Usability Assessment of a Mobile Application: Experience and Effects among Family Medicine Residents

Diana Ramos

Department of Educational and Counselling Psychology

McGill University

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Abstract

This study aimed to identify factors affecting the usage of the IAM mobile application, and to provide a better understanding of residents' needs and experiences as they prepared for their board examination. Twenty family medicine residents at McGill University received the IAM App for their smartphone, loaded with the 99 Priority Topics deemed essential by the College of Family Physicians of Canada to the development of competence in family medicine. One alert to a priority topic was delivered via weekly push notification. The App's usability and residents' experiences were assessed via interview guided by log data on their usage of the App. Fifteen interviews were analyzed. Residents considered the IAM App as a valuable tool for spacing out their learning, and the majority described it as "intuitive" and "easily accessible". Three usage patterns were identified among the residents: continuers, discontinuers and non-users. Cross-case analysis revealed 5 themes: factors that influenced App use, the App's role, motivation for App use, use preference and the App's acceptability. Individual needs, learning strategies and push notifications were the factors that influenced the use of the App. However, proximity to exam dates sustained the use of the App. Barriers to use of the App included technical issues and lack of technical support. The IAM app supports traditional preparation and different learning approaches while promising to foster reflection. Further studies are needed to identify other factors that influence App use and clearer the role of mobile apps to prepare for the board examination.

Résumé

L'objectif de cette étude fut d'identifier les facteurs influençant l'utilisation de l'application mobile IAM, et d'acquérir une meilleure compréhension par rapport aux besoins et expériences des résidents lors de leur préparation pour leur examen du comité en médecine. L'application fut téléchargée par 20 résidents en médecine familiale à l'Université McGill sur leurs téléphones intelligents, incluant 99 sujets prioritaires jugés essentiels par le Collège des médecins de famille du Canada pour le développement de compétences en médecine familiale. Une alerte pour un sujet prioritaire fut envoyée sur une base hebdomadaire. La facilité d'utilisation de l'application et expériences des résidents furent évaluées à travers entrevues et à l'aide de registres de données sur l'utilisation. 15 entrevues furent analysées. Les résidents ont évalué l'application IAM comme étant très utile pour organiser et répartir adéquatement leur apprentissage, et la majorité ont décrit l'application comme étant «intuitive» et «facilement accessible». Trois types d'utilisateurs furent identifiés parmi les résidents: Utilisateurs réguliers, utilisateurs temporaires et non-utilisateurs. L'analyse de cas multiples a révélé cinq principaux aspects d'utilisation: les facteurs influençant l'utilisation de l'application, le rôle de l'application, facteurs de motivation pour utiliser l'application, préférences par rapport à l'utilisation et l'acceptation générale de l'application. Les besoins individuels, les stratégies d'apprentissage et les envois d'avis furent des facteurs qui influencèrent l'utilisation de l'application. Cependant, l'utilisation fut davantage soutenue en se rapprochant des dates d'examens. Les contraintes par rapport à l'utilisation inclurent aspects techniques et le manque de support technique. L'application IAM soutient les activités traditionnelles de préparation, ainsi que différentes approches d'apprentissage tout en soutenant les activités de réflexion. D'autres études sont requises pour identifier autres facteurs influençant

l'utilisation de l'application et rôles plus précis d'applications mobiles pour la préparation à l'examen du comité en médecine.

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CHAPTER 1

Introduction

Family doctors provide all primary care within a health system; they are pivotal to building a clinically and economically efficient health system (Groopman & Prichard, 2007). The role of family doctors is fundamental to preventing illnesses and promoting and protecting health (Stewart, 2003). Several well established functions of family physicians have been recognized in this area, such as delivery of quality care to patients with defined and undefined health-related issues (Phillips & Haynes, 2001), optimal use of health resources, contact facilitation between the patient and community health services, collaboration in multidisciplinary and primary care teams (Rivo & Heck, 1995) and management of health problems within cultural, social, psychological and physical contexts.

In spite of the constant expansion of the primary care health teams and growing sub-specializations, evidence has shown that general practice is the keystone of any good health system (Rivo, 1993) and plays an essential role within the community. One reason for this is that family doctors are still the only doctors who address all the various aspects of a patient's concerns, providing continuity of care (Evans, 2004; Schoen et al., 2004). In addition to this, organizing and consolidating knowledge (Stange, Miller, & McWhinney, 2001), they must develop a number of skills, including cognitive, motor, and interpersonal abilities (Ericsson, 2006).

Many efforts have been made to create novel learning tools in medical education and to help train future physicians. Mobile technology systems, in particular, are said to be useful and convenient in providing a supportive learning environment (Ward, Gordon, Field, & Lehmann, 2001).

Mobile systems have become more effective, innovative, and useful as their capabilities to integrate diverse services such as data storage, video capabilities, wireless connections, and improved screens, have increased, creating what are now widely known as smartphones.

Applications developed for smartphones are both popular and promising resources, likely due to their portability and the wide variety of services they provide; they can be used in various settings and at various times. In addition to making it possible to access clinical information, they also enhance teaching and learning in a variety of ways within different population, (Burdette, Herchline, & Oehler, 2008).

Mobile technology (such as smartphones, iPods, or tablets) has provided significant benefits to users and served as an interface for the development of multiple applications. However, with regards to the outcomes and usage of mobile software applications in medical education, few studies have demonstrated effectiveness of mobile learning in preparing trainees for their board exams (Gadbury-Amyot, Austin, & Overman, 2013). Moreover, most studies related to training have been carried out at the undergraduate level. For instance, instructional videos using the iPod touch showed improvement in patient presentations by medical students during their emergency rotation (Tews, Brennan, Begaz, & Treat, 2011).

Although mobile learning has increased in popularity and credibility within the medical field, providing doctors with access to different resources and the retrieval of medical information (Chang et al., 2012), it is still difficult to conduct usage testing and implementation of a potential mobile application. Factors such as software system operations, unstable wireless networks, device storage capacity, and restrictions on data entry are some issues that must be considered when creating a mobile application. For this reason, selecting the appropriate technological design and conducting usability studies are necessary in order to succeed and

achieve the desired outcomes (Zhang & Adipat, 2005), while creating and introducing novel educational tools to stimulate learning.

One of the goals of any family medicine training program is to produce highly competent, responsive family doctors who effectively respond to the needs of communities and maintain the health system chain (Committee, 2004; Coyle, Strumpf, Fiset-Laniel, Tousignant, & Roy, 2014; Rivo & Heck, 1995; Wilson, 1999). Evidence has shown that failing to successfully prepare residents for family medicine, as well as for other specialties, disrupts the whole health system, indicates poor educational quality (Blumenthal, Gokhale, Campbell, & Weissman, 2001) and negatively affects patient outcomes (Wiest et al., 2002).

Several factors should be considered in training new physicians in the current context. First, family medicine residency programs last only two years, and this has been found to affect preparation to meet patients' needs and expectations (Duane et al., 2002). Second, the constant growth of medical knowledge, rapid emergent technologies, budget issues (Arnetz, 2001), reduced working hours and intense work load (Scallan, 2003) have reduced learning opportunities.

It seems that students' time in residency may never be enough to allow them to master the body of knowledge and the independent practice required to adequately prepare them for their job. The importance of factual knowledge is supported by correlations between high certification exam scores and improved clinical performance in actual practice. Evidence for this can be found in two studies of Québec family medicine residents' performance in the early years of practice (Tamblyn et al., 2002). Tamblyn's work revealed the following: family physicians who achieved high certification exam scores prescribed more disease-specific medication and fewer contraindicated drugs. Initially, her assessment of these outcomes was limited to the

physicians' first 18 months of practice. Subsequently, she found a sustained relationship between certification examination scores and disease management over 4 to 7 years of practice (Tamblyn et al., 1998). Although this association cannot be assumed to be causal, any intervention intended to improve our future family physicians' knowledge will ultimately improve Canadians' health and health care system.

Based on the fact that creating and developing new educational tools to support learning has become a priority (Alegria, Boscardin, Poncelet, Mayfield, & Wamsley, 2014), a smartphone mobile application has been designed by a research team (principal investigators and the author of this thesis) at McGill University. This thesis begins by building a deep understanding of the end user's work environment, followed by the design process and a usability assessment of this mobile application, exploring this tool's impact on residents' learning, and on their preparation for their board certification exam.

