

# South African health sciences students' perspectives on utilisation, constraints and future possibilities of mHealth and e-Learning

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## Abstract

The global COVID-19 pandemic has added considerable complexity to the education and training of health care professionals as well as patient care. Literature suggests that e-Learning and mobile health (mHealth) technologies have great potential, but research studies are sparse, especially in low- to middle-income countries. The paper presents South African health science students' perceptions of the importance, relevance, constraints and future possibilities of e-Learning and mHealth. Students from five universities participated in a modified Delphi. The first phase of student focus groups and interviews (n = 5), established baseline experiences and perceptions of e-Learning and mHealth during and post-COVID-19. These findings informed the design of an online survey (n = 155) for the second phase of the study. The majority of students were familiar with e-Learning, less so with mHealth; however most believed both to be a beneficial complement to theoretical and clinical teaching. Reasons for an integrated Learning Management System (LMS), also known as virtual learning environments, include increased flexibility, access and enhanced learning; and issues of anxiety, reduced interactivity, an absence of context and a lack of discipline- or profession-specific features as reasons against. The perceived importance of particular features of e-Learning and mHealth tools were highlighted. These findings will contribute to the redesign of online work-integrated curricula and the development of an inclusive, student-centred, health sciences-specific integrated and multi-modal LMS directed towards student-centred learning while addressing concerns around the digital divide and social justice.

**Keywords** e-Learning · mHealth · Health sciences curricula · Health Innovation · COVID-19

## 1 Introduction

The International Commission on the Future of Education stresses the need for a new collective social contract for education, in a rapidly changing world, that addresses injustices of the past and builds a transformed future for all [1]. This includes education practices that are participatory (i.e., co-constructed) and contextually-localised (i.e., relevant, authentic, appropriate or ecologically-valid) [1]. Their framework recommends increasing access; interdisciplinary educational experiences; collaboration; connectedness and equitable cooperation [1].

Education in health professions faces additional challenges of global health inequities world-wide given, "[The] ample evidence that social factors, including education, employment status, gender and ethnicity have a marked influence on how healthy a person is ... and that there are wide disparities in health status of different social groups in all countries—whether low-, middle- or high-come" [2].

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There is a considerable literature on the mismatch between clinical education and training, health care practice and societal need as evident in the WHO guidelines on transforming and scaling up health professionals' education and training [3], and more recently [4–6].

The introduction of competency-based health professional education evolved in response to the rapidly expanding scientific knowledge of disease conditions, as well as the changing and increasingly complex health conditions that require a broader range of competencies (knowledge, skills and attitudes) in graduating health professionals [7–9].

This shift to competency-based health professional education was occurring in the context of international debates about socially relevant and accountable educational and training programmes [10] as well as appropriate pedagogies for promoting student-centredness to strengthen preparedness for life-long professional learning [11, 12].

Continually expanding content and evolving curricula designs, as described above for innovative health care approaches, especially relating to prevention and health promotion, have been challenging to keep up with in resource-constrained environments [13]. E-Learning was posited as a way forward, but has not delivered as anticipated in low- to middle income countries [14].

With the advent of COVID-19, emergency-remote teaching was imposed on health professional educators globally. Some view it as an opportunity to reimagine and innovate Health Sciences Education (HSE) [15, 16]. However, while HSE becomes increasingly globalised, the global South demonstrates an awareness where it cannot merely import and apply theories and practices from the global North into global South contexts [17]. This is highlighted in recent reflections on the realities of COVID-19 and online practices within South Africa: the definition of the 'digital divide' has been expanded [18] to refer not only to the physical or resource gaps between those who are able to access digital technologies (e.g., devices, stable electricity, internet connection, e-Learning and mHealth platforms) and those who do not, but to include epistemological access (e.g., knowledge, skills, digital literacies) [18–25]. The issue of inequity [26] cannot be ignored, or else we risk reproducing social and epistemic injustice [17, 27], which could further weaken health professional training and health system outcomes.

Arocena and Sutz (2021, p.1) ask, "Can universities contribute to social innovation including in such effort reorienting the power of knowledge to better serving people?" [28]. For these reasons, exploring technological innovation for sustainable social development from perspectives in the global South, within conditions of scarcity, are needed [28]. Our participatory and co-constructed research approach [1] amplifying marginalized student perspectives from a Southern setting, addresses issue within a conceptual framework that emphasises equity and justice.

## 1.1 e-Learning

The benefit of e-Learning (see Table 1 of key definitions) integration into undergraduate, graduate, and continuing health sciences education is the promotion of a student-centred pedagogy in which educators will no longer serve solely as distributors of content but become facilitators of learning and competency assessors [29]. More recent recognition of the value of digital technology to facilitate more personalised, flexible, and student-centred teaching has been reported in the European Commission in their Education Action Plan (2021–2027) [30].

The integration of mobile digital devices into LMS and health databases, referred to as tele-education [31], can further contribute to active engagement on meaningful learning tasks that is associated with student-centred pedagogy [32,

**Table 1** Definitions of concepts

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- *e-Learning (electronic learning)* the use of electronic technologies and digital media to deliver educational content and facilitate learning (e.g., computer-mediated, ICT-enhanced online education)
  - *mHealth (mobile health)* the use of mobile technology and devices, such as smartphones, tablets and wearables (e.g., watches), to support healthcare delivery, services, education and promote health and wellness [41]
  - *Digital divide* the gap between those who have physical and epistemological access to digital technologies, such as the internet and computers, and those who do not, often due to economic or geographic factors [18]
  - *Social justice*: a framework that seeks to promote equity, fairness, and inclusion in society, and to challenge systemic and structural forms of oppression and inequality [52, 53]
  - *Decoloniality*: a framework that seeks to challenge and dismantle the ongoing effects of colonialism and imperialism, particularly in the areas of knowledge production, education, and culture [53, 54]
  - *Critical race theory*: a framework that emphasizes the role of systemic racism and power structures in shaping social, political, and economic outcomes, and seeks to promote social justice and equity through this lens [50]
  - *Epistemic injustice*: the ways in which individuals or groups are denied recognition or credibility of their knowledge, experiences, and ways of knowing due to their social identity, resulting in harmful outcomes [27]
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33] in this complex health professional learning and teaching environment. Further emphasis on the value of tele-education in continuous health professional development is warranted as it enables health practitioners to access electronic libraries, databases, or electronic data including databases of knowledge [31].

Related to our context, e-Learning is still under-exploited in its potential to support student training and strengthen the capacity of healthcare workforce, WHO's call for strengthening e-Learning usage for quality training and empowering of healthcare workers as change agents remains [34].

## 1.2 mHealth

While the potential of mobile health applications (mHealth) for the transformation of health service delivery worldwide has been reported [35], its use of for education is under-explored, nor mainstream. In HSE there is a growing movement for decentralised or distributed training (e.g., student clinical training placements in rural or peri-urban areas where the majority of LMIC populations live, in comparison to residential or institution-bound programmes) [36]; decentralised training platforms, such as integrated LMS with eLearning and mHealth, are a necessary feature of such an educational strategy. Decentralised training is of utmost importance in the global South for it can enable the equitable development of an effective and sustainable health workforce for underserved populations. While others have argued for the need for technological solutions and support for decentralised training [37–39], but none specify mHealth. Moreover, with the penetration of smartphones in LMIC contexts [40], mobile technologies for learning cannot be ignore.

For instance, the iHeed institute [41] has been researching the role of mobile applications in the health sector. They reported that more than 3.8 billion active mobile devices are in the developing world. More recently, and according to Statista (2023), the number of mobile network subscriptions globally reached almost 6.6 billion in 2022, and is forecasted to exceed 7.8 billion by 2028. mHealth has been helpful with the training, testing, support and supervision of healthcare workers, which provides health information to individuals, giving rise to the concept of “mHealthEd” [41].

