efficient and accessible.[13]

e-Health technologies are also described as transforming the processes of prevention, health promotion, monitoring, management, health equity, and surveillance of public health disasters.[14]

To effectively implement e-health technologies, several conditions are necessary. These include adequate strategic planning, acceptance by the population and users, a robust infrastructure, well-structured systems, and adequate management. Investment is also essential, and can come from either the private sector or the government.[15]

Because they involve different branches of knowledge, their implementation can be described as interdisciplinary, since it involves different fields that complement each other, such as Computer Science, Engineering, Information Science, Clinical Medicine, Epidemiology, and Public Health.[14]

Segundo,15 in a review carried out between 2014 and 2019, identified the countries with the highest number of research projects on health technologies: the United States (109), Australia (41), the United Kingdom (32), China (23), Italy (19), Germany (18), Norway (14) and France (10). The main e-Health practices established were mobile applications and telemedicine, with the most benefited specialties being psychiatry, dermatology, rehabilitation, ophthalmology, cardiology, and dentistry.

In the health sphere, various technologies can be used to provide care, and they are classified as soft, soft-hard, and hard. Soft technologies refer to the process of building interpersonal relationships, bonds, and communication; hard technologies express the knowledge structured in different areas of health, and hard technologies are structured in machines, equipment, and organizational processes.[16]

The humanized welcome provided by health professionals and health advice via Short Message Service (SMS) messages, telephone contact, or social networks such as WhatsApp are considered soft technologies. Building a bond through home visits, as well as the use of specific forms, protocols, and questionnaires, falls under hard and soft technologies. In turn, the use of sophisticated equipment, mobile applications, and software corresponds to hard technologies.[17]

The main hard technologies used in various countries around the world include sensors connected to mobile applications, also known as “wearable technologies”, which allow passive real-time capture in certain situations; the use of online webcams, with the potential to extend specialist access to a large number of patients; and the popularization of the “Internet of Things” concept, which has expanded these innovations through low-cost disposable sensors, providing connectivity with everyday objects.[15, 18]

Despite the broad evolution of e-Health technologies around the world, there are still significant barriers to their implementation in the provision of health services, such as high costs related to the use of telemedicine, challenges that may interfere with regulations and legislation, possible security flaws in the use of “cloud computing”, limitations on the possibility of clinical trials involving digital technologies and restrictions related to database infrastructure and interoperability.[19]

m-Health, also known as mobile health, refers to mobile health applications and is an essential component of e-Health. Secondly1, such technologies are software programs for mobile devices such as smartphones and tablets, used in healthcare, which play an indispensable role in many aspects of healthcare, including patient education, data monitoring, symptom control, chronic disease management, behavior modification, and preparation or adaptation.

Mobile applications are part of the New Information and Communication Technologies (NICT) and are capable of providing a wide range of functionalities such as capturing, storing, retrieving, receiving, analyzing, and sharing data. Additionally, due to their versatility, they can be used for numerous purposes and customized according to the needs of their creators.[3]

It's worth noting that mobile applications emerged with the creation of smartphones, or smartphones, when the world's first smartphone, the IBM Simon, was launched in 1994. The IBM Simon allowed users to access “software applications” via a pen and touchscreen. However, the IBM Simon did not have mobile internet, and due to other peculiar characteristics, it was considered poorly enabled and had low take-up.[20]

With the evolution of smartphones, new mobile applications have emerged, since ICT has added great data storage capacity.[20] Considering the variety of possibilities offered by smartphones, it is not difficult to see how widespread they are worldwide.[21]

In the field of health, mobile applications have been recognized as viable alternatives to traditional products, offering new perspectives and forms of communication and action that enhance care. Studies indicate that apps have the potential to improve outcomes, reducing instability and health-related risks, while also promoting health.[22] In nursing, the largest health sector in several countries, apps have been used as tools for clinical practice, health education, and management.[3] However, it is clear that health professionals need to rethink the methods they use and embrace the mobile technologies that are increasingly available as support tools for care.[22]

It is estimated that in 2012, there were more than 40 billion app downloads on smartphones. By 2016, this figure had already exceeded 300 billion. In terms of downloads of health apps, it is estimated that in 2015, there were more than three billion downloads worldwide.[21]