1.1 Problem Statement

Upon completing residency training, provincial licensing bodies require all family medicine residents to write the certification examination of the College of Family Physicians of Canada, to ensure that residents are properly prepared and have the level of knowledge, skills and clinical judgment to practice in a safe and responsible manner. To pass this exam, family medicine residents must study a vast amount of content to gain and demonstrate their competency. Failure to pass the exam will prevent residents from entering independent practice, delay their employment, raise costs, and cause psychological distress.

It is important to provide tools that can be available at all times to support, complement, and sometimes replace traditional teaching methods. Information Systems technology, such as a smartphone mobile application, offer opportunities to increase study time, consolidate

knowledge, and explore the user's experience and needs while allowing the Application's effect on learning to be identified. The key is figuring out how to better support family medicine residents as they prepare for the board examination.

Due to the challenges of implementing a new mobile application (as demonstrated by various factors related to compatibility and design), it is essential to identify usability issues and assess this application's impact in family medicine.

Discovering these barriers and identifying residents' learning needs will be crucial to improving the design and continuing the development of a potential mobile application as a tool to support learning.

1.2 Purpose of the Study

This study introduces a mobile Application called the Information Assessment Method (hereafter referred to as the IAM App) to family medicine residents currently training at McGill University.

The aim of this study is to identify factors that affect the Application's effectiveness and use through weekly notifications and feedback questionnaires, and to provide a better understanding of residents' needs and experiences through the use of IAM. Also, this study attempts to use these findings as a starting point to develop a protocol to test the effect of the Application on residents' scores on the family medicine board examination.

1.3 Theoretical Frameworks

This study used the following theoretical frameworks: spaced learning and usability frameworks, explained below.

1.3.1 Spaced learning framework.

The first framework used for this study is based on the theory of spacing learning to facilitate long-term knowledge acquisition in learners.

The spaced learning framework is based on the theory of distribution of learning overtime (Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). Several studies have reported the mechanisms to acquire long-term memory using space learning methods. For example, this theory was used to describe the acquisition and generalization of new concepts in elementary children by comparing 3 different learning methodologies. This study' results showed that spaced learning improved retention (Vlach & Sandhofer, 2012). Other studies have used this theory to help to adopt new vocabulary and knowledge to create new educational frameworks (Lahti, 2012). Additionally, in the medical field, this theory has been also employed. It has shown to improve feedback, identification of gaps, facilitation of performance' self-assessment (Kerfoot, Kearney, Connelly, & Ritchey, 2009), and sustainability of clinical behavior (Kerfoot & Baker, 2012; Kerfoot, Lawler, Sokolovskaya, Gagnon, & Conlin, 2010). Flexibility is also an asset for spaced learning. For instance, games have been used to deliver questions by email in order to assess residents' knowledge of urology (Kerfoot, Armstrong, & O'Sullivan, 2008; Kerfoot & Baker, 2012), to teach physical examination skills to medical students (Kerfoot et al., 2008) and to promote global education (Kerfoot & Baker, 2012). It is important to add that this method has been well received by medical residents and clinicians (Kerfoot & Baker, 2012).

Spaced learning has demonstrated improvement in knowledge acquisition through the following three psychological attributes, which seem to act as a cycle. First, the spaced effect consists in the process of recalling information over time, thus minimizing recall deficit. Second, the spaced repetition, which relates to the exposure to repetitive information at intervals, and third, the testing effect (Kerfoot et al., 2009). These cycles are illustrated in Figure 1.1.

1.3.1.1 Spaced effect.

The spaced effect promotes recall. This occurs in the following three ways: encoding, retrieval and duration of knowledge in working memory (Rubin, 1998). Spaced effect is also called "distribution of practice", and is based on the knowledge that the dentate gyrus of the hippocampus (a structure responsible for learning and memory), produces cells continuously every day, but many of them die after a period of weeks. This effect has been studied in mice. Spaced training has been shown to improve neuron survival through learning tasks (Sisti, Glass, & Shors, 2007). This demonstrates that task learning over time permits task repetition.

1.3.1.2 Spacing repetition.

Spacing repetition is exposure to repetitive information and is the most important factor in improving knowledge retention (Toppino & DeMesquita, 1984). It has been demonstrated in adults and children that spacing repetition has substantial benefits when repetition occurs at intervals, instead of massed distribution of content. (Toppino, Kasserman, & Mracek, 1991). Repetition depends on the chain of encoding, retrieving, and storage time in working memory. However, when an item has been encoded, a second presentation of that item is needed in order for it to be easily remembered (Glenberg & Smith, 1981). Frequency of repetition is also important; as repetition interval increases, recognition of an item decreases but performance assessment improves. This means that to obtain maximum effectiveness in remembering an item, the item should be either partially accessible or forgotten. Initially forgetting an item makes the process of a second presentation of that item more difficult; the spacing interval of an item and a test of it are necessary to improve retention performance (Cuddy & Jacoby, 1982).

1.3.1.3 Testing effect.

The testing effect ensures durability of information in the context of spaced learning (Kerfoot, 2009; Kerfoot & Price, 2009; Kerfoot et al., 2011). Testing has been proven in specific medical specialties (Kerfoot, 2010) and high-stakes exams among medical students (Kerfoot et al., 2011). This effect improves retention, an indicator of learning improvement in which the effects of learning become longer-lasting (Kerfoot, 2009).