The report argued that the first wave of mHealthEd applications for health workers enables workers to learn new treatment procedures, exchange ideas on crucial diagnostic and treatment decisions, and test their knowledge after training courses. In addition, the mHealthEd applications have assisted health practitioners in taking certification exams remotely and looking up information in medical reference publications. However, there is still a gap as current applications target nurses and community health workers rather than doctors—nor students. Undoubtedly, there is the need to design an application that embraces all other health practitioners—and those in training. This is important since the current mHealthEd is not designed to replace classroom-based training but acts as mobile refresher quizzes and allows quick access to reference materials, real-time feedback, and updates about new or improved treatment procedures.

It has been argued that mHealth could be the solution for health sciences students and professionals access to health information such as symptoms, exposures, treatments, and disease prevention strategies [42]; with access being vital in the context of the rapid advancement of research within the public health sphere in urban and rural settings. mHealth, digital applications, and tele-medicine have increasingly been developed for healthcare settings or specifically tailored use by health professionals [43, 44]. Recent studies have been reporting the benefits of mobile applications for patient care and healthcare services [45]. Similar studies for learning, teaching, clinical supervision and practice in tele-education contexts, and mobile application usage are beginning to emerge [46], however, further research is required [47]. This work would add its Southern voice to a growing body of evidence of the necessity and benefit of mHealth for HSE student training.

## 1.3 Research rationale

This research study is part of a broader research project that aims to establish optimised e-Learning platforms for health sciences students and academic staff, as well as exploring the integration of mHealth to better prepare students for their future work environments and enhance healthcare for patients in South Africa. The end goal of the larger project is the creation of a stakeholder- and evidence-informed multi-modal platform that is validated and tested [48].

Given the limited success rate of e-Learning (uptake) within the health sciences field in low- to middle-income countries, this article aims to fill this gap by establishing South African students' understanding of e-Learning and mHealth, their use within their curriculum, constraints and possible future developments.

Despite mHealth technologies' impact on health research, it is assumed that the exponential growth of technology has outpaced the science of mHealth [49]. Since some health science curricula do not include mHealth training, health stakeholders do not have sufficient time to research the necessary new approaches and mediums; hence, further research needs to understand the capabilities and needs of students and staff stakeholders in the fourth industrial revolution (4IR). In addition, an mHealth application that conforms with a robust network and promotes healthcare technology and innovation within the health sector should be developed, especially since there is an unsuccessful rate of e-Learning within the health sciences [46]. In addition, research on how platforms and curricula are established, merged and evaluated should be conducted to optimise learning and healthcare with patients and enhance quality assurance with students' involvement.

Consistent with the principles of inclusivity, participation, collaboration and contextual relevance outlined earlier, the study has embraced a multi-lens critical framework as conceptual framework.

## 1.4 Conceptual framing

In order to critically explore e-Learning and mHealth in SA the following frameworks could be helpful: critical race theory (CRT) [50, 51], social justice [52, 53] and decoloniality [54] (see Table 1 for definitions).

Briefly, CRT explores racial positionality and privilege, emphasizing race as a social construct with related disadvantages; recognizing that race and racism are pervasive in society and that they intersect with other forms of oppression, such as class, gender identity and sexual orientation [50]. Through exploring the experiences and outcomes of marginalised and underrepresented (vs dominant, i.e., White) racial groups, CRT could uncover how systemic and structural racism perpetuate health inequalities and limit access to quality healthcare education and services [50, 51]. It would further highlight the ways in which e-Learning and mHealth HSE may reproduce or challenge existing racialized power structures and social inequalities. Emancipation, empowerment, social justice and multi-racial democracy are aims of CRT [50].

A social justice framework emphasizes the importance of equity, diversity, and inclusion in HSE [53]. It seeks to understand and address the systemic and structural barriers that prevent disadvantaged groups from accessing and participating in quality healthcare and HSE. This perspective recognizes that health inequalities are not the result of individual choices or behaviours, but rather are the product of social, economic, and political systems that perpetuate inequity. We need to be careful in our desire to integrate e-Learning and mHealth into HS curricula to not perpetuate power imbalances, but lead to participatory, critically-conscious, socially-accountable, equitable, contextually-responsive and relevant HSE practices that develop students as change agents [52].

Decoloniality seeks to challenge the continued Western, Eurocentric, colonial and imperial legacies, and their ongoing effects, that shapes the education and healthcare systems in 'post'-colonial settings [54]. Decoloniality could help to identify and challenge the ways in which digital technologies and HSE may reinforce dominant colonial power structures and perpetuate epistemic injustice. For example, do e-Learning and mHealth promote Western biomedical knowledge systems, while marginalizing or erasing plural Indigenous and African knowledge systems—or not? We, in the global South have varied and diverse, but legitimate and valuable perspectives to share.

In summary, these overlapping critical frameworks provide a lens for understanding the complexities of power, oppression, social and epistemic inequalities within the globalized and local contexts, and stress the need for greater diversity, inclusivity, participation, community-engagement, contextual-responsiveness and equity in HSE.

In conclusion, while e-Learning and mHealth have become increasingly important in HSE in SA for addressing educational and health disparities, especially in light of COVID-19, there are still several criticisms and challenges that need to be addressed in order to ensure that all students have access to high-quality, effective, and equitable education [55] and that the need for practical strategies that address the promotion of disease prevention as well as health sciences education are aligned. Capacity training to strengthen the health workforce, retain graduates as well as give students working conditions that promote knowledge and skills development are central to the purpose of the proposed multi-modal platform LMS.

## 2 Methods

This research study is part of a broader modified Delphi project that aims to establish optimised e-Learning platforms for Health Sciences students and academic staff, as well as exploring the integration of mHealth to better prepare students for their future work environments and enhance healthcare for patients in South Africa. The end goal of the larger project is the development of a multi-modal platform for piloting and validation for sustainable, future-proof Health Sciences curricula and healthcare in South Africa and further afield.

The larger research project employs a modified Delphi method to realise five objectives in various phases. The main benefits of using a modified approach are that it enables contributions and building on previous work experiences in the field, irrespective of whether this has been published, as well as fostering co-operation. This study reports on the first two phases, entitled 'Pre-survey Focus Group Discussions' (FGDs) and 'Online Questionnaire Survey'.

The qualitative method of FGDs, and interviews if unable to join an FGD, was deemed appropriate as a first phase to gather in-depth student perspectives across institutional and disciplinary boundaries from which closed and open questions could be constructed for the subsequent phase.

The shift to a quantitative method in the second phase, via a primarily inductively constructed survey questionnaire drawing on the findings of the FGDs and interviews, would considerably increase the sample size of South African Health Sciences (HS) students. The benefit of employing qualitative methods prior to survey questionnaire design is that it contributes to reducing researcher bias inherent in closed questions, as well as building a community of practice in that students in other universities and disciplines discuss how to make "tools of impact" that move beyond the university's boundary within the HSs.

The FGDs, interviews and survey questionnaire addressed the following objectives within the larger project: (i) assess health sciences students' perceptions and understanding of these two applications, as well their perceptions on the importance and relevance of these applications to their curricula and future practices, and (ii) establish challenges and opportunities of e-Learning and mHealth applications in the health sector. The online survey, using Google forms, consisted primarily of structured and semi-structured questions (requesting comments or reasons), based on findings in the previous qualitative phase, as well as a few open-ended questions. It was piloted before use (pilot participants responses were excluded from data collection and analysis).

