Chapter 7

Mobile-based Formative Assessment and Feedback in Medical Education – Work in Progress

Veena S. Singaram
ORCID iD: https://orcid.org/0000-0002-6974-7423

Abstract

In medical education, assessment and feedback are critical elements for effective clinical learning and training. However, feedback and formative assessments are often neglected in resource-constrained environments due to a lack of quick, accessible, easy-to-use digital tools. The disruptions of the Covid-19 crisis have also underlined the need for more digital tools to support educational continuity and assessment in clinical training environments. Mobile-based technology was adopted for this research project to develop a generic formative-assessment, mobile-based application that is accessible, quick and easy to use. This chapter reports on the preliminary development and design of this mobile-based feedback application prototype to facilitate and create opportunities to prompt self-assessment and constructive formative feedback conversations between trainers, trainees, and peers in the clinical training environment at the University of KwaZulu-Natal. This project adopted participatory action research and Agile methodology for software development. Convenience sampling was used for the pilot test of the prototype. Six clinical teachers and five students from the School of Clinical Medicine, University of KwaZulu-Natal (UKZN) consented to participate. The prototype of the app was commended by all participants who reported that it was simple and easy. The menu items finalised for the proposed app aim to facilitate self-assessment, bi-directional feedback, reflection, feedback-seeking behaviour, and feedback utility to enhance graduate competencies and clinical performance in medical education. Future work will report on the subsequent iterations, development,

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and implementation of the mobile-based formative assessment feedback application.

Keywords: mobile-based assessment, formative assessment, feedback, self-assessment, self-regulated learning

Introduction

The disruptions of the Covid-19 pandemic were initially anticipated to be temporary. However, there is a mounting belief that medical education might change more permanently (Ten Cate *et al.* 2021). The global adaptations, evolvement of web-based technology and increased acceptance of distance learning have nurtured extensive support for online teaching and learning paradigms (Chen *et al.* 2021). Hence, Covid-19 has ushered in a new era of online learning resources and electronic tools to facilitate teaching, learning, and assessments. In addition, studies on the impact of technology in education highlight the need for educators to embrace and design technological innovations to facilitate student learning in the 21st century (Mackay 2017).

One such innovation is the use of mobile technology. Smartphones perform many of the functions of a computer. In addition to a standard touch-screen interface and internet access, smartphones have an operating system capable of running downloaded apps. Further, mobile devices and applications have many customizable features. These features can be tailored to the learners' needs to improve and facilitate learning in informal and diverse learning contexts beyond the traditional learning environments (Ramos, Conde-González & Garcia-Peñalvo 2015). Smartphones are frequently used across the different levels of healthcare staff to improve clinical communications in specialist training (Martines *et al.* 2017). Hence mobile technology contributes to the flexibility of education due to its 'mobility, access, immediacy, situativity, ubiquity, convenience and contextuality' (Naylor & Gibbes 2018:63).

Smartphone apps have also been reported to influence how formative assessment feedback is collected and analysed positively in clinical training (Gray *et al.* 2016). However, formative assessment and feedback are paper-based on the resource-constrained South African medical training platforms, as there is a lack of digital tools for formative assessment feedback (Naicker, Govender & Singaram 2021). Further, medical training environments are

largely summative in resource-constrained training environments. Hence, formative assessment and feedback are often neglected due to time constraints, the extra resources needed to implement continuous formative assessment, and the discomfort created by giving negative feedback in clinical work and training environments (Bagwandeen & Singaram 2016a). These challenges were further exacerbated during the constraints of the pandemic (Singaram, Naidoo & Ramrathan 2021), highlighting the need for effective digital tools for educational continuity.

Since the ownership of digital devices such as smartphones and tablets and the use of handheld computing devices have been increasing in the clinical settings, mobile technology was adopted in this research project to develop a generic mobile-based formative assessment application that is accessible, quick and easy to use. Mobile devices provide an opportunity for medical students and faculty to access apps quickly and complete assessments in real-time or between clinical tasks. Unlike computer systems which can be time-consuming, mobile-based applications do not require lengthy login processes.