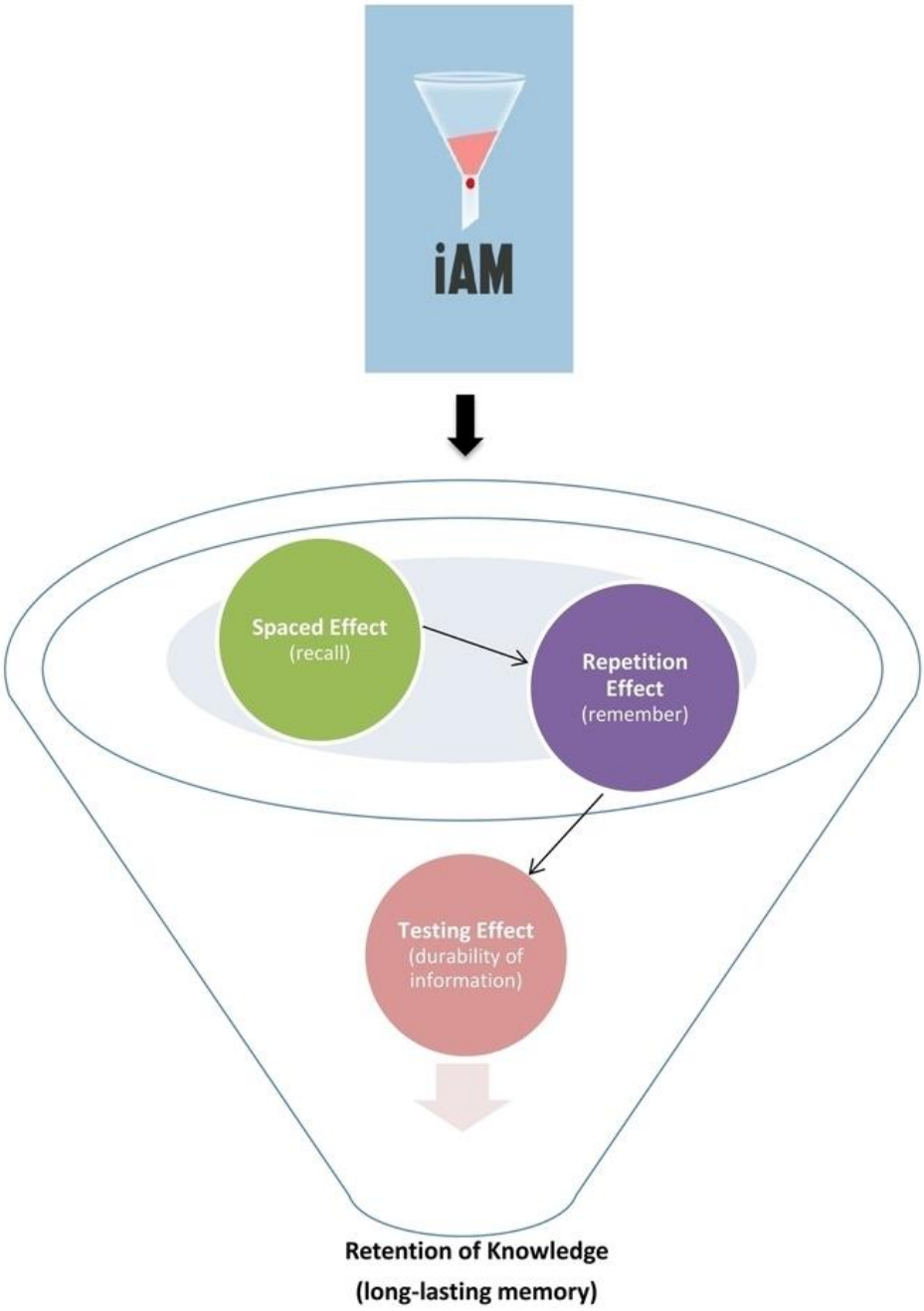


Figure 1.1 Spaced learning theoretical framework

As a result of this cycle knowledge retention is developed. This can have a significant impact in medical education and in supporting long-term memory. For example, evidence has shown students' tendency to quickly forget medical content. Therefore, some studies have tested

the effect of on-line spaced learning to enhance retention among trainees obtaining positive results (Kerfoot, DeWolf, Masser, Church, & Federman, 2007).

1.3.2 Usability framework.

With regards to the usability framework, this study used Nielsen's framework in which *Usability* is defined as follows: "Any object, product, system or service that will be used by humans has the potential for usability problems and should be subjected to some form of checking for usability engineering" (Nielsen, 1994, p. 7). Nielsen (1994) also states that usability is one of the main components of system acceptability, as illustrated in Figure 1.2. Several methods are employed to identify usability issues; and these methods will ultimately help in the process of improving the design of a human-system interaction. It is important to distinguish between the terms usability and utility. While *Utility* refers to the features of the system that the user needs, usability refers to how pleasant these features are to use. Both features are equally important and together determine whether something is useful. It matters little that something is easy if it's not what you want. Representation of this concept is illustrated in Figure 1.3. Nielsen (1994) proposes that for the design of any system, the following five attributes are equally necessary for a system to be usable: learnability, efficiency, memorability, effectiveness and satisfaction. These aspects are precise and measurable, allowing the investigation of usability problems (Nielsen, 1994).

Learnability relates to how easily the learner uses the system, and according to Nielsen this is considered the most important aspect of usability. Efficiency is associated with the time used to complete a task. Memorability is an essential aspect, because if a system is easier to remember then infrequent users will not have difficulty using the system after a period of inactivity.

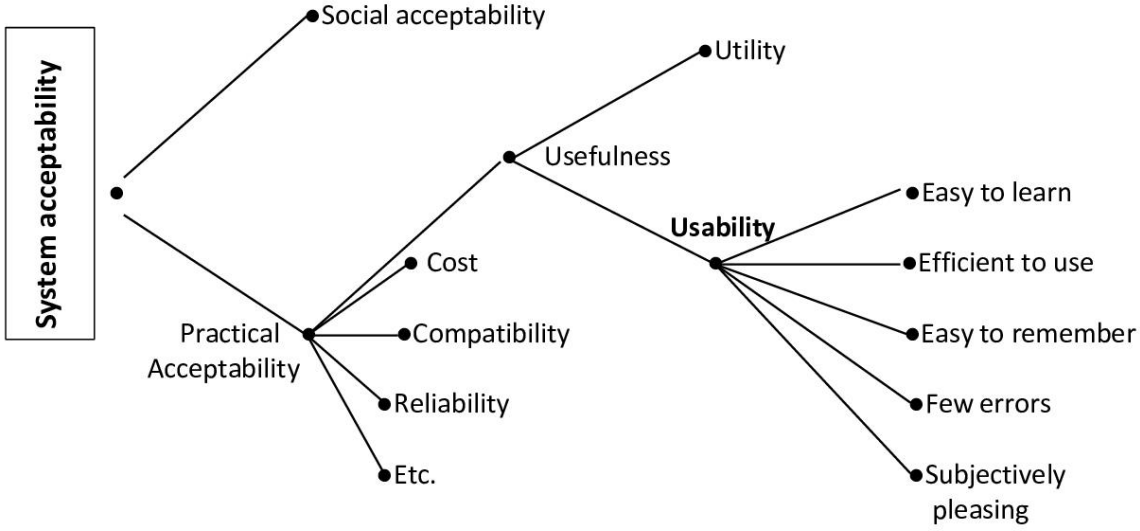


Figure 1.2 A model of attributes of system acceptability

Effectiveness indicates the number and types of errors that the user makes when using a system. Error is defined as any action taken by the user that delays navigation and transitions. Finally, satisfaction tells how pleasant the system is to use, and whether the users are pleased when they use it (Nielsen, 1994).

According to Nielsen's (1994) first principal, to fully understand a human-system interaction, it is necessary to determine the use of a system: "Your system will be best tested by users. Your only choice is to do the testing yourself so you can make the changes early or play catch for the rest of the product cycle" (Nielsen, 1994, p. 7).

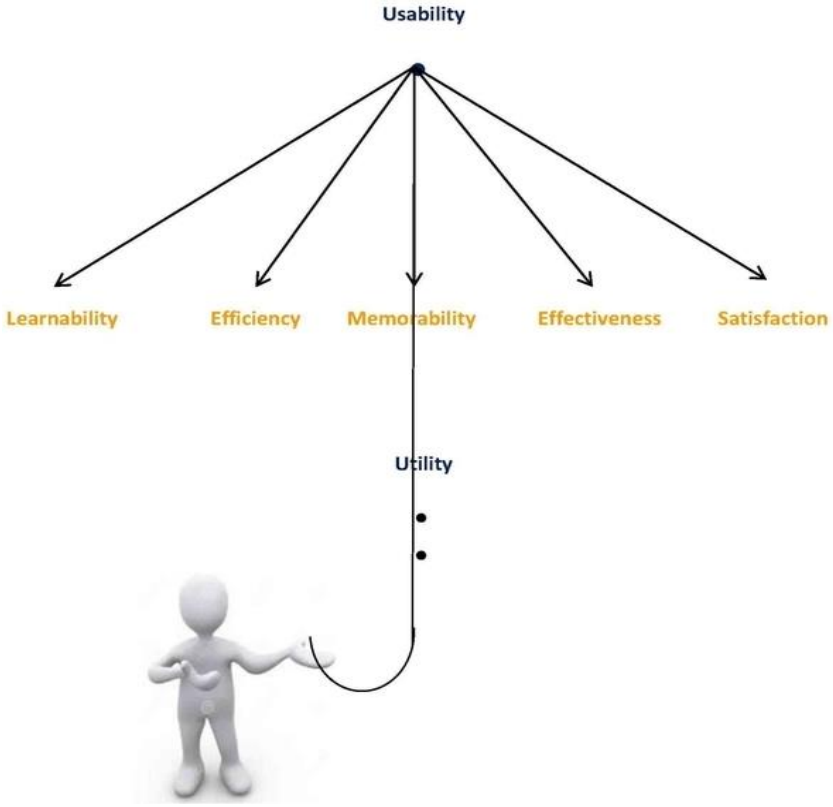


Figure 1.3 Key features of usefulness

Testing and assessment of a system have been applied broadly in the area of digital libraries (Joo & Yeon, 2011) as well as mobile internet services, where evaluating usability has been shown to have an impact on improving quality of services for all users (Buchanan et al., 2001; Flood, Germanakos, Harrison, McCaffery, & Samaras, 2012). In the development of medical applications, aspects such as the possibility of multitasking and reduced cognitive load have been discovered through usability (Arellano et al., 2012; Zhang & Adipat, 2005). The role of usability in the design of online learning programs and likely mobile systems is essential; usability measurements have demonstrated that a system is easily used if it encompasses all the aspects to develop and encourage learning (Ghaoui, 2003).

1.3.3 Conclusion.

Any worthwhile educational outcome is essential to professional growth (Ryan, 1993).