### 2.1 Study participants

Both phases were conducted amongst Health Science students (medicine, nursing, physiotherapy, occupational therapy, biokinetics and sport science, speech and language pathology therapy, audiology, optometry, etc.) from across South African Higher Education Institutions. Inclusion criteria were students above 18 years of age and registered in a Health Sciences discipline programme. The FGDs, interviews, and survey, sampled undergraduate and postgraduate students from the University of the Witwatersrand (Wits) and the University of Johannesburg (UJ); and survey from UJ, the University of Cape Town (UCT), the University of the Western Cape (UWC), and Rhodes University (RU). Aligned to our conceptual framework, diverse sampling from five diverse South African universities, ranging from old (100+ years) to new (20+ years), historically White and well-resourced to historically Black and under-resourced institutions, was of central importance, moreover as technological innovations need to be contextually-localised [1].

Note, UCT, UJ and UWC have faculties of (community and) health sciences, with a number of medical and allied health professional departments, whereas Rhodes University does not; students from the science faculty's human kinetics and ergonomics department, relating to the health sciences field, were specifically invited.

Research ethics approval was obtained from all participating institutions, with primary ethics approval from UJ (REC-1141-2021). Students were contacted through internal networks and Faculty Administration Offices. The channels consulted did not involve students being approached directly by academics responsible for academic outcomes. The researcher ensured that all participants understood the importance of voluntary participation and signed the consent form.

### 2.2 Study procedure

For phase 1, the total number of participants were  $n = 5$ . An online FGD ( $n = 3$ ) and interviews ( $n = 2$ ) were conducted via Microsoft Teams or Zoom, with each 45 to 60 min in duration. The line of questioning for the FGD and interviews were the same (see guide questions below). The FGD and interviews were conducted in 2021.

For phase 2, the total number of students who completed the survey was  $n = 155$ . The online survey was conducted via Google forms; estimated to take 10 to 15 min to complete. Data collection from the survey took place in 2022 and 2023.

### 2.3 Data analysis

Atlast.ti was used to analyse the responses from both the FGDs and interviews. Deductive thematic coding was applied as researchers used pre-formulated guide questions drawn from the literature to facilitate discussion in the context of the range and diversity of experience with mHealth and e-Learning in South African HSE domains. Participant responses were coded and synthesised into categories derived from the pre-formulated guide questions.

The qualitative data obtained via the survey questionnaire was derived from responses to the open-ended questions and requests for explanations in structured questions. The deductively derived responses were recorded per question in a Word document. Repetitions or very similar comments were not repeated. Responses to the few open-ended questions were inductively coded, and quotations selected to support the coding in this paper.

## 3 Results: phase 1

A number of themes developed from the pre-survey FGDs and interviews (see Table 2). This included being familiar with e-Learning, less so with mHealth, and perceiving them as tools for both student- and patient-focused learning; however perceptions of effective engagement with these tools by students across different institutions was varied. In particular, e-Learning was effectively engaged with during COVID-19 and ERT, and was useful for distributed (distance or decentralised) learning, mHealth to a lesser extent. Patient-use of mHealth applications, for public and primary healthcare initiatives, was mentioned. Students thought that stronger national governance around these tools was needed.

Perceived challenges by HS students included a lack of digital literacy, resources, social connection and suitability of these tools. Yet, students still believed that these tools could be effective in HS curricula in terms of supporting the development of clinical and other transferable skills, such as communication, interpersonal and digital literacies skills. Students recommended additional resourcing, training, social support, content creation and platform development to enhance e-Learning and mHealth for HS curricula. Students used a range of digital devices, LMS and applications for their learning; and thought that the development of a HS-specific LMS that incorporated e-Learning and mHealth tools would be of valuable to their HS training.

## 4 Results: phase 2

HS students were enrolled at a number of SA universities; close to a third (32%; 50) were from Wits, a third (28%; 44) from UCT, a third (27%; 41) from UJ, with the remainder from UWC (11%; 17) and RU (2%; 3) (see Table 3). Students were enrolled in several HS programmes across a number of year-levels. Interestingly, 'other' was selected the most (30%; 47) but students regarding programme of study (possibly radiography or postgraduate programmes), followed by medicine (27%; 42), nursing (12%; 19), both basic/biomedical sciences and sports science/biokinetics (10%; 14), physiotherapy (7%; 11), occupational therapy (2%; 3), and both pharmacy and speech and language pathology (1%; 2). Students were enrolled in their first year of study accounted for 10% (16); second year 20% (32); third year 28% (44); fourth year 26% (40); fifth year 8% (13); sixth year 5% (7) and 3% (5) as postgraduate students.

More than three-quarters (76%; 117) of students found e-Learning to be helpful to their theoretical learning (see Table 4). For mHealth applications, more than half (56%; 86) of students had not used them before; however, the majority of those who had used them found them to be helpful to their clinical and workplace-based learning and training (41%; 64) compared to those who did not (3%; 5) (see Table 4).

Quotations supporting qualitative themes and sub-themes relating to the student perceived usefulness of e-Learning: Flexibility is a key theme, enabling access to lecture material when it is most convenient to do so, and especially for re-visiting aspects not understood: *"It has made resources available to me, both to look up extra information & to revise at whatever time I wanted or needed to. This is an easy way to share resources, instead of the lecturer trying to do this in class (but in person classes are essential in my view)"*; *"It has also helped me combine academic and my personal work which could not be possible if there was no e-learning."*

**Table 2** An overview of phase 1’s pre-survey focus group discussions and interviews

Guide questions	Researcher categories	Codes	Illustrative quotes
What are your perceptions and understanding of mHealth and e-Learning within health sciences?	<ul style="list-style-type: none"> <li>Student un/familiarity;</li> <li>- Multi-modal;</li> <li>- Databases (health-related information)</li> </ul> <p>Student-focused (learning)</p> <p>Patient-focused</p>	<p>Students are aware of e-Learning &gt; mHealth within HS</p> <p>Multi-modal (lectures, videos, social media) mHealth and e-Learning are mobile and/or online applications that contain health-related information</p> <p>mHealth and e-Learning enhances/is valuable for student learning</p> <p>mHealth and e-Learning are mobile and/or online applications that contain health-related information (specific to diagnosis, prevention and treatment of illnesses) for end-users (patients) to stay health</p>	<p><i>"e-Learning platforms were used for student learning during COVID-19."</i></p> <p><i>"All the devices transmitting information that educates consumers about health care services. And e-Learning, also called online learning, involves using videos as education, lectures, lights and everything on social media"</i></p> <p><i>"mHealth uses technology to support the achievement of health objectives which enables the user to know preventive measures to access their data on the mobile phone"</i></p> <p><i>"e-Learning uses online applications to help and enhance learning among students, and mHealth uses mobile apps to allow people access information on how to stay healthy"</i></p> <p><i>"mHealth works more with patient stuff"</i></p> <p><i>"mHealth and e-Learning have been used 100%. Both mHealth apps and e-Learning have been used in our department"</i></p> <p><i>"To some extent, health sciences have embraced e-Learning, which was used during the lockdown period and is still being used"</i></p> <p><i>"Both platforms have been effective; it saves time and money as well. You don't have to travel around. You can log into your devices, and [the university] also gives you data. I know all these students do get dates are, and I think it helps retain students for the university"</i></p> <p><i>"No, health sciences have not been engaging effectively with mHealth and e-Learning. With eLearning, yes; but with mHealth, no. An example is our department has different online platforms provided by the library and the research capacity development group for the students"</i></p> <p><i>"There's a little bit of awareness about mHealth because I also got this attention through this meeting. It would be an excellent platform for long-distance students if initiated"</i></p>
Do you think Health Sciences have been engaging effectively with mHealth and e-Learning?	<p>Effective engagement (learning; patients, students)</p>	<p>Our institution/faculty/department has been engaging effectively with mHealth and e-Learning platforms</p> <p>mHealth platforms are mainly for patient use (e.g., educating population on available health care services)</p> <p>E-learning platforms are mainly for student learning use</p> <p>mHealth and e-Learning are effective tools for HS teaching, learning and curricula—especially with COVID-19 and hard lockdown</p> <p>mHealth and e-Learning are effective tools for long-distance/distributed HS teaching, learning and curricula</p>	<p><i>"mHealth and e-Learning have been used 100%. Both mHealth apps and e-Learning have been used in our department"</i></p> <p><i>"To some extent, health sciences have embraced e-Learning, which was used during the lockdown period and is still being used"</i></p> <p><i>"Both platforms have been effective; it saves time and money as well. You don't have to travel around. You can log into your devices, and [the university] also gives you data. I know all these students do get dates are, and I think it helps retain students for the university"</i></p> <p><i>"No, health sciences have not been engaging effectively with mHealth and e-Learning. With eLearning, yes; but with mHealth, no. An example is our department has different online platforms provided by the library and the research capacity development group for the students"</i></p> <p><i>"There's a little bit of awareness about mHealth because I also got this attention through this meeting. It would be an excellent platform for long-distance students if initiated"</i></p>