These health apps are aimed at different audiences and age groups, including pediatric, adult and elderly patients, caregivers, university students, and health professionals. The apps encompass general niches such as managing health or a disease, promoting a healthy lifestyle, and obtaining health information, so there are a multitude of apps and categorizations available.[23]

Ramdurai [23], classified mobile health apps into five categories: clinical and diagnostic apps, aimed at data collection and evaluation, electronic records and visualization of laboratory tests; remote monitoring apps, which mainly check vital signs and promote home care for the patient without the need for the professional to travel; healthy lifestyle apps, which track health metrics such as diet, exercise, heart rate and sleep; clinical reference apps, which gather data and information based on scientific evidence and classify diseases; and productivity apps, associated with intelligent resources for optimizing tasks.

A similar study by Bezerra [22], identified four main dimensions specifically related to mobile applications aimed at health care. These categories were defined as: “Living well with chronic diseases”, focused on caring for people who live with a chronic disease such as circulatory diseases, cancer, respiratory diseases and diabetes; “Accessing instructions and information”, related to preparing for exams; “Carrying out rehabilitation activities”, aimed at post-treatment monitoring of diseases that have caused problems; and “Improving dental care”, mainly aimed at sending appointment reminders.

Health professionals who used apps as tools to support clinical decision-making were found to make more appropriate clinical diagnostic decisions when compared to professionals who did not use such tools. Many professionals associated the effectiveness of apps with interactive features such as calculators, highlighting their influence on clinical scores, indices, and drug doses quickly.[24]

Regarding applications targeted at health professionals, it is known that there are several, designed for different professions and specialties, predominantly aimed at doctors and nurses. However, it is essential to note that most of these apps do not undergo the usability analysis phase, resulting in a low level of evidence regarding their effectiveness and applicability.[4]

**Applicability of mobile technologies in health teaching**

The verb “to teach” comes from the Latin insignare, meaning “to mark with a sign”. This sign would be of life, search, and awakening to knowledge. Teaching involves two dimensions: the intention and the result, i.e, the intention to teach and the achievement of that goal. In this context, even if there is a sincere intention to teach, if the apprehension and appropriation of the content by the student is not effective, it cannot be said that it has in fact “been taught”.[25]

About teaching strategies, it is known that the word “strategy” originates from the Greek and Latin strategia, which is based on the art of applying or exploiting favorable and available means and conditions in favor of specific objectives. In this context, the teacher becomes an excellent strategist, as he or she must study, select, organize, and propose the best facilitating tools for students to acquire knowledge. Other terms are also commonly used to refer to the means or processes that the teacher will use for teaching, such as “techniques”, ‘dynamics’ and “methods”.[25]

Changes have emerged in university teaching profiles. Higher education is seeking to overcome the traditional method of memorization with an active approach, based on knowledge retention and student engagement. Traditional practices that involve reading, showing slides, and listening are being replaced by more complex active practices that include talking, debating, illustrating, reproducing, dramatizing, teaching, and exposing summary ideas.[8]

Technological innovations are being introduced as teaching strategies in order to complement and, over the years, even replace traditional education based primarily on memorization. Many of the technological tools available for teaching are designed to facilitate the acquisition of information and retention of knowledge through mobile devices, such as cell phones and tablets.[26]

Combining active methodologies with technological tools is also a practice that is more attractive to students. This practice makes classes more dynamic, enhances the discussion of specific topic,s and can drastically contribute to advances in teaching practices by arousing student curiosity. Given that active methodologies are teaching strategies centered on the primary participation of students, combining them with digital technologies is an essential pedagogical innovation.[26]

The integrative review written by [11], identified that the main teaching strategies that make use of technological tools in health teaching include virtual learning environments, educational technologies, telemedicine, virtual learning objects, digital narratives (blogs), virtual simulation, electronic quizzes, e-learning, and gamification. Chart 1 summarizes information on technological tools used in health teaching.