Following the design of the IAM Application, usability standards were employed to improve understanding of the user experience and to adapt this App to current users' needs. Although the IAM App contains a large amount of information, we foresaw the need to help residents prepare for their examination; this App allowed us to deliver content periodically. This is why the IAM App supports a spaced learning approach, which has been proven to offer valuable learning opportunities. As an instructional method, it also promotes efficient learning. In the current study, the IAM App begins to apply the spaced effect and spaced repetition attributes. The data generated will contribute to further studies, designed to improve students' knowledge by introducing the testing effect.

1.4 Significance of the Study

This study's significance is three fold. First, we will build a tool that has the potential for information delivery, information retrieval, and data collection, in which the usability framework is employed to evaluate usability issues in the context of postgraduate medical education. Second, this study employs a participatory approach, allowing residents to provide immediate feedback with regards to content, technical issues, or other factors they consider important. Third, this study will inform future research by providing important findings to allow new versions of the IAM Application to be optimized. This usability study will inform the development of a protocol for a feasibility study starting July 2015.

The overarching objective is to eventually determine the impact of the IAM on resident knowledge, represented by examination scores on the board certification examination of the CFPC. Therefore, this study will be foundational in helping family medicine residents handle the the challenges and opportunities of the healthcare system in the digital age.

1.5 Definition of Concepts

Table 1.1

Definitions of Concepts

Concept	Definition
Android	Operating system created by google
IOS	iPhone operating system
End-user	The person who uses a determined product
High-stakes exam	Tests that assess several complex skills and that according to passing or failing outcomes, implies potential consequences
Mobile application	A computer program designed to run on smartphones, tablet computers and other mobile devices
Mobile Information and Communication Technology	Technology and systems that are portable
Perceived ease-of-use	The end users perception of learnability and memorability of the application
Resident	Individual medical specialty trainee
User interface	The component of the computer where the end-user interacts with the application
Usability	Extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use

1.6 Research Questions

The main research question guiding this study was the following: *What is the usability of the IAM App among family medicine residents over a period of 7 months?*

The second research question was: *What is the role of the IAM app to help family medicine residents to prepare for the board examination over a period of 7 months*?

The first question allowed us to investigate the usability of this mobile App in the context of family medicine. Due to the importance of evaluating whether a mobile application can work properly (Zhang & Adipat, 2005), we expected this question to provide information about the usability issues, deficiencies in functionality, and usage frequency, with the aim to identify the most important aspects to improve and optimize future versions of the IAM App.

We expected that the second question would allow us to know how residents use and evaluate the IAM App to support their preparation for their board certification exam. Because the purpose of any mobile app is to adapt to users' needs and help users to achieve their goals (Zapata, Fernández-Alemán, Idri, & Toval, 2015), we expected that this question would also provide information about residents' learning needs and expose the potential of this App compared to other learning materials in residents' preparation for the board examination.

1.7 Summary

A mobile Application offers a unique and useful method for spaced delivery of content-specific medical information. Due to challenges in residents' daily work and difficulties in implementing new mobile apps, this study adopted the usability framework to guide and assess application design and system usage applicable in the field of general practice. Family Medicine residents need a novel, portable and accessible learning tool to both prepare for high-stakes exams and build self-directed learning habits. The present research was the first step towards the more ambitious objective of assessing the impact of the App use on residents' examination scores, while offering learning opportunities and assessment of learning needs.

CHAPTER 2

Literature review

This literature review will first explain the current context in which medical training takes place and its impact on learning. This discussion will be followed by a review of literature on adult learning and self-directed learning in family medicine, with a focus on some strategies that support learning via mobile technologies, followed by a brief description of one example of a modern mobile device: the smartphone. This chapter also includes an illustration of usability studies in the context of mobile applications and concludes with a section about currently documented usability methods. The review ends with a summary of gaps and areas that require further research according to the literature.

2.1 Modern Medical Practice and Learning Needs

Long work hours and twenty-four to thirty hour shifts have been the rule in most residency programs. They have been regarded as necessary for developing professionalism and acquiring sufficient knowledge (Veasey, Rosen, Barzansky, Rosen, & Owens, 2002). More recently, research has found that long work schedules for junior residents lead to conditions such as fatigue and sleep deprivation, which are ultimately hazardous to the residents' health. Consequently, countries such as the United Kingdom, the Netherlands, Denmark, France, Germany, Ireland, the USA and more recently Canada have become interested in limiting the number of work hours for junior residents. For example, in the UK the total hours worked per week was reduced from 58 hours in 2004 to 54 by 2007, 48 hours by 2009 and 37 hours by 2010. In spite of international concern, other countries with similar health systems, such as Australia, have taken a different approach to this issue; by 2000 approximately 70% of junior residents in Australia were still working 50 hours per week (Scallan, 2003).

Alongside these changes, the number of hours residents stay in-hospital between shifts has also been reduced. While these regulations have improved residents' quality of life and reduced burnout due to work-related stress, they have had an impact on educational outcomes. Several programs have adopted the night float schedule (in which the coverage is for 5 nights per week). Several outcomes have been measured, including alertness, attention, psychomotor skills, sleep time, program satisfaction, quality of life, and learning, and these have shown to differ from program to program. For example, an Australian study by Fletcher et al. (2005), found that Gynecology and Obstetrics' residents demonstrated reduced procedural volume with regards Obstetrics' procedures . This indicated that opportunities to learn procedural skills were more limited for this group of residents. Similar findings were reported in surgical programs. However, in other programs, such as pediatrics and psychiatry, no changes were reported. In family medicine, one study revealed that the night float schedule improved or did not change reading opportunities, but it decreased educational opportunities in other cases. However, it did improve residents' quality of life (Fletcher et al., 2005).

Despite these mixed results and multidisciplinary efforts, by 2010, the Accreditation Council for Graduate Medical Education (ACGME) established duty hour restrictions for physicians-in-training. The recommendation was to eliminate work shifts over 16 hours. According to the ACGME, this would not affect educational outcomes, but instead would ensure patient safety and quality of care (Levine, Adusumilli, & Landrigan, 2010).

In contrast, some studies have reported that the reduction in work and duty hours has negative impacts, including degradation of skills, lack of continuity of care, and decreased responsibility for patient care (Britt et al., 2009). According to Schwartz et al. (2011) one of the reasons for these detrimental effects is the fact that academic activities take place primarily

during work and duty hours. In addition, other aspects of training have suffered, such as the opportunity to acquire autonomy and responsibility necessary for developing clinical skills. Also, as a result of recent changes in medical training, resident supervision, which is essential to assessing and guiding the skill acquisition process, has been interrupted (Schwartz et al., 2011).

In each medical specialty, it is important to ensure patient safety while balancing learning opportunities. To keep up with these demands, adult learning must be promoted in postgraduate medicine training by providing effective learning strategies and tools to support and foster learning among trainees.

2.2 Self-directed Learning in Family Medicine

Several studies have shown that when physicians engage in self-directed learning, they are more likely to change their clinical practice (Mazmanian & Davis, 2002). Also, by participating in self-directed learning activities, they improve their conceptual knowledge (Murad, Coto-Yglesias, Varkey, Prokop, & Murad, 2010). Several self-directed activities have been studied in a family medicine context, such as journal readings, consultations with colleagues, and continuing medical education programs, which provide credits. Physicians are expected to complete a specific amount of credits per year. Also electronic databases have been an excellent resource for promoting learning in the field of psychiatry (Lim, Hsiung, & Hales, 2006). These forms of engagement are intended to provide different opportunities and to study how these options can change and improve medical practice (Mazmanian & Davis, 2002). Notwithstanding the range of options, evidence has shown that self-directed learning is the most effective form of continuous medical education in improving patient care and outcomes (Candy, 1995).

The field of family medicine has a broader scope and demands deeper clinical competency to manage multiple problems, treat various populations and integrate physical and social aspects into patient care. To maintain and improve the necessary skills to accomplish this goal requires commitment to life-long learning. For physicians in rural practice, the importance of engaging in and fueling self-directed learning during training is even more salient. For example, in rural locations in Canada, physicians are not provided with the same or as many resources as those in urban areas. Under these circumstances they must be able to design and construct their own learning opportunities (Curran, Hatcher, & Kirby, 2000).