This chapter focuses on the development of a prototype or minimum viable product of the mobile-based formative assessment feedback application that could be used by both the clinical trainees and trainers at the School of Clinical Medicine, University of KwaZulu-Natal to provide formative assessment and feedback on trainees' performance and competence.

Background and Literature Review

Formative assessment is an essential aspect in developing a professional's lifelong learning and reflection skills. Even though the importance of reflection for the professional development of physicians is well established, it does not happen 'intuitively or spontaneously' (Könings, Van Berlo & Koopmans 2016:365). It needs to be prompted proactively and more needs to be done to improve the frequency of self-assessment and feedback amongst medical students and junior doctors (Hawkins *et al.* 2012). Könings *et al.* (2016) explored using a smartphone app to promote medial registrars' reflection in the workplace and found that trainees using the app captured more learning moments on their reflection forms than non-app users. They found that the app allowed users to capture their reflections in various ways, using voice notes, text notes, pictures, or video recordings. Automated formative assessment feedback created in virtual environments has also facilitated frequent, timely

access for reflection and self-assessment (Pishchukhina & Allen 2021). These findings highlight the importance of mobile-based application features and other Artificial Intelligence (AI) functions to stimulate formative assessment as well as feedback quality and efficiency.

Several studies have reported the positive benefits of mobile technology in undergraduate, postgraduate, and workplace-based assessments in healthcare professional training. Mobile-based assessments were found to be feasible and acceptable (Torre *et al.* 2007; Duggan *et al.* 2020) and encourage more feedback, which leads to improvement of clinical skills (Coulby *et al.* 2011), and creates more flexible modes for assessments (Ferenchick *et al.* 2013). Nikou and Economides (2018), in their review of mobile-based assessments, also found that mobile-based, formative assessments have a significant impact on student learning performance, motivation, and attitudes. They also highlight the need for more studies on mobile-based assessments to explore the use of mobile-based assessments and the relationship between student motivation and different mobile-based assessment practices.

The factors influencing behavioural intention to use and accept mobile-based assessments were explored using the Technology Acceptance Model (TAM) and the Mobile-Based Assessment Acceptance Model (MBAAM) (Nikou & Economides 2017a). TAM includes the constructs of perceived usefulness, perceived ease of use, and attitude towards usage. MBAAM consists of the constructs related to facilitating conditions, social influence, mobile device anxiety, self-efficacy, and others. Nikou and Economides (2017a) found that the construct of perceived usefulness had the highest mean value, followed by social influence. This means that students perceive mobile-based assessment as a valuable educational activity, especially when their teachers and peers use it as well. Nikou and Economides (2017a) also highlight that when the appropriate technical and administrative infrastructure for the use of mobiles in assessments exists, students perceive the procedure as accessible and acceptable for use. However, Bacca-Acosta and Avila-Garzo (2020) found that students' acceptance of mobile-based assessment influences their engagement, even though the user interface and feedback have no impact on students' engagement. Further investigation is needed to research mechanisms for automatic engagement detection effort and regulation strategies to enhance engagement with mobile-based assessments, as shorter time-frames for engagement are recommended.

On the other hand, George, Bohnen and Goreback (2020) found that

using smartphones as the assessment instrument for medical trainee performance in the workplace is convenient, easily accessible, faster, and less cumbersome than starting up and logging into computers in the hospital. Nonetheless, in their description of their smartphone-based work assessment app called the System for Improving and Measuring Procedural Learning (SIMPL), they highlight important considerations for successful app development and implementation. These include being aware of the financial, operational, and ethical issues, which could become a hindrance, particularly in under-resourced settings. However, Khan and Malik (2021), who investigated the use of smartphones amongst medical students in a developing country context, found that, despite some constraints, the use of smartphones continues to increase, illustrating the need for more novel developments of medical apps and educational resources to enhance the training of medical students.