Chart 1 - Summary of information on technological tools used in health teaching

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| **Tool** | **Description** |
| **Educational technologies and virtual learning environments** | It has shown benefits such as active learning, deconstruction of the traditional teaching model, shared production of knowledge, innovation in the teaching proposal, exploration of new ideas, exercise of creativity, autonomy, dissemination of digital culture, and greater motivation to study. |
| **Telemedicine** | The aim is to make it possible to assist, educate, research, preven,t and promote health in a single tool. This tool can support clinical reasoning and decision-making skills based on real problems when used by students and residents during their undergraduate or specialization studies through anamnesis, physical examination, indication of tests, and diagnostic formulations. |
| **Virtual learning objects** | They cover a range of educational resources in various formats. They include slideshows, videos, animations, text files, hypertexts, among others, for use on computers, notebooks, smartphones, or tablets. |
| **e-learning** | Content is made available electronically over the Internet through digital platforms, such as e-modules on the Moodle Platform (Modular Object Oriented Dynamic Learning Environment). |
| **Gamification** | It involves the use of games as a teaching method. It is a recent proposal and has been evaluated as an innovative teaching method in health. The use of games in the teaching process has provided a favorable space for the assimilation of concepts, discussion, motivation, and criticality, as well as greater student engagement. Gamification is closely tied to the use of mobile applications as teaching methods. |

Source: Adapted11, 12

Apps aimed at health learning are being heavily developed in technologically advanced regions such as Europe, North America, and parts of East Asia, including low-cost models with limited functionality and more expensive models with more extensive features.[12]

The systematic review [27], identified that the areas of health that most use mobile apps for teaching are medicine, nursing, physiotherap,y and biomedicine, with medicine predominating. Among the main specialties are pediatrics, surgery, general practice, neurology, anatomy, anesthesia, psychiatry, and cardiology. The main resources identified were texts, images, quizzes, exercises with explanations of the answers, videos, annotations, 3D animation,s and graphics.

With the advance of smartphones, there are now a wide variety of features on mobile devices such as video playback, photo displays, and larger media storage spaces. With such resources, mobile technologies can allow teachers and students to interact anytime and anywhere, which reinforces the potential of using mobile applications for learning, evaluation, and teaching in health.[28]

Medical students in Pakistan are using online applications via smartphones to add to medical education as an educational tool for a variety of purposes, including clinical practice guidelines, medical calculators, drug reference tools, and other decision support aids, textbooks, and literature search portals. Some apps are used to simulate surgical procedures, while others are used to assess various sensory functions of the body, including auditory and visual tests.[26]

It must be considered that nowadays, with the decrease in the value of smartphones, many individuals already own a mobile device, making it a reality in which many academics can have access to mobile teaching devices. Through mobile teaching devices, it is possible for students to ask questions in real time, something that used to take time when waiting for a teacher or even a classmate to reply.[10]

There are also gamification apps with other teaching media, such as question and answer quizzes, package leaflet databases, calculators, quick diagnosis queries, interactive decision-making games, clinical case sharing and testing, clinical information references, clinical case sharing through photographs, anatomy atlases, health news, exam questions, terminology dictionaries, surgery simulators and prescription guides.[10]

Students in the health sciences have highlighted various benefits of using mobile applications in teaching, such as the greater supply of content in a fast and accessible way, increased participation in learning activities, access to a greater number of clinical cases, improved interpretation of study images, preference over the use of books, improved performance in assessments, improved execution of practical activities, contextualized learning according to the level and pace of the learner, as well as monitoring student results in real time.[27]

However, it has been noted that students still face some difficulties in using apps for teaching, such as the need for more content and clinical cases on specific subjects, the high cost of some apps, the difficulty of adapting to new mobile technologies, content that is far removed from the reality of the fields of practice, the small size of the screens or fonts, making it difficult to understand, and the need for an internet connection.[27]

In the field of nursing, most teaching applications have focused on the organization of services, the use of forms and assessment tools, and support for disease diagnosis and rehabilitation. The use of these tools has been seen as positive, promoting significant changes in traditional teaching activities, improving social representations, and contributing to the acquisition and retention of knowledge, combining virtual and real environments.[29]

The use of educational applications has helped both health professionals and students develop clinical judgment and critical-reflective reasoning, contributing to the improvement of care quality. However, for apps to be effective as teaching strategies, they need to have some essential characteristics, such as usability, compatibility, security, maintenance, and portability 29 as described in Chart 2.