Other studies have proven that self-directed learning in the context of medical education can supplement traditional learning methods and can also be cost-effective (Murad et al., 2010).

Although several modalities have been proven to effectively develop and maintain competency among physicians, in practice it is both difficult and urgently important for physicians to identify, choose, and find the information to be learned and used (Gorman & Helfand, 1995).

This challenge can be overcome by providing efficient strategies that encourage self-directed learning while allowing for external guidance in how to use the available learning tools. In this regard, technological tools might be useful as they can enhance self-direction with the aim of not only improving professional medical practice but also improving patient outcomes. That family physicians have shown to be far more self-directed than the general population (Fox & Bennett, 1998) might make the use of technological tools for learning even more relevant. Other studies have shown that this group will choose methods that best meet their learning needs, including multiple resources and live events (Barrett, 2014).

These findings provide important information for designing efficient learning tools that can not only enhance but also maintain self-direction in the context of family medicine postgraduate education.

With the rapidly emerging trends in mobile learning technology, efforts should be made first, to identify convenient technological tools; second, to assess their usability according to the context; and third to assess their effects in supporting training and preparation for independent medical practice.

2.3 Mobile Learning Technology

2.3.1 Definition of mobile learning.

The definition of mobile learning (m-learning) is context and interest-dependent. The greater the interest in this area, the more variation in definitions has been documented. Researchers and educators most commonly see mobile technology as the immediate descendant of electronic learning (e-learning). For instance, Pinkwart et al., (2003) define mobile learning as the type of learning that uses handheld devices or electronic tools and wireless connection. Quinn (2000) defines it simply as learning that takes place with the help of mobile devices. In keeping with this definition, other authors such as Turunen et al., (2003), view mobile devices as a pervasive learning tool with the potential to help people combine study, work, and relaxation in several meaningful ways. Polsani (2003) defines mobile learning as "a form of education whose site of production, circulation, and consumption is the network" (p. 1). Traxler (2005) defines it as "any educational provision where the sole or dominant technologies are handheld or palmtop devices" (p. 262).

Another concept found in the literature alongside m-learning is e-learning. The pedagogical distinction is based on the fact that the former occurs anywhere whereas the latter

occurs in classrooms or computer laboratories. It seems that the distinction is environment-dependent (Taylor, Sharples, O'Malley, Vavoula, & Waycott, 2006).

Despite these definitions, other authors define “learning” and “mobile” together. For example, one definition states that learning in a mobile context is the process by which learners form interpretations of their world in collaboration with their peers and teachers, construct transiently stable interpretations of their world (Corlett, Sharples, Bull, & Chan, 2005). This suggests that mobile technologies are considered to be a very valuable tool for communication.

Also, Barbosa and Geyer (2005) agree that mobility is related to increasing a learner’s capability to take their own learning environment along with them as they move. Michie et al. (1998) suggest that this allows the learning process to be taken out of the classroom and into authentic environments.

Another definition explains that mobile learning occurs when the following aspects interact together: time (when learning can take place), space (virtually situated instead of in-classroom), environment (formed by pre-defined tasks, access to knowledge, facilitation or coaching, and opportunities for community interaction), content (structure of educational themes or topics), technology (features and characteristics of handheld devices, interface interactions, and other), mind (mental abilities, knowledge, motivation attention), and method (means by which content is delivered and all parameters that interact with content), (Laouris & Eteokleous, 2005) .

2.3.2 Design and development of mobile technology.

Personal digital assistants (PDAs) were one of the first tools to enhance and support portable learning. PDAs have played several roles in medical education. For example, the most common use of PDAs is in clinical education, granting residents remote access to information.

This means that portable devices are well accepted by trainees when introduced as part of the medical curriculum (Omori, Wong, & Nishimura, 2013). By 2006, about 70% of medical students were using handheld devices during training and clinical practice (Kho, Henderson, Dressler, & Kripalani, 2006) . They were also used as a polling tool in classrooms, in teaching evaluations, to inform residents about medication use, and as a research tool to collect data (Grad, Pluye, Meng, Segal, & Tamblyn, 2005).

Benefits of PDA use have been documented in medical education. For example, a model of learning in clinical settings was developed through using PDAs (Davies et al., 2012). A number of obstacles have also been associated with PDAs. For instance, PDAs have fallen short with respect to collect and store data quickly and accurately (Kho, Henderson, Dressler, & Kripalani, 2006a). Like other systems, PDAs have failed due to software issues (Scott, Wilson, & Gowans, 2005), technological incompatibility, improper backup with consequent loss of information, the need for internet access via Wi-Fi or low connectivity networks. High costs and training time have also been identified as potential problems associated with PDAs (Kho, Henderson, Dressler, & Kripalani, 2006b) and have affected their use and applicability as a learning tool (Luanrattana, Win, Fulcher, & Iverson, 2012; Waycott & Kukulska-Hulme, 2003; Wright, 2014).

Apart from PDAs other pedagogical electronic resources, such as e-books, web courses, and digital libraries were initially created to fulfill the demands of distance learning.

One example is the creation of a collaborative learning environment in the form of a computer program. This program was based on a clinical case, provided simulation of symptoms, teleconsultation aid (as an opportunity to interact with physicians and colleagues), and access to multimedia resources (to gather clinical information of the simulated clinical case). This program

demonstrated that students can enhance clinical reasoning learning and improve the way they look for medical information (Medelez Ortega, Burgun, Le Duff, & Le Beux, 2003).

In addition, designing multimedia tools to target specific areas such as anatomy or surgery was shown to be effective in integrating learners' dexterity and cognition. However, usability was not assessed at that time (Grunwald & Corsbie-Massay, 2006).

The use of mobile technology has provided several benefits to both educators and students. For example, it facilitates communication, it is portable, and it encourages efficient use of time, among other benefits (Wallace, Clark, & White, 2012). However, negative aspects such as the possible distraction of mobile devices, perceived lack of professionalism, and the risk of superficial learning have been a challenge for the development and use of these types of tools (Gaitsgory, Burgess, & Mellis, 2013).

2.3.3 Use of mobile technology in different contexts.

The role of mobile technologies has been recognized and studied in biochemistry, and molecular biology (Parslow, 2013). Also, mobile technology has been used to support interventional programs. For example, one such study involved college students and aimed to prevent alcohol consumption. The program was successful in preventing alcohol consumption and it was well accepted among young people (Kazemi, Cochran, Kelly, Cornelius, & Belk, 2014).

2.3.3.1 Mobile apps in psychology.

Mobile apps inspired by cognitive behavioral therapy also have the means to evaluate mood and accordingly recommend therapeutic exercises and physical relaxation activities to increase self-awareness and cope with stress. A study evaluated one app's effects on participants' lives and their experiences following use of the app. Participants were prompted to rate their

mood several times per day using a Mood Map with scales for anger, anxiety, and sadness. Results from the case studies using open-ended interviews showed a positive impact on participants who developed insights that allowed them to make meaningful personal changes. This study demonstrated that the use of mobile apps has extended to become an additional therapeutic tool (Morris et al., 2010).

2.3.3.2 Mobile apps in clinical practice.

Hospitals are complex work environments in which multiple events occur simultaneously. In this context, mobile apps have been shown to be beneficial in supporting hospital based physicians' work practices and patient care. They facilitate rapid response towards retrieval of updated information to prevent medication errors, and access data (Prgomet, Georgiou, & Westbrook, 2009). A study on physicians' use of smartphone apps conducted by the ACGME showed that over half the respondents reported using apps in their clinical practice. The most commonly used app types were drug guides (79%), followed by medical calculators (18%), coding and billing apps (4%) and, pregnancy wheels (4%).

The most frequently requested apps were textbook/reference materials (average response: 55%), classification/treatment algorithms (46%) and general medical knowledge (43%). This study demonstrated the continuous use of smartphones and apps in the clinical context. While there appears to be a high demand among physicians and trainees for such apps, there have been few methodologically robust studies on such apps, and little usability testing to determine their impact (Franko & Tirrell, 2012).

There are more than 7000 documented health applications available (Kailas, Chong, & Watanabe, 2010). Thousands of these apps target health professionals to encourage usage. To help physicians better identify, select and use mobile apps, most researchers have studied

strategies such as web resources, peers, and app stores. It has been asserted that a combination of these methods will allow physicians to safely and appropriately use apps (Aungst, Clauson, Misra, Lewis, & Husain, 2014).