Several studies in South Africa have explored the frequency and quality of formative assessment feedback practices in medical education settings. Bagwandeen and Singaram (2018) found that the diverse multilingual South African training environment could create tensions that hinder verbal, face-to-face feedback. A study exploring the trainers' perceptions of the quality of feedback given to registrars found that formative assessment feedback is very poor and rarely done (Bagwandeen & Singaram 2016a). The medical and surgical trainers in that study provided feedback in less than half of the learning encounters. Bagwandeen and Singaram (2016b) also examined the trainees' perceptions. They found that although trainers claimed to have provided feedback, trainees disagreed and reported overall dissatisfaction with the quality of the feedback process. Another study also noted some concerns regarding the lack of standardised and structured assessment criteria and variation in feedback (Abraham & Singaram 2016). However, trainers and trainees agreed on the need and importance of formative assessment feedback to enhance clinical competence. These findings highlight the need for standardised formalised formative tools to improve the frequency and quality of feedback, as feedback is critical in clinical training.

Feedback creates opportunities for students to 'self-direct their learning in response to an assessment of their performance that fosters lifelong learning, promotes good ethical practice, and improves patient outcomes' (Naicker *et al. 2021*:180). Students value feedback comments that are supportive and encouraging and ask questions that enhance personal or professional reflection. (Bowen, Marshall & Murdoch-Eaton 2017). The most

dominant form of feedback is unidirectional and is initiated by the trainer rather than the trainees. These forms of feedback hinder the students' competency in enabling feedback discussions and providing feedback across power differentials (Myers & Chou 2016). In contrast to unidirectional feedback, bi-directional feedback can increase the likelihood of improving future performance and strengthening the feedback interactions (Holmboe *et al.* 2004). Hence there is a need to explore the use of mobile applications to prompt trainees to initiate bidirectional feedback.

Since medical training adopts the apprenticeship model, the most convenient way to carry out regular performance assessments is by the clinical supervisors who work with the trainees. However, although effective feedback is critical for developing competent graduates and professionals, it is often neglected or absent as it disrupts the routine clinical workflow (Naicker, Govender & Singaram 2021). Therefore, the formative feedback process may pose several limitations, especially in resource-constrained public healthcare clinical settings such as South Africa. A recent study with South African Anaesthetics trainers found that most trainers raised concerns about the infrequent use of current paper-based formative assessments and reported a preference for digital tools to provide formative assessment feedback (Naicker, Govender & Singaram 2021). These clinical trainers were also willing to use an app on their own mobile devices to provide feedback more frequently and timeously. Trainers also indicated that they would like to receive feedback about the feedback they gave. Providing trainers with feedback about their feedback could improve the quality and impact of their formative assessment feedback.

This research project aims to design and develop a mobile application to enable bi-directional, specific, non-judgemental feedback to improve self-regulated learning and enhance clinical competence in daily educational learning encounters in the clinical training environment at the University of KwaZulu-Natal. The mobile-based formative feedback application will also facilitate and create opportunities to prompt self-assessment and constructive formative assessment conversations between trainers, trainees, and peers.

Theoretical Framework

The SDL theoretical framework of Knowles (1975) and the conceptual framework for effective feedback processes by Hattie and Timperley (2007) underpin the development of the menu items of the mobile-based formative

assessment feedback application in this study.