**Table 2** (continued)

Guide questions	Researcher categories	Codes	Illustrative quotes
How effective do you think mHealth and e-Learning have been in contributing to Health Services?	Government	Government (state) guidance for health professionals (and therefore health services)	<p>"We engage in-house with Essential Medicines List (EML) guidance as provided by the government. The government Essential Drugs List (EDL) sets the standardized guidelines that each health practitioner works and engage with"</p> <p>"Doctors are already using online platforms such as Skype, Zoom during consultations. However, most results have attested to poor interaction and less diagnosis of patients, unlike physical talk"</p>
What has challenged or constrained your use of mHealth and e-Learning platforms, or why do you think the uptake rate of e-Learning within Health Sciences has been unsuccessful?	<p>Technical and cognitive (a lack of digital literacy)</p> <p>Resources and infrastructure (a lack of)</p>	<p>Use of mHealth and e-Learning is challenged by student experience of tools</p> <p>Use of mHealth and e-Learning is challenged by access to resources and infrastructure (e.g., digital devices, data, stable internet connection, electricity, digital applications, funding)</p>	<p>"Internet access, load-shedding" preventing students from connecting "Lack of data, insufficient funding"</p> <p>"No collaboration, reading in isolation"</p> <p>"Studying in isolation and no physical interaction are issues constraining students from fully utilising eLearning"</p>
Do you think mHealth and e-Learning will be valuable if integrated into Health Sciences curricula and future practices? What transferable skills do you think can be embedded within the future curriculum using e-Learning and mHealth?	<p>Social (lack of human connection, motivation)</p> <p>Suitability (misalignment)</p>	<p>Use of mHealth and e-Learning is challenged by a lack of human connection and a sense of isolation (e.g., poor online social engagement, interaction and collaboration)</p> <p>Use of mHealth and e-Learning is challenged by suitability/practicality of mHealth and e-Learning tools (e.g., available content, tools)</p>	<p>"Amongst many challenges is the notion of staying motivated. The pandemic and isolation have made it challenging to stay motivated when all you have to do is wake up and log in on your computer, unlike attending classes and avoiding fewer distractions at home."</p>
Do you think mHealth and e-Learning will be valuable if integrated into Health Sciences curricula and future practices? What transferable skills do you think can be embedded within the future curriculum using e-Learning and mHealth?	<p>Clinical skills (including decision-making)</p> <p>Communication and interpersonal skills</p>	<p>Video content on e-Learning and mHealth platforms especially useful for learning clinical skills</p> <p>The embedding of mHealth and e-Learning into HS curricula will also lead to the development of communication, interpersonal and professional competencies (skills)</p> <p>The embedding of mHealth and e-Learning into HS curricula will also lead to the development emotional intelligence</p>	<p>"To a certain extent, online platforms have been a successful learning model because of COVID-19. Still, clinical skills have also been essential, which was limited due to pandemics. If new modal platforms are developed to assist clinical skills, it will be of great value to clinical services and assist doctors in diagnosing patients proficiently"</p> <p>"Communication skills, interpersonal skills"</p> <p>"Decision-making skills, communication skills"</p> <p>"Emotional Intelligence, digital literacy, interpersonal skills"</p>
Do you think mHealth and e-Learning will be valuable if integrated into Health Sciences curricula and future practices? What transferable skills do you think can be embedded within the future curriculum using e-Learning and mHealth?	Digital competencies	The embedding of mHealth and e-Learning into HS curricula will also lead to the development of technological/digital competencies (skills, literacies)	



**Table 2** (continued)

Guide questions	Researcher categories	Codes	Illustrative quotes
What factors would need to be addressed to improve student learning and skill development in the Health Sciences via e-Learning and mHealth?	Resources	Resources are needed for improved mHealth and e-Learning platform access and use (e.g., stable electricity and internet connection)	"More mHealth and e-Learning platforms should be developed in health sciences, which are more interactive and user-friendly" "It is not enough to develop the platforms, but adequate resources to access the platforms should be provided. And both students and staff should be trained on how to access the platforms"
	Training (digital literacy)	Training is needed for improved mHealth and e-Learning platform access and use (e.g., workshops, conferences)	"(There is a need for) collaboration and networking, capacity training such as workshops and conferences to train on new applications available"
	Social support	Online mentorship (via mHealth and e-Learning platforms) would support my HS learning and skill development (e.g., online networking, collaboration)	"Students need to buy data to access (these platforms). It should be an application that you can download with the internet and use continuously without an internet connection"
	Platforms (utility, access)	e-Learning and mHealth platforms should be user-friendly in order to improve student learning (e.g., more interactive) and accessible (i.e., zero-rated for data)	"mHealth has lots of glitches, and the data needs to be updated ... Also, there is insufficient data in most apps that need to be revised ... if there is an improvement either in the content or in the way it works, it will improve (learning)"
	Content	There is a need for more relevant curricula content for e-Learning and mHealth platforms	"I access the Blackboard every day with my laptop and then use my phone in my spare time" "More of my mobile phone than a laptop" "Laptop and phone"
Which device do you most often use when accessing technological platforms or learning management systems?	Digital devices	I access mHealth and e-Learning platforms via my mobile phone, laptop, tablet and desktop computer	
	Learning management systems	Learning management systems are better suited for mHealth and eLearning platforms for study or work (e.g., Sakai; Blackboard; Canvas)	
What mediums and platforms do you think would be most effective in bridging or providing optimal balance between mHealth and e-Learning to advance teaching and engagement for Health Sciences?	Applications	Applications are better suited for mHealth and e-Learning platforms for study or work (e.g., MD Calc; UpToDate; Medscape; Osmosis; YouTube; Khan Academy)	

**Table 2** (continued)

Guide questions	Researcher categories	Codes	Illustrative quotes
Do you believe that if a multi-modal platform and curricula are developed both learning (for students and academic health staff) and healthcare (patients) in South Africa will be optimised?	Little value  Essential	e-Learning and mHealth are not effective for HS learning  Integration of multi-modal mHealth and e-Learning platforms into HS curricula optimises student learning	<p>"No, I prefer the traditional ways and do not believe that e-Learning and mHealth will greatly value learning"</p> <p>"During COVID-19, it wasn't easy to learn (online) since most health workers learn more through collaboration and group work. We have done lots of exercises online, which was difficult and boring to do alone"</p> <p>"I would say yes. I do think that would work. Understanding multi-modal and information management systems or like Blackboard and Microsoft Teams would add value to health sciences curricula"</p> <p>"My answer is yes. As I have mentioned before, having a health app on my phone that monitors my blood pressure, health exercises etc., adds daily value. Hence, developing a multi-modal platform will be of great help to the health sciences"</p> <p>"My answer is also yes because it will help detailed access information online and through mobile devices"</p> <p>"I believe this is the way forward in the future"</p>