Chart 2 - Usability, compatibility, security, maintenance, and portability in healthcare applications.

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| **Term** | **Description** |
| **Usability** | It is closely tied to the user experience. When compromised, the user has difficulty interacting with the system, and when the system has a poorly designed interface, it leads to discontinuity. |
| **Compatibility** | It is essential that the software developed can exchange information with other products, systems, or components performing their functions while sharing the same environment, thus meeting this quality requirement. |
| **Security** | It has a significant impact on software quality because security standards have positive effects on reducing costs and information loss, and are essential to support security management in organizations/institutions. |
| **Maintenance** | This is an insightful characteristic for software development, as guaranteeing the maintenance of a system is a fundamental criterion for its use in institutions. |
| **Portability** | Characteristic of software quality that is fundamental to enabling the widespread, efficient, and effective use of cloud technologies. |

Source: Adapted.29

The widespread adoption of apps in education requires the development of these resources by trained professionals. Teachers in the health sciences must develop more evidence-based research, in collaboration with students, to support teaching and learning outcomes through the use of mobile technologies.[7]

Technological educational practices are a significant challenge. However, such practices are justified, as the use of advanced technological tools can significantly contribute to making teaching more attractive, as well as stimulating learning based on the four pillars of innovative education, such as integrative and innovative knowledge, development of self-esteem, and training of entrepreneurial students and citizens.[11]

**Validation of educational technologies in health**

The term “validate” refers to the degree to which something is appropriate for measuring the true value of what it is intended to measure, making it possible to infer how much the results obtained through the use of the instrument represent the truth or how much they deviate from it.[30]

There are three main types of validation: content, construct, and criterion. Content validation refers to the structure and basis for formulating questions that will adequately assess the content, the concept and the dimensions of the components of a product concept. Construct validity refers to the extent to which a test measures a trait or theoretical construct. In contrast, criterion validity indicates the degree to which the research subject's performance when using the measurement tool and their actual behavior are related.[31]

In the health field, there is constant concern about the validation of new instruments that have already been used by other researchers, making it necessary to investigate reliability and validity. Chart 3 summarizes the main types of instrument validation.

Chart 3 - Main types of instrument validation

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| **Type of validity** | **Definition** |
| **Content validity** | It is the degree to which a test includes all the items necessary to represent the concept being measured. |
| **Validity of criteria** | It is evaluated when a result can be compared to a gold standard |
| **Construct validity** | It is the extent to which a set of variables represents the construct it was designed to measure |
| **Predictive validity** | First, the target test is applied, and then the gold standard. |
| **Concurrent validity** | This can be verified by applying both the target test and the gold standard simultaneously. |
| **Known groups technique** | Different groups of individuals complete the survey instrument, and then the results of the groups are compared. |
| **Convergent validity** | It is obtained by correlating the focal instrument with another instrument that assesses a similar construct, expecting high correlation results between the two. |
| **Discriminating validity** | It tests the hypothesis that the target measure is not improperly related to different constructs, i.e., to variables from which it should diverge. |
| **Structural or factorial validity** | It tests how well a measure captures the hypothesized dimensionality of a construct. |
| **Cross-cultural validity** | The extent to which evidence supports the inference that the original instrument and a culturally adapted one are equivalent. |

Source: Adapted.32

Regardless of the validation method chosen, it is necessary to validate the health product developed to assess its reliability. Validation goes beyond measuring a value and involves a whole process of investigation.[33]

Researchers must be careful when selecting the instrument to validate their product, ensuring the quality of the results. It is necessary to know the instrument in detail, in terms of items, domains, forms of assessment, and measurement properties before using it.[32]

Content validity, which is widely used in the evaluation of mobile health apps,[4,34,35,36,37] concerns the judgment of the instrument, i.e., whether it really covers the various aspects of its subject and does not contain elements that could be attributed to other subjects. Content validity is carried out by experts, who judge and analyze the product in question in relation to its elements, content areas, and relevance.[33]

Through content validation, the domains and content to be assessed are defined, ensuring that the components of the product are closely associated with the definition of the instrument in question.[38]