As defined by Knowles, self-directed learning (SDL) theory involves a process in which students take the initiative, diagnose their own learning needs, create goals, implement suitable learning strategies, and evaluate their learning outcomes (Knowles 1975). Students become self-regulated learners by becoming agents of formative assessment practices through peer assessment and self-assessment as they diagnose and address their own learning needs (Granberg, Palm & Palmberg 2021). Self-assessment is a fundamental skill that empowers professionals to appraise the value of their clinical performance critically and improve through self-directed learning (Kornmehl, Patel & Agrawal 2021). Studies have also shown how self-assessment facilitates the development of critical skills and increases medical students' interest and motivation level, leading to enhanced learning and significantly higher academic performance (Rajeev *et al.* 2016). SDL has also gained greater relevance in the new Covid-19 normal, with remote learning implemented in higher education sectors and the rapid expansion of digital learning platforms (Mahlaba 2020).

Hattie and Timperley (2007:86), in their conceptual framework for feedback, emphasise that effective feedback processes are based on evaluating performance using three key questions by either a teacher, peer or self: 'Where am I going? (i.e. what are the learning goals?); How am I going? (i.e. to achieve this goal what progress is been made?), and Where to next? (i.e. to make better progress what activities need to be undertaken?)'.

Methodology and Development of the Prototype

A participatory action methodology (Turnbull, Friesen & Ramirez 1998) was adopted for this project to create collaboration, participation, and interactions between the researcher and the stakeholders in the different phases of the research project. These collaborations between the researcher and various stakeholders include the external software development team, the clinical trainers, trainees and the institution. This chapter reports on the preliminary development and design of the prototype of the mobile-based feedback application.

Prototype

The software development process of the prototype is based on the Agile methodology (Ribeiro & Domingues 2018).

The Agile methodology is a project management methodology purposely adopted for the development of software. Agile incorporates a collaborative approach that allows for iterations or development cycles (Martines *et al.* 2017). These approaches aim to minimise errors and are flexible enough to accommodate changes throughout a mobile app development lifecycle. Hence, the Agile methodology was adopted for this research project as the focus is on collaborative planning and goal formulation to develop the mobile app with continuous user feedback regarding the app's features. This approach facilitates a system of constant improvements. Hence, the mobile app development is organised into sprints discussed weekly between the author (VSS) and the design team.

Beta Testing, Implementation, Evaluation

After the piloting the prototype, the mobile-based feedback application will be developed into a fully functional app. Thereafter, it will be distributed to 50–100 users to test the app for bugs. After fixing any identified bugs, the app will become available to all users across the clinical and medical training environments in the academic hospitals in KZN. Training sessions will also be held regarding the rationale for formative assessment and how to use the app to facilitate frequent constructive feedback to enhance clinical training and development of our students into competent, self-directed lifelong learners.

The mobile-based feedback application is currently being engineered for use on both Apple iOS and Google Android, the two most popular operating platforms for smartphones. The medical trainees and trainers will be able to download and use the feedback application on their mobile devices for ease of access to encourage frequent use.

This project was approved by the Human and Social Sciences Research Ethics Committee at UKZN (HSSREC/00003007/2021).

Preliminary Results

Mobile-based Feedback Application Prototype Development and Pilot

A convenience sample of six clinical teachers and five postgraduate clinical trainees from the School of Clinical Medicine, University of KwaZulu-Natal (UKZN) consented to participate in the pilot. These 11 participants, who are

potential users of the app, were recruited from four specialties (Orthopaedics, Anaesthetics, Psychiatry and Internal Medicine) to participate in the prototype's development phase. This test sample consisted of seven males and four females.

Two rounds of online Zoom interviews or telephonic consultations were held with each of the volunteers individually. In round one, the design of the mobile-based feedback application was presented and discussed. In round two, the prototype of the app was emailed before the individual discussions.

The majority of the feedback received were commendations. The clinical trainees and trainers found the app *'simple', 'quick and easy to use'*. Both the trainers and trainees reported that the design of the proposed app *'looks good'* and the design favoured, *'I like the 3 step 3 tab design'*. Overall the prototype was well received as participants felt that app *'will enhance clinical training and hence improve patient care'*.

Minor suggestions and recommendations were made to refine the content and layout of the prototype.