**Table 3** Participant background information

Background information	N =	Percentage (%)
Gender identity		
Male	43	28
Female	110	71
Prefer not to say	2	1
Age		
< 18 years	2	1
19–24 years	108	70
25–29 years	23	15
> 30 years	22	14
University		
Rhodes University (RU)	3	2
University of Cape Town (UCT)	41	27
University of Johannesburg (UJ)	44	28
University of the Western Cape (UWC)	17	11
Witwatersrand University (Wits)	50	32
Year of study		
1	16	10
2	32	20
3	44	28
4	40	26
5	13	8
6	7	5
Postgraduate	5	3
Programme of study		
Audiology	1	1
Basic/biomedical sciences	14	9
Medicine	42	27
Nursing	19	12
Occupational therapy	3	2
Pharmacy	2	1
Physiotherapy	11	7
Speech and language pathology	2	1
Sport science/biokinetics	14	10
Other	47	30

Controlling the pace is an important sub-theme of flexibility; being able to read and review material at own pace as lecturers' cover material too rapidly: "*(The) ability to pause video to write down important information ... skip through content I already know and slow down for information I need to focus on ... enjoy it more and tailor it to my needs*".

Convenience is a sub-theme of flexibility; being able to access: "*in own time and anywhere*"; "*It has made resources available to me, both to look up extra information and to revise at whatever time I wanted to or needed to*".

Enhancing Learning theme: Depending on task design in online presentation of lecture materials, students can be encouraged to search and read more widely as evidenced in these comments: "*(We are) forced*" to study more in-depth, read further and discover more information as not all information was provided"; "*Combining online learning and in-person sessions have served more of a consolidation role rather than teaching, which in turn reinforced theory learning*"; and, "*Online learning forced assessments tend to be more application-based rather than parrot learning ... a better reflection of someone's understanding than repetition of facts*".

Greater efficiency in learning is a sub-theme of enhancing learning: "*It has also helped me find the best strategies to tackle my theoretical work*"; "*It has allowed me to further research a confusing concept, as it is being taught, having the relevant tools at my disposal*"; and, "*This is an easy way to share resources, instead of lecturer trying to do this in class ... but in person classes are (also) essential in my view*".

**Table 4** Student experiences and perceived learning usefulness of e-Learning and mHealth applications

Student experiences of e-Learning and mHealth	N=	Percentage (%)
Has e-Learning helped your theoretical learning?		
Yes	117	76
No	38	24
Have mHealth applications helped your clinical, workplace learning and training?		
Yes	64	41
No	5	3
I have not used mHealth applications	86	56
Overview of qualitative themes and sub-themes (with a selection of supporting quotations below):		
	e-Learning	mHealth
Useful	Flexibility - Controlling the pace - Convenience  Enhancing learning: - Greater efficiency - Concentration and focus  Access: - Inclusion and diversity - Access despite lockdown Student support	Access: - Convenience  Enhancing learning: - Convenience - Efficient learning - Effective learning
Not useful	Less beneficial, efficient and effective for learning Reduced motivation Reduced interactivity Anxiety	Absence of context  Profession dependent

Concentration and focus are inter-related sub-themes of enhancing learning: *“(I am) better able to focus on content”*; *“(Online material) does not go off the topic”*; *“(It is) less tedious than lectures”*; and, *“I can grasp concepts at my own pace and during times of the day when I am most productive”*.

A respondent articulated how the flexibility of e-Learning has enhanced their learning efficiently: *“More time to take in content—e.g. an online lecture allows you to pause and rewind to difficult concepts, time to research something mid-lecture, time to make good and comprehensive notes during the lecture. It also allows you to explore content at your own pace and in the order that suits you on the day—good days you can tackle difficult subjects and on bad days you can do easier aspects. For me it optimised the learning experience”*.

The access theme with reciprocal beneficitation fostering inclusivity and diversity as a sub-theme. Traditionally students have only been able to access teaching materials once they have registered for a certain course. Yet, with online practices, they have access to a much larger base of knowledge for wider knowledge construction; *“(It) presents an excellent opportunity to add to an institution’s academic interests (It) adds a paradigm which younger students with little life experience lack”*.

A sub-theme of access was access despite lockdown, related to being able to continue teaching and learning during COVID-19 lockdown.

*Student support* was theme, in terms of being able to connect online with classmates: *“(It is) Easier to contact people for help.”*

Quotations for qualitative themes and sub-themes relating to the student perceived un-usefulness of e-learning.

Some perceived e-Learning and mHealth to be less beneficial, efficient and effective than being taught by lecturer: *“(It) offers less engagement with theory in order to retain information”*; and, *“(I) could easily search for information without grasping idea of the chapter or content being taught.”* Students also struggled to understand content on their own, and long waiting periods for online responses to questions led to delays in arriving at understanding as they were not confident to continue on their own *“lest I confuse myself more”*.

Reduced motivation theme related to students finding it difficult to remain motivated for online tests and exams; and some struggled with missing the stimulation and interaction of the classroom, in which group activity contributed to understanding; leaving these students unmotivated to learning by themselves.

Relatedly, the theme of reduced interactivity was found with a student who self-identified as an *"interactive learner."* As they did not experience online learning as interactive: *"(Online there are) no real interactions with the lecturers upon discussing a topic"*, and they accordingly felt as though they learnt less: *"(I am) wasting more time learning a concepts online than interacting in class"*.

In short, with the affective theme students shared that online education created anxiety.

Quotations for qualitative themes and sub-themes relating to the student perceived usefulness of mHealth:

Themes of ease of access to information and convenience as enhancers of learning: were found: students can access *"reliable information"* quickly and *"can assist other people to access health information quickly on their phones as well"* with, over all, *"Enhanced my practical learning and application of knowledge; "They make accessing diagnostic, screening and pharmaceutical data so convenient, and in so doing, make me a lot more efficient in my learning and practice"; and, "They aided my learning and consumption of information because access is easier and readily available"*.

Efficient learning theme, touched on above, in that students are able to access useful information on the clinical platform: *"During ward rounds, I can quickly look up a concept or approach to a condition so I can follow the consultant's train of thought with a patient's treatment"*.

The effective learning theme also relates to the content students are able to access, such as relevant, up to date guidelines or accurate clinical information that assists with developing their understanding and practical applications: *"I use EMguidance mainly for up-to-date prescriptions and other SA guideline management plans. I use Drugbank for Pharmacology to understand medicines and usually when focusing on specific topics Medscape gives a thorough breakdown of most topics"; "The AMBOSS app has helped me significantly"; and, "(mHealth applications) has helped me understand different ways in which different people [clinicians] treat different pathologies presented to me during my clinical studies."*

Quotations for qualitative themes and sub-themes relating to the student perceived unusefulness of mHealth.

An absence of context is an critical theme, especially in a resource-constrained environment like South Africa. Clinical guidelines from the global North may not be applicable, or feasible, in our differing context. This is a criticism towards tools and applications developed in resource-rich contexts: *"It limits clinical training as you do not always get all the necessary information you want and patients sometimes leave information out where if you see that patient in person you can gain more information through observation"*.

Similarly, utility of many online tools and applications depend on the profession; and when developed in another health sciences, nor non-health sciences, field, lack usefulness in a clinical setting: *"(There are) very limited benefits. Scientific papers aren't cited on a lot of these sources and they aren't accurate. e.g. Many of the programmes that help track macros and micros in your diet do not include vegetarian and vegan choices. Therefore, according to these programmes, you're deficient in almost everything if you follow one of these diets"*.