Content validation can be carried out by judges who are experts in the field, experts from other fields, and the target audience. It can occur in two ways: through agreement or consensus. In concordance (assessment by expert judges and the target audience), the researcher establishes a minimum level of agreement in order to consider the product validated, and in consensus (assessment by experts), the researcher demonstrates that they will only consider the product validated once everyone has agreed.[39]

The literature converges on the sample number and selection criteria for defining expert judges. Some recommendations suggest a minimum of five and a maximum of ten people, while others indicate a range of six to twenty subjects. Among the criteria recommended for selecting experts are having clinical experience; publishing and researching on the subject; being an expert in the conceptual framework involved, and having methodological knowledge about the construction of questionnaires and scales.[40]

If five or fewer subjects participate, they must all agree to be considered representative. The sample size and the criteria for selecting the judges must be clearly defined, taking into account the characteristics of the instrument used and the qualifications and availability of the necessary professionals. The evaluation by judges can be analyzed qualitatively or quantitatively. The process begins with a letter of invitation to the judges, which includes instructions on the product to be validated.[40]

The Delphi method is usually used to validate content with experts. The name of the method comes from the Oracle of Delphi and was developed by agencies associated with the US Defense during the Cold War in 1950 with the aim of obtaining a reliable consensus from a group of military defense experts on possible attacks with atomic bombs. This precept aims to facilitate and enhance decision-making by experts without requiring interaction between them.[41]

In this method, the results are analyzed through rounds of questionnaires. The product to be evaluated, along with the validation tool, is sent to the experts. In each round, the experts have the opportunity to observe, refine, change, or defend their opinions on the product in question. The process is repeated until a consensus is reached, i.e., when the desired levels of stability in the responses are achieved.[41]

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There is no specific statistical test for assessing content validity. However, the Content Validity Index (CVI) is typically used to employ a quantitative approach. The CVI measures the percentage of judges who agree on specific aspects of an instrument and its items. This index is used in parallel with the Likert scale, which scores the items evaluated from 1 to 4: 1 (item not equivalent); 2 (item needs significant revision to assess equivalence); 3 (item equivalent, needs minor changes); and 4 (item equivalent). Items that receive a score of 1 or 2 should be revised or eliminated.[32]

The sum of the CVI only takes into account the responses to items 3 and 4. The acceptable agreement index in the sum must be at least 0.80 and preferably greater than 0.90.32 The statistical formula for calculating the CVI is the total number of responses 3 and 4 divided by the total number of responses.

Reliability, also known as trustworthiness, indicates the extent to which differences in scores are due to variations in the characteristic being examined and not to random errors. It is usually expressed as a coefficient and represents the stability of the results of a test, i.e., the degree of consistency and precision of the scores. The two primary methods for calculating reliability are the test-retest method and the method of halves.[33]

The test-retest method, also known as the stability coefficient, refers to the stability of the examinee. The values are obtained by correlating the scores of a test with the scores of a second application of the test to the same subjects. The method of halves, or coefficient of consistency, is used when a single form of the test is applied in a single session and only the influence of sampling is to be known, but not the variation in responses.[33]

Reliability refers to how stable, consistent, or accurate an instrument is. It has three main components: stability, internal consistency, and equivalence. Stability shows the degree to which similar results are obtained at two different points in time. This is achieved using the test-retest method. Internal consistency or homogeneity indicates whether all the subparts of an instrument measure the same characteristic. This is a crucial measurement property for instruments that assess a single construct using a range of items.[32]

Equivalence refers to the degree to which two or more observers agree on the scores of an instrument. The most common way of assessing equivalence is inter-observer reliability, which involves the independent participation of two or more assessors. The Kappa coefficient is the most commonly used measure for inter-observer evaluation, applied to categorical variables.[32]

It is a measure of agreement between the evaluators and has a maximum value of 1.00. The higher the Kappa value, the greater the agreement between the observers. Values close to or below 0.00 indicate no agreement.32 Values greater than 0.75 represent excellent agreement. Values below 0.40 represent poor agreement, and values between 0.40 and 0.75 represent average agreement.

Review studies on the validation of mobile health applications 42,43 have shown that the most commonly used validation methods include content validation with experts, the Delphi method, the Likert scale, CVI calculation, comparison with a validated method (test-retest), the system usability scale, the intraclass correlation coefficient, and the Bland-Altman test.