2.3.3.3 Mobile apps to improve performance in medicine.

A randomized control trial assessed the use of an app designed to teach advanced life support to junior residents from various specialties. The use of this app significantly improved scores during cardiac arrest simulation testing (Low et al., 2011). This study demonstrated that there might be a role for mobile apps in preparing trainees for tests and examinations by improving performance. However, no other studies were found to support this perspective.

Another study on mobile learning technology, explained that further research is needed to examine the impact of mobile apps on educational outcomes, specifically in promoting new learning (Valk, Rashid, & Elder, 2010).

2.3.4 Challenges and perceptions of mobile apps.

Despite the rapid development and expansion of mobile apps in many fields and populations, special considerations are encountered in the design, purpose, launching and implementation of smartphone mobile apps. In medicine, maintaining the confidentiality of patient information becomes an issue. The portability of these devices and their small size becomes a threat when using the smartphone in public spaces. Other factors, such as loss or theft of devices may also impact the security of data held on mobile phones (Lin & Vassar, 2004).

The majority of studies demonstrated that the use of mobile apps has a significant positive impact. Aspects of the apps that people feel positively about were reported in one qualitative study. These included convenience, efficiency, information retrieval opportunities, low cognitive effort, monitoring and tracking features.

Some concerns were reported as well, including lack of confidentiality, accuracy and reliability of the content of these apps, as well as the presence of external control through the network connection that apps require. These concerns were primarily related to the consequences of giving out personal information (Dennison, Morrison, Conway, & Yardley, 2013).

2.4 Usability Studies

2.4.1 Definition of usability.

The most common definition of usability arose when computer vendors first started to see users as more than an inconvenience; thus, the most popular term was "user friendly" systems. According to Nielsen (1994) this term is not really appropriate, for several reasons. First, it is unnecessarily anthropomorphic: users don't need machines to be friendly to them, they just need machines that will not make the things they try to do more difficult than necessary. And second, it suggests narrowing users' needs to a single dimension with systems that are more or less friendly. In reality, different users have different needs, and a system that is "friendly" to one may feel very tedious and not at all “friendly” to another. Because of these problems with the term "user friendly," “user interface” and other terms have become increasingly common in recent years (Nielsen, 1994, p. 7).

In his book entitled “Usability Engineering”, Neilsen (1994), states that:

> Usability is a narrow concern compared to the larger issue of system acceptability, which basically is the question of whether the system is good enough to satisfy all the needs and requirements of the users and other potential stakeholders, such as the users' clients and managers. The overall acceptability of a computer system is again a combination of its social acceptability and its practical acceptability (J. Nielsen, 1994, p. 24).

Further, usability was earlier defined as the aspects of human-computer interaction, particularly the user interface (Burns, Vicente, Christoffersen, & Pawlak, 1997).

In contrast, the International Organization for Standardization (ISO) defines usability as the capacity of the product to help the user to achieve goals effectively, efficiently and satisfactorily in a determined context (Abran, Khelifi, Suryn, & Seffah, 2003). This definition identifies 3 factors that should be considered when evaluating usability: user, which refers to the person who interacts with the product; goal, which refers to the intended outcome; and context of use, which includes users, tasks, equipment (hardware, software and materials), and the physical and social environments in which a product is used (Baber, Smith, Butler, Cross, & Hunter, 2009; Jokela, Iivari, Matero, & Karukka, 2003).

2.4.2 History of usability.

At the beginning of the 20th century, several methodologies had begun to shape what is known today as usability. In 1911, Taylor introduced the concepts of time and motion in "Principles of Scientific Management". In 1916, Frank and Gilbreth made work faster and easier by breaking it into smaller steps. This method was used during World War I when soldiers were shown how to assemble and disassemble weapons in the dark.

In1936 the word "Usability" appeared in an advertisement in "The Palm Beach Post", listed as one of the features of a new refrigerator.

In 1943, Chapanis, a lieutenant in the U.S. Army, stated that pilot error could be reduced by a more intuitive layout of airplane cockpits.

Along with the evolution of student learning and assessment, in 1967 Scriven published work on formative and summative evaluations in the educational literature, which would later be applied to usability evaluations. Similarly, in 1979 permanent labs at companies such as IBM

performed “Summative usability testing”, which became the first scientific publication with the usability word in its title: “The Commercial Impact of Usability in Interactive Systems” by Bennett (1979) is one such example.

Usability came into its own in 1980 when Ericson and Simon used the Think Aloud Method to publish “Verbal Reports as Data”, which would later be used as a usability test. The interest in focusing on usability was demonstrated in 1985 when Gould and Lewis studied the importance of giving early, continuous attention to users, measurements and iterative design.

2.4.3 Modern usability.

The birth of usability in modern times involves two representatives of this concept: Nielsen and Molich. In 2013, Norman published “The Design of Everyday Things”, the premise of which is that user error is really a problem of bad design. Nielsen and Molich made fast, cheap improvements to user interfaces and developed several usability methods.

Between 1994 and 2001, usability research focused on determining ideal sample sizes for usability studies, planning and conducting effective testing, establishing the effectiveness of usability testing, and comparing evaluation methods. It is at this time that usability became standardized under the International Standardization Organization model “ISO 9241-11”. This evolution shows the extent to which a product can be used to effectively achieve specific effectiveness (referring to achievement of task completion by user), efficiency (referring to on-time task completion) and satisfaction (responsive to user experience). This model allowed improvements to the user experience design.

After 2002, publications concentrated on comparisons of testing environments, such as lab vs. remote testing of web sites. Measuring usability was found to be expensive, and so new methods were developed such as large-scale testing to evaluate user experience.

This sort of testing has expanded to all types of information systems technology and continues to evolve. During the last decade, usability measurement has become increasingly qualitative (Tullis & Albert, 2008).

2.4.4 Attributes of usability.

Several attributes of usability have been identified. These have been grouped into models of usability. The following are the most representative, most commonly used and most influential models. According to the International Organization for Standardization (ISO), ISO 9241-11, usability has three attributes: effectiveness, efficiency and satisfaction. Jokela et al. (2003), stated that effectiveness relates to completion of tasks or when the users accomplish their goals; efficiency means the accuracy with which users achieve goals in a determined period of time; and satisfaction is the freedom of effort and positive attitude to use a product (Jokela et al., 2003).

According to Nielsen (1994), usability has 5 attributes: efficiency, satisfaction, learnability, memorability, and errors. He explains that efficiency when the completion of a task maintains a steady level of performance within a period of time. Also, he defines satisfaction as freedom from discomfort, and positive attitudes towards product use; learnability as the ease of learning a system, which facilitates the user's rapid completion of the work; memorability as how easy a system is to remember, allowing the casual user to return to the system after a period of inactivity without having to learn everything all over again; fewer errors when a system is only permitted a low error rate, which indicates the users make few errors using the system and user errors are easily recovered from (Nielsen, 1994).

The "People at the Center of Mobile Application Development" (PACMAD) model has been studied in mobile application usability and describes 2 additional usability attributes to the

model described above by Nielsen (1994): effectiveness and cognitive load. Effectiveness is defined as the user's ability to complete the task and cognitive load refers to the fact that a user should not have to put too much effort into using a system. What is unique in this model is that it depicts three factors affecting a mobile application's usability: user, task and context of use as illustrated in Figure 2.1 (Harrison, Flood, & Duce, 2013).