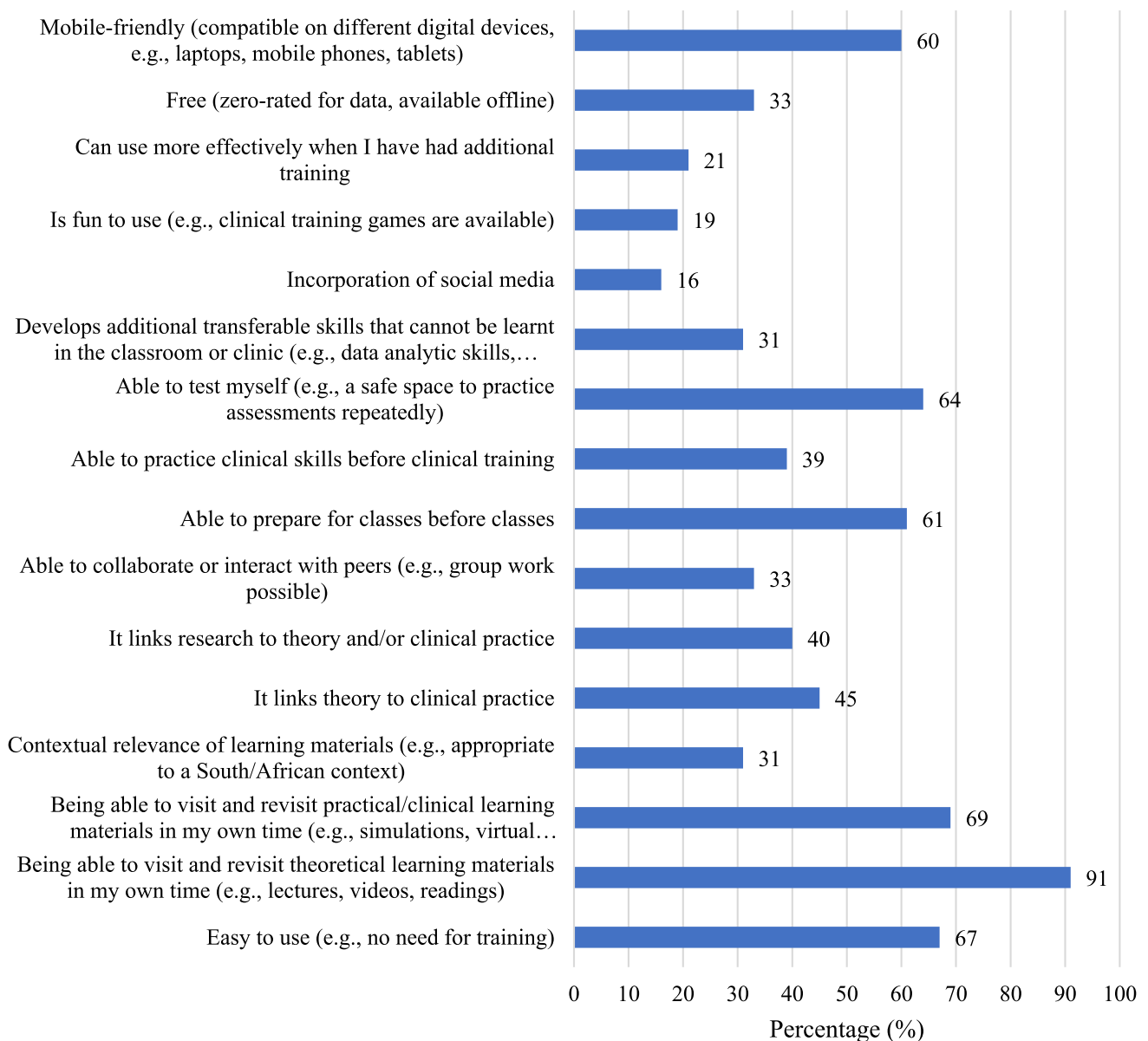
In terms of perceived importance of varied e-Learning and mHealth features by students (see Table 5), the top five e-Learning features that students found to be the most important were being able to re/visit theoretical content as needed (91%; 141), being able to re/visit practical or clinical content as needed (69%; 106), the e-Learning platform is easy to use (67%; 103), students are able to assess themselves (64%; 101), and being able to prepare before class (61%; 95), closely followed by being mobile-friendly (60%; 93) (see Fig. 1). Other features of intermediate importance were being able to link research to theory and practice (45%; 69), linking theory to clinical practice (40%; 63), able to practice clinical skills before clinical training (39%; 60), both being zero-rated and able to collaborate and interact with others (33%; 50), and both the ability to contextually-situated teaching and learning and the development of transferable skills (31%; 49). Other features such as being fun to use (i.e., gamification) (19%; 28) and the incorporation of social media (16%; 24) were not rated highly. A requirement for e-Learning training was not particularly prevalent (21%; 32).

The top three mHealth features students selected as important were its mobility/portability (62%; 95), ease of use (55%; 86) and access to quality and relevant material (54%; 83). These were followed by linking theory to clinical practice (38%; 59) and linking research to theory and/or clinical practice (32%; 49). Of intermediate importance were zero-rating (29%; 45), being able to prepare ahead of class (26%; 41), ability to practice clinical skills before clinical training (23%; 36), developing transferable skills (22%; 34) and being able to collaborate or interact with peers (20%; 32); with the rest rated as less essential (see Fig. 2).

Student shared a number of alternative ICTs for their theoretical and practical learning: virtual classrooms and various LMSs (Google classroom, CANVA, Blackboard), video conferencing (Zoom or Teams for patient counselling role plays), videos (YouTube, Khan Academy, Osmosis), VR (3D anatomy), podcasts, social media sites and applications (Instagram,

**Table 5** Perceived importance of e-Learning and mHealth features by Health Sciences students  
Student perceived importance of e-Learning and mHealth features

	N =	Per- cent- age (%)
<b>Which features of e-Learning are the most important to you?</b>		
Easy to use (e.g., no need for training)	103	67
Being able to visit and revisit theoretical learning materials in my own time (e.g., lectures, videos, readings)	141	91
Being able to visit and revisit practical/clinical learning materials in my own time (e.g., simulations, virtual reality, etc.)	106	69
Contextual relevance of learning materials (e.g., appropriate to a South/African context)	47	31
It links theory to clinical practice	69	45
It links research to theory and/or clinical practice	63	40
Able to collaborate or interact with peers (e.g., group work possible)	50	33
Able to prepare for classes before classes	95	61
Able to practice clinical skills before clinical training	60	39
Able to test myself (e.g., a safe space to practice assessments repeatedly)	101	64
Develops additional transferable skills that cannot be learnt in the classroom or clinic (e.g., data analytic skills, digital literacy)	49	31
Incorporation of social media	24	16
Is fun to use (e.g., clinical training games are available)	28	19
Can use more effectively when I have had additional training	32	21
Free (zero-rated for data, available offline)	51	33
Mobile-friendly (compatible on different digital devices, e.g., laptops, mobile phones, tablets)	93	60
<b>Which of the following features of mHealth applications are the most important to you?</b>		
Easy to use (e.g., no need for training)	86	55
Mobile and portable	95	62
Quality and quality of relevant data (e.g., access to local health-related information)	83	54
It links theory to clinical practice	59	38
It links research to theory and/or clinical practice	49	32
Able to collaborate or interact with peers (e.g., group work possible)	32	20
Able to prepare for classes before classes	41	26
Able to practice clinical skills before clinical training	36	23
Able to test myself (e.g., a safe space to practice assessments repeatedly)	22	14
Develops additional transferable skills that cannot be learnt in the classroom or clinic	34	22
Incorporation of social media	22	14
Can use more effectively when I have had additional training	33	22
Free (zero-rated for data, available offline)	45	29