Some researchers have created specific instruments for evaluating health apps. Paula McNiel and Erin C. McArthur, researchers at California State University, created a scale of evaluation criteria called CRAAP.[29]

The scale assesses the credibility of mobile health apps. It involves five evaluation criteria, which are Currency (timeliness of information), Relevancy (importance of information in relation to the need), Authority (knowledge of the author and their qualifications), Accuracy (reliability, truthfulness and accuracy of the content) and Purpose (reason why the information exists).[44]

In addition to evaluation tools and data analysis, structured steps are needed to create and develop health apps. Numerous methods have been developed to build new mobile applications that can serve as health support tools and enhance the teaching-learning process for nurses who use them. It should be emphasized that, for the app to yield a useful end product, it is essential that the steps of the chosen method are followed in a structured manner.[3] Chart 4 ilustrate the methods most commonly used specifically in the development of mobile health apps.

Chart 4 - Summary of the most widely used methods for developing mobile health applications.

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| **Method** | **Context** | **Steps** |
| **Systematic Instructional Design** | Developed by Walter Dick and Lou M. Carey in 1978, it takes a systems approach to practical instruction to support a successful teaching-learning process. | Analysis, design/development, implementation, and evaluation. |
| **Contextualized Instructional Design** | It considers human activity to be central, seeking a balance between the automation of planning processes, personalization, and contextualization of instruction/content, and the technological tools available. | This method adopts the same stages as the Systematic Instructional Design method. However, the implementation stage takes place simultaneously with the analysis/design stages, adding new stages and greater detail to the technological tool. |
| **User-centered design** | Mainly used to develop applications in the area of Geriatric Nursing and Primary Care (prevention of chronic diseases). End users can have a direct influence on all methodological stages, and it is essential that the researcher, developer, or designer understands the context in which the technological tool will be used and the requirements provided by the users. | Identify requirements, create alternative solutions, build testable prototypes, and evaluate with users. |
| **Systems Development Life Cycle** | It has three approaches to systems development: the classic life cycle, the spiral life cycle, and the prototyping life cycle. These are designed to help developers and researchers identify user needs. | Analysis (needs assessment and identification of the needs of the institution/user); design (detailed project specifications); development (includes development or acquisition of the software); implementation (after undergoing evaluative tests); and maintenance (constantly updating the system). |

Source: Prepared by the authors, 2023. Adapted.[3]

It should also be noted that private developers often create apps and are mostly unrelated to academic or scientific research, which highlights the need for development to be encouraged adequately with structured methodologies.[21]

**CONCLUSION**

This review examined the applicability and validation of educational technologies in healthcare, with a focus on mobile applications. It was observed that these tools have played a significant role in the education of health professionals, enabling greater accessibility to knowledge, active interaction in the learning process, and support in clinical practice.

However, despite the widespread use of m-Health applications, challenges remain, especially in relation to the quality and reliability of these technologies. The lack of rigorous validation, often due to development by individuals without specific training in the health field, compromises the safety and effectiveness of the apps. Validation using well-established criteria, such as content analysis by experts and structured development methods, is essential to guarantee their practical applicability.

Additionally, the review emphasizes that integrating active methodologies with the use of applications can enhance learning and optimize the training of healthcare students. Combining these tools with innovative pedagogical approaches favors the development of critical skills, promoting greater student engagement.

It is therefore essential that the implementation of educational technologies in health teaching is accompanied by rigorous validation, ensuring their effectiveness and contributing to the development of evidence-based teaching that aligns with the needs of both professionals and patients.

AcknowledgEments

This work has been supported in part by the Fundação Araucária de Apoio ao Desenvolvimento Científico e Tecnológico do Paraná (FA) through a call for proposals for Applied Basic Research.

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Finance Code 001.

Competing interests

Authors have declared that no competing interests exist

AUTHORS’ CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript

**CONSENT**

Does not apply to this work.

**ETHICAL APPROVAL**

This article is a review and does not need to be approved by the ethics committee.

Disclaimer (Artificial intelligence)

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during the writing or editing of this manuscript.

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