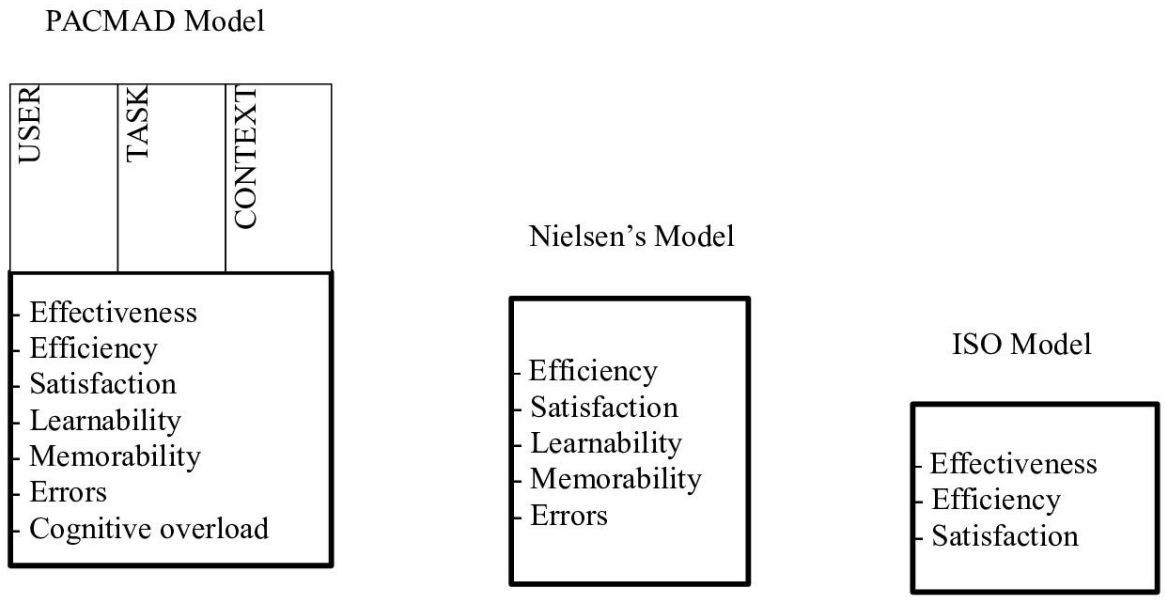


Figure 2.1 Usability models

2.4.5 Approaches to usability.

The first approach to usability arose in a digital map library. The rapid growth of web information technology made it necessary to provide electronic materials, which have been replacing traditional library services in academia. Usability was defined in this context as the extent to which a digital library is easy to use, efficient in performing tasks and judged satisfactory by users. Evaluation measures have determined the usability of digital libraries from the user's perspective (Aitta, Kaleva, & Kortelainen, 2008; Joo & Yeon, 2011).

To better determine which aspects related to usability should be measured, and how to measure them, digital libraries have also relied on measurement system interaction. According to Tsakonas and Papatheodorou (2006), usability and usefulness are part of systems interaction. Another application of usability studies has been used in online learning programs. For example, one study showed that one of the obstacles for not using online learning programs was the fact that there was a mismatch between the learner's culture and the culture of the learning system in which the systems are placed. These results in learning situations are ill-formed, and thus inefficient, with subsequent rejection either of the teacher or the learner. This study explains that usability should be understood as "situated". Also, it supports the fact that usability in these contexts needs to be evaluated in order to determine how a user uses a tool in a given context, and what factors influence the relationship between the user, the tool, and the community to which they belong. Because using and learning to use tools will eventually be deeply rooted in users' cultures, usability must take into account the users' social and material environments (Ghaoui, 2003).

Since PDAs came into common use studies conducted in the field of education, have provided information about the importance of looking at usability issues. One recommendation they offered is that future efforts should concentrate on design, which should also take the evolution of use over time into account, as well as the unpredictability of how devices might be used in different educational contexts. A second recommendation concerns the importance of tracking over a long period of time from the users' initial learning phase to a state of relative experience with the technology (Rahmati & Zhong, 2013). It is necessary to measure usability in education with the aim to improve access, explore the potential for changes in teaching and learning, while reaching alignment with institutional purposes (Kukulska-Hulme, 2007).

The use of mobile internet presented several difficulties related to use, flexibility, and robustness, all leading to poor user experience. Thus, researchers in technology design foresaw the need to evaluate and measure aspects of user experience and the results of their work are impressive. By identifying and adjusting interfaces through iterative usability assessment, they demonstrated improvement in user performance and increased user satisfaction (Buchanan, et al., 2001).

2.4.6 Usability of mobile phone applications.

Mobile devices like smartphones and tablets have posed important challenges to usability models. According to Zhang et al. (2005), several issues are noteworthy, including mobile context, connectivity, small screen size, display resolution variations, power, and limited processing capability and data entry modes. They recommend broadly examining the context in which a particular application is designed instead of looking at the mobility aspect (Bardram, 2009).

In terms of medical applications, researchers such as Arellano et al. (2005) have developed a model to test usability in mobile medical applications. The testing model includes aspects such as data, layout, feedback, and interface interaction. They add simplicity (relevant information is highlighted and function options are easy to understand), naturalness (workflows match the clinician's practice, and are intuitive and easy to learn), consistency (graphic design and terminology should be consistent across screens), forgiveness and feedback (when the user makes a mistake, the app should give the opportunity to recover promptly, and feedback helps give users information about actions to take or actions they have taken), effective use of language (uses the most common words), efficient interactions (an app should minimize the steps required to complete a task, such as shortcuts, navigation methods using scrolling and switching

between typing and tapping), effective information presentation (information on screen has enough white-space and large fonts to be easily read, colors help express meaning, for example red symbolizing medical urgency), preservation of context (the app should keep visual interruption to a minimum; dialogue boxes are an example of a visual interruption), and minimization of cognitive load (information required to perform a task should be kept separate in multiple screens; alerts are clear, concise and informative, and calculations should be performed by the app automatically), (Arellano et al., 2012).

Other studies have supported this view of cognitive load as an attribute in mobile applications and have also highlighted the importance of identifying the onset of cognitive load in a new application (Flood et al., 2012).

2.4.7 Usability evaluation methods.

Nielsen is one of the most influential authors in usability methods and usability studies. He states that the first condition of testing system usage is establishing clear goals and defining the study's purpose (Nielsen, 1994). He describes two types of usability evaluation method: testing and assessment. The two main types of usability testing are the inspection and user-experience methods. These methods are well-documented techniques that have been developed to test usability and detect user interface issues (Nielsen, 1994). Inspection methods such as technical walkthroughs, heuristic evaluations, and cognitive walkthroughs, use a quantitative approach. User experience methods include usability lab studies, ethnographic field studies, and remote usability studies among others, and use a qualitative approach (Aitta et al., 2008).

2.4.7.1 Usability testing methods (summative evaluation).

Usability can be tested quantitatively or qualitatively according to Nielsen (1994). The quantitative approach relates to inspection methods (technical walkthroughs, heuristic

evaluations and cognitive walkthroughs).

A technical walkthrough is an evaluation conducted by external testers who go through the whole system (all pages and options) and make sure that links, function buttons, and navigation features work properly.

A heuristic evaluation focuses on the system itself. It is usually performed by experts in the field to determine whether the system fulfills heuristic guidelines (these are not rules, but include issues such as user-control, human limitations, model integrity, accommodation, linguistic clarity, aesthetic integrity, simplicity, predictability, accuracy, flexibility, consistency, fulfillment, forgiveness, precision, user support, responsiveness and cultural propriety).

A cognitive walkthrough emphasizes task performance. It is based on system goals; users answer questions and experts go through the system to see if it will allow users to perform tasks (Nielson, Mack, & Elser, 1995; Wilson, 2014)

The qualitative approach relates to methods testing user experience (usability lab studies, ethnography field studies, remote usability studies, etc.). These methods are conducted with observations of real users performing real tasks (in which the think-aloud technique is the ideal method to analyze task performance). They can take place in laboratory or real settings. Some of the methods include participatory design, ethnographic field studies, focus groups, interviews, eye-tracking studies, usability benchmarking, moderate remote usability studies, and concept testing. Others include diary cameras, customer feedback, desirability studies, card sorting studies, A/B testing, true intent studies, and email surveys (Nielsen, 1994).

There is evidence that supports the use of these methods individually or combined; the most commonly used have been lab experiments, field studies and hands-on measurements (Nayebi, Desharnais, & Abran, 2012).

2.4.7.1.1 Examples of usability testing methods.

Studies have been conducted in a number of contexts employing some of these methods to evaluate the usability of new tools or technological systems. One such study focused on the usability and user experience of a game-based smartphone pain-assessment tool for adolescents with cancer. Researchers used qualitative usability testing to measure this tool's usability and feasibility, along with qualitative semi-structured, audio-taped interviews to explore user experience (Stinson et al., 2013).

Another study employed an eye-tracking method to measure the internet experience in participants from 18 to 31 years old (Djamasbi et al., 2008).