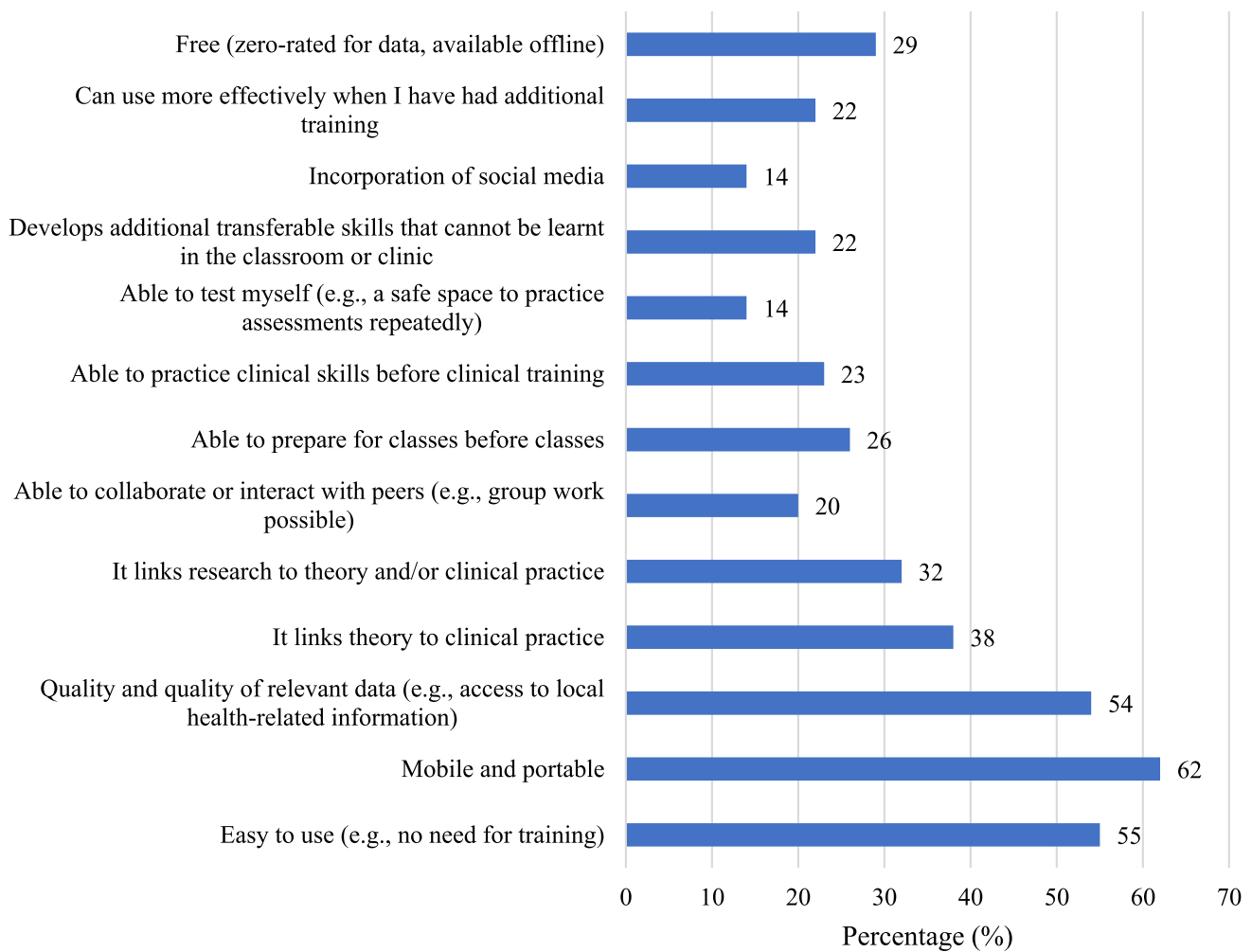


**Fig. 1** Perceived importance of e-Learning features by health sciences students

Twitter), applications and websites (DSM5, Oxford clinical medicine handbook, ECG app, medical flash cards, WedMD, UpToDate, EM guidance).

While most students had not used mHealth applications before, the majority (63%) of those who had, perceived them to be very/useful (see Table 6; Fig. 3).

Student comments around the benefits and challenges of integrating e-Learning tools and mHealth applications into a health-sciences specific LMS are summarised in Table 7. Briefly, such a platform, with the integration of social media page, could maximise connectivity between students, staff, patients and wider stakeholders through the creation of a centralized space. Moreover, the platform should be open access, for all stakeholders to use, further facilitating learning, developing curiosity, contributing to continued professional learning and enabling informed decision-making for patients and career choices for health professionals. An integrated platform would further complement the traditional curriculum, providing valuable “add ons”. Lastly, with such a platform, depending on where relevant and up-to-date content is drawn from, or who is allowed to contribute and access the content, there needs to be some form of qualified peer review and quality control. One student suggested citing where the information is from, including its context, in order for them to more fully and critically engage with the content—not just if it is trustworthy, but relevant.



**Fig. 2** Perceived importance of mHealth features by health sciences students

**Table 6** Student perceived usefulness of alternative ICTs on their theoretical and practical learning

Student experiences of alternative ICTs		N=	Percentage (%)
How useful were alternatives	Not useful at all	5	6
	Not useful	2	2
	Neutral	26	29
	Useful	33	36
	Extremely useful	24	27

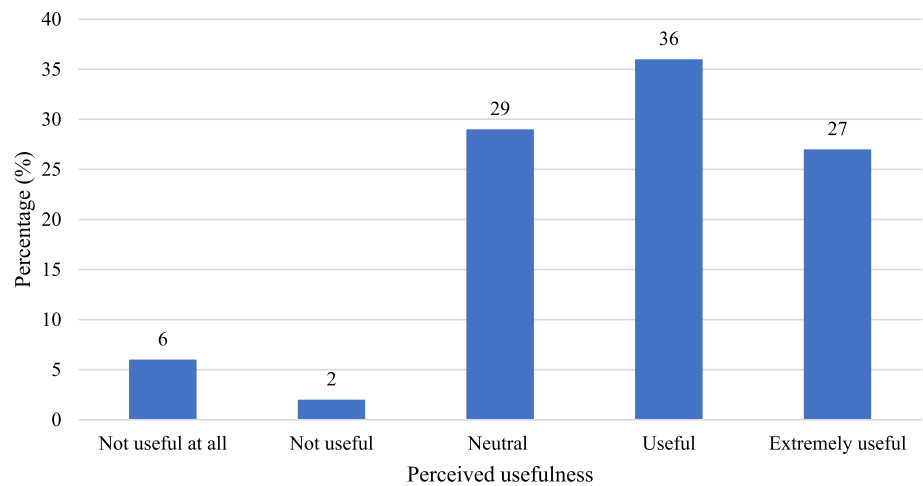
The majority of respondents appreciated the role of e-Learning as it afforded flexibility, widened access to further relevant resources which was stimulating and motivating for their learning. These findings applied irrespective of level of study year or discipline.

A smaller proportion found e-Learning unsatisfactory and unhelpful as they preferred teacher-led approaches or were insufficiently motivated for self-study or taking greater responsibility for their learning. Of these, a proportion were nevertheless strongly supportive of mHealth applications.

The majority of respondents who had used mHealth valued it for rapid, efficient access to necessary information timeously, assisting with the application of theory into practice and widening their exposure to various aspects of clinical practice. Some were concerned about reliability, and others about relevance to local health conditions.