Mobile-Based Feedback Application – Menu

Based on the literature, theoretical framework, and suggestions from the pilot, the proposed mobile-based feedback application will be available in two versions, one for trainers and the other for trainees. The trainees will have access to three menu items: *learning encounter, self-assessment,* and *feedback reflection*. Trainers can view all menu items but only need to provide formative assessment feedback on *performance and competence.* The trainees can also seek peer feedback from one another. All the menu items have open-ended questions for narrative feedback comments.

The mobile-based feedback application developed will consist of the menu items as outlined below.

Learning Encounter

This section of the app is designed to encourage the trainees to initiate feedback on any of their learning encounters, e.g. case, procedure, skill, etc. In addition to describing the learning encounter, trainees can also upload one to four related pictures or images.

Self-assessment

In this section of the app, trainees need to complete a self-assessment of the learning encounter before requesting formative assessment feedback from the trainer.

Formative Assessment Feedback

The trainer receives the description of the learning encounter and self-assessment conducted by the trainee. The trainer will then receive a prompt to evaluate and provide formative assessment feedback on the same learning encounter.

Feedback Reflection

This section on the app encourages bi-directional feedback as the trainee gives feedback on the feedback received to the trainer. The trainee also reflects on the impact of the feedback to create improvement goals for future performance. The reflection is then sent to the trainer. If further clarity is needed, the trainer and trainee can set up an appointment to further discuss the formative assessment feedback of this learning encounter, or the feedback cycle can be restarted.

Archive

An archive or information repository will also be created and linked to the smartphone app. This section will keep a log of the data that can be used to map student progress and competency development. This data will also be used to inform faculty development programmes. All data will only be accessible to secure registered users.

Conclusion

It is essential to explore the use of mobile apps that encourage and enable timely and frequent formative feedback in resource-constrained clinical training environments, particularly under pandemic constraints. We also need to investigate how technology could enhance the ability of clinical trainees to

track the evolution of their learning through effective and neutral formative assessments that enhance the acceptance and adoption of feedback to feed-forward action plans that strengthen competence and, ultimately, patient care.

In this chapter, the mobile-based formative assessment prototype that was piloted was well received. All the clinical trainers and trainees reported that the mobile app prototype was easy to use with a simple design to facilitate feedback and formative assessment timeously and frequently. Both clinical trainers and trainees will be able to use the app. Trainees will use the app to initiate feedback on their learning encounters, based on a three-step approach with open-ended questions for narrative feedback comments. The first step involves a self-assessment conducted by the trainee before they seek formative assessment feedback from the trainer. After the trainer has assessed and provided feedback to the trainee in the second step, the third step creates an opportunity for the trainee to provide feedback regarding the formative feedback received from the trainer. Closing the feedback loop promotes a culture of life-long, self-regulated learning that fosters a growth mindset in medical trainees. Hence the formative mobile app is based on assessment for learning and not of learning. Further development and implementation of the app described in this chapter will be reported in future publications.

Mobile devices and mobile applications in healthcare and medical education will continue to gain momentum as handheld devices become increasingly accessible in clinical settings. Although research on mobile-based assessments is still an emerging topic, several advantages regarding mobile-based assessment systems have been reported. These relate to ease of access, convenience, usefulness, independence, personalisation, and the positive impact of mobile technology on learning outcomes and motivation. The ubiquitous use of mobile technology in learning environments and clinical platforms also creates unique opportunities 'to assess performance and competence at the highest levels of Miller's Pyramid, thereby reflecting real-world practice' (Lumsden *et al.* 2015:244).

The dynamic influence of technology to improve the training of medical professionals will continue to flourish as the ultimate goal is to improve patient healthcare (Masters *et al.* 2016). Hence, developing mobile-based assessment tools is vital to prepare and train future generations of frontline healthcare workers.

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Veena S. Singaram
Senior Lecturer
Clinical and Professional Practice
University of Kwa-Zulu Natal
Durban
singaram@ukzn.ac.za