**Fig. 3** Student perceived usefulness of e-Learning and mHealth alternatives



Numerous respondents commented that blended learning was essential as face-to-face interaction with patients or clients was vital for comprehensive history-taking or assessment.

Overall, the findings point to students wanting a blended learning environment that is multi-modal and interactive. Multi-modal refers to the combining of text, audio-visual resources and face-to-face workplace learning activities. Interactivity with teaching staff as well as amongst themselves is considered most desirable for retaining or deepening motivation. More comments conveyed a tendency to extrinsic than intrinsic motivation.

## 5 Discussion

The findings from the FGDs, interviews and survey offer different perspectives, ranging from negative [56, 57] to positive [22, 58], on Health Sciences student experiences of e-Learning and mHealth at South African universities during and post COVID-19. Students were more familiar with e-Learning tools than mHealth applications, but both were perceived to be beneficial to theoretical and clinical learning. mHealth in particular was seen as useful for accessing relevant, up to date information (when available) quickly and remotely in work settings (e.g., for patient diagnoses and care); whereas e-Learning was helpful for revising content, accessing additional content for more expansive self-directed learning, and less so for interacting with peers, staff or patients.

These findings overlap with those relating to efficiency afforded by mHealth is supported in the literature [59]. In considering the African perspective, others too have recommended mobile learning for improving higher education equity and student performance, including the development of transferable twenty-first century skills [60]. On the notion of transferable skills, students indicated that skills such as communication, decision-making, emotional intelligence, digital literacy, interpersonal and clinical skills could be outcomes of e-Learning and mHealth usage.

Overall, there was overwhelming support for the establishment of an integrated, centralised, multi-modal, Health Sciences-specific platform to complement traditional Health Sciences curricula and optimise learning (for students and academic staff) and a potential to enhance healthcare (for patients) in South Africa. In short, such a platform could enable more effective and efficient service delivery to all health practitioners and patients within the country.

However, the contextual challenges remain: load shedding (rolling power blackouts) and connectivity issues, studying in isolation, and a lack of physical interaction [18–25]. The findings of this study reinforce the concerns raised by several authors relating to a potential danger of entrenching the digital divide thereby perpetuating epistemic exclusion and social inequalities within Higher Education in Africa and South Africa. A recent inclusive and multifaceted approach for the development of electronic work-integrated curriculum could assist in avoiding the traps entailed in the barriers identified by the majority of students in this study, and supported in the literature, as previously discussed [61].

While online education has the potential to increase access ('anytime, anywhere') and staff-student, student-student, student-patient interactions [21]; students still expressed feeling a sense of isolation and psychological distress with online (remote) educational experience. Student mental health and wellness cannot be ignored; there should be a move

**Table 7** Student qualitative comments regarding benefits and challenges of an integrated e-learning and mHealth LMS

Theme	Illustrative quotes
Maximised inter-connectivity	<i>"(Include) Social media—Twitter and Instagram medical pages"</i> <i>"Social media pages of clinical practice demonstrations"</i>
Open access	<i>"Adding to a positive learning experience and outcomes in regard to personal accomplishment"</i>
Complementarity	<i>"e-Learning and mHealth are important and beneficial 'add-ons' to clinical and medical training but cannot replace in-person classes and clinic/ward experience"</i>
Qualified peer review	<i>"The main issue is the accuracy and control over the information you can provide with mHealth. There are certainly good and useful apps and websites that contribute greatly to theoretical knowledge but because it's impossible to verify information it's difficult to apply in real life ... If a good source of information comes from a well renowned hospitals web page, their information is based on their circumstances in their country. It's biased and doesn't take into account the context where the information was found. However, with something that is subjective like drugbank, it's easy to verify the accuracy of information because it's all based on pharmacological which cannot be disputed based on opinion."</i>

to developing online communities of practice with authentic engagement, social presence and psychological support [22, 25, 26, 57, 62, 63]. Perhaps the inclusion of social media applications could bridge this gap [64].

In comparing the consensus findings from staff [48, 65] versus student experiences, perceptions and recommendations for Health Sciences curricula, staff and students overwhelmingly support a form of blended learning, recognising the flexibility it affords. Reluctance towards blended Health Sciences curricula was more evident in staff (Noorbhai, Sims & Hartman, 2023), than students, although present with some students, due to perceptions of limited practical/clinical and patient-based teaching and learning benefits. Exploring where and how it can be beneficial is vital to shifting these kinds of mindsets (*"Lecturers and students would require a mindset shift to embrace the use of these tools in learning"*).

Adopting multiple rounds of a collaborative, participatory and student-centred approach to the utility and development of a LMS platform is a strength of this study [1, 21, 22, 24, 61]. However, while we employed a diverse sampling strategy, we cannot claim to have sampled a representative population nor established consensus on e-Learning and mHealth in HSE. This issue can be addressed by the fact that this work is part of a larger multi-stage research and development project; future will include additional rounds of engagements with and feedback from key stakeholders, both students and staff, on the development, piloting, and evaluation of a new integrated eLearning and mHealth application/platform. Specific avenues for investigation could include whether or not it enhances multi-disciplinary and interprofessional collaboration and teamwork (including patients). A key question that would need to be formulated is: does it lead to the development of transferable skills? Is it able to address the cultural, linguistic, socio-economic diversity of our students, or does it perpetuate inequities and discrimination against our neediest and remote (e.g., rural) students? Is there a measurable impact on work-integrated learning, health systems strengthening and patient care?.

As data collection took place in 2021, 2022 and early 2023, this study did not explore AI, such as ChatGPT, which enter mainstream use later in 2023. AI, along with extended reality (XR) are being considered in the development of the proposed integrated learning platform. Future work will consider student, and staff, experiences and views on AI and XR in HSE.

Another issue of importance in considering technology-usage is the matter of ethics (e.g., consent and confidentiality or privacy around patient data), which was not specifically explored in this study. Related, the rise of mis- or dis-information (i.e., "fake news") also raises the challenge of content creation and fact-checking of information uploaded on online platforms. While staff and students need to take responsibility on how they interact with and use such platforms, leadership and regulation by universities is needed too. Critically, LMS use by universities are 'closed' platforms, meaning that only staff and students have access, and only staff may upload learning content, in comparison to 'open' online platforms in which the public has greater access. The embedding of 'open' tools or applications in the proposed integrated LMS must be considered in future research and development.

## 6 Conclusions

The paper presents the health science students' perceptions of the importance and relevance of different aspects of e-Learning, mHealth and their curriculum, which will significantly impact their future healthcare learning and practice post-COVID-19. While COVID-19 may have obligated the use of e-Learning tools, as we pursue effective and sustainable educational technological innovations for social development (e.g., enhanced training, healthcare practices and patient outcomes in underserved rural communities in LIMIC contexts), an evaluation of key stakeholders' experiences and their recommendations for the future are crucial. This article presents the findings from initial interviews and focus group discussions, followed by an extensive survey, from health sciences students across South Africa on their opinions on how a multi-modal platform and curricula can be developed to optimise learning (for students and academic staff) and healthcare (for patients). Our mHealth focus, and proposed integration with e-Learning, has not previously been explored extensively in South Africa. Critically, an integrated and multi-modal application has the capacity to not only assist health practitioners and the public to access information to diagnose illnesses, track diseases and provide timely information among resource-constrained contexts; but additional support education of health sciences students—in residential and decentralised training programmes. Together, this technological innovation could help address challenges around educational and health inequities.

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**Data availability** The datasets generated during and/or analysed during the current study are not publicly available due to regulations in the University Research Ethics Committee, but may be made available from the corresponding author on reasonable request.

## Declarations

**Competing interests** The authors declare no competing interests.

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