A preliminary study by the Canadian Task Force on Preventive Health Care (Cameron et al., 2014), employed formal testing to identify the most common issues and user experience in the context of the design of their website; they used methods such as the think-aloud protocol combined with follow-up interviews.

In addition, questionnaires were used to provide data on the usability of a web-based research tool designed to support decision-making in patients with rheumatoid arthritis being treated with methotrexate. These questionnaires were intended to inform the patient about the potential benefits and harms of various treatment options. The researchers also used the think-aloud protocol following responses questionnaires and highlighted the importance of using formative evaluation methods (Li et al., 2013).

Another study involved individuals with schizophrenia or schizoaffective disorder. This study aimed to examine the subjects' current use of mobile devices and their interest in mHealth services. Laboratory-based testing was conducted using the think-aloud method (Ben-Zeev et al., 2013).

Questionnaires have been the most common evaluation method found in the literature, followed by interviews, logging, and think-aloud methods. Usability evaluations have been most commonly applied to health conditions such as dementia and autism. Other conditions where usability evaluations have been applied include blindness, deafness, cardiac problems, dysarthria, Parkinson's disease, skin cancer, trauma care, and pain management, as well as recording sleep and sleep disorders, such as insomnia and apnea (Zapata et al., 2015).

2.4.7.2 Usability assessment methods (formative evaluation).

Undoubtedly, testing is the cornerstone of usability practice. However, there are alternatives for evaluating usability, such as observation, questionnaires and interviews, focus groups, logging actual use, and user feedback.

Logging actual use allows automatic data collection about how actual users use the system in their life and work; this method can also be combined with others to support findings or guide the evaluation process. This method is very helpful when future versions of the systems are planned, as it allows data on system errors to be collected. Although logging use raises certain concerns related to privacy of the user's interaction with the system, a system that offers the option of disabling the logging might be a viable response to such concerns. The major advantage of logging compared with most other usability methods is that it does not interfere with users in any way. Basically, users can ignore the log and use the system in the way they would if it were not being recorded (Nielsen, 1994).

Feedback is another option for assessing usability, and it has advantages and disadvantages. One benefit is the fact that feedback comes from the user, who is in a position to provide a great deal of valuable information. Furthermore, feedback can be easily collected using multiple methods; it can even be collected through the system being tested through the creation

of special features. However, feedback is usually initiated by unsatisfied users and thus might not be representative of all users' opinions. Still, it is essential to be responsive to that feedback. If users do not receive an appropriate response, they stop giving feedback, and this valuable source of information is lost (Nielsen, 1994).

Inspection methods have been reported to be the most effective. However, evidence has shown that the best option is a combination of various techniques (Nielson et al., 1995; Wilson, 2014). It is important to know that each method has its pros and cons, and each will have implications in the number of participants required for that specific usability evaluation method. A summary of the usability methods according to Nielsen (1994) is illustrated in Table 2.1.

Table 2.1

Summary of Usability Methods

Method Name	Lifecycle Stage	Users Needed	Main Advantage	Main Disadvantage
Heuristic Evaluation	Early design, "inner cycle" of iterative design	None	Finds individual usability problems. Can address expert user issues.	Does not involve real users, so does not find "surprises" relating to their needs.
Performance Measures	Competitive analysis, final testing	At least 10	Hard numbers. Results easy to compare.	Does not find individual usability problems.
Thinking Aloud	Iterative design, formative evaluation	3-5	Pinpoints user misconceptions. Cheap test.	Unnatural for users. Hard for expert users to verbalize.
Observation	Task analysis, follow-up studies	3 or more	Ecological validity; reveals users' real tasks. Suggests functions and features.	Appointments hard to set up. No experimenter control.
Questionnaires	Task analysis, follow-up studies	At least 30	Finds subjective user preferences. Easy to repeat.	Pilot work needed (to prevent misunderstandings).
Interviews	Task analysis	5	Flexible, in-depth attitude and experience probing.	Time consuming. Hard to analyze and compare.
Focus groups	Task analysis, user involvement	6-9 per group	Spontaneous reactions and group dynamics.	Hard to analyze. Low validity.
Logging actual Use	Final testing, follow-up studies	At least 20	Finds highly used (or unused) features. Can run continuously.	Analysis programs needed for huge mass of data. Violation of users' privacy.
User feedback	Follow-up studies	Hundreds	Tracks changes in user requirements and views.	Special organization needed to handle replies.

2.5 Gaps in the Literature

According to this review, the gaps in the literature were classified in regard to the present study in Table 2.2.

Table 2.2

Gaps in the Literature

Aspects of the Literature Review related to this Study	Gaps
Mobile Learning	• Studies in family medicine and emergency medicine that address information needs by medical specialty (Chang et al., 2012). • Studies at the postgraduate medical training level (Reese Bomhold, 2013).
Mobile Applications	• Studies on mobile applications to improve performance in high-stakes examinations (only one study found that mobile app use could help improve scores in cardiac arrest simulation testing: (Low et al., 2011)). There is insufficient evidence on the design, use and implementation of mobile apps to prepare for testing or high-stakes examinations. • Mobiles apps for reflection or that included an instrument to encourage reflection were not found. • Studies on the role of mobile applications in medicine. Further studies are needed to better understand how to use these systems (Ozdalga, Ozdalga, & Ahuja, 2012). • Studies on the impact and benefits of mobile applications in patient-care, families, physicians, and students (Ozdalga et al., 2012).
Usability Studies	• Studies on user experience in the context of mobile applications • Studies of mobile applications using combined evaluation methods • Studies on formative evaluation methods in the context of patient care • Studies with higher numbers of participants • Studies conducted over longer periods of time

2.6 Summary

The need to use technology to support learning has been seen in education due to difficulties accessing conventional learning or information delivery methods. Therefore technology has been increasingly used in medical education to help meet the need to support learning at all times, allowing management of greater amounts of information and updating of medical knowledge.

With advances in technology, more benefits have been seen during the transition from e-learning to m-learning. For example, uses of mobile apps have spread in the fields of education, communication, research, general health, and patient care.

In spite of the potential barriers, mobile devices have proved promising tools to aid physicians in clinical decision-making, providing rapid access to information. Mobile apps have been used to fulfill the needs of healthy people for patient care monitoring, medical applications, as decision making aids for patients, in the context of symptom-rating applications, and in many other medical contexts as well.

However, it is important to remember that mobile technology is still an emerging, though rapidly developing area. The literature has a tendency to view any device's mobility as inherently beneficial without clear evidence demonstrating how, why or in what circumstances this mobility provides value.

What is required is a more evidence-based approach to the evaluation of mobile technologies to determine whether, and when, they are useful in supporting postgraduate medical training, preparing for high-stakes exams, improving clinical practice, and ultimately improving health care delivery.

CHAPTER 3

Methodology

This section will first explain the origin, design and development of the IAM mobile application, which was designed based on the concept of spaced learning framework (as described in Chapter 2), to deliver content at intervals. Second, this section will describe the study design and the rationale for selecting a qualitative research methodology and the procedures for data collection and data analysis.

3.1 The IAM App Design Phase

3.1.1 App name.

IAM stands for "Information Assessment Method". This tool has been developed, validated and implemented by two physicians and researchers at McGill University, Dr. Roland Grad and Dr. Pierre Pluye. These researchers have studied the value of clinical information obtained from electronic knowledge resources by asking health professionals to rate that information using the IAM questionnaire (Bindiganavile, Pluye, & Grad, 2013).

Their early work was based on evidence that retrieving information from electronic resources can have a positive impact on practice by providing support for clinical decisions (Pluye, Grad, Dunikowski, & Stephenson, 2005).

One advantage of the IAM questionnaire is that it allows physicians to earn continuing education (CE) credits by submitting completed questionnaires concerning clinical information they have read. The IAM questionnaire promotes reflective learning and Information Assessment Method-based continuing education programs are accredited as individual reflective e-learning activities for physicians and pharmacists in Canada (Pluye et al., 2005). By 2014, it was estimated that over 10,000 Canadian physicians and pharmacists had used the Information

Assessment Method in CE programs after receiving email alerts of clinical information, such as the daily "POEM": Patient Oriented Evidence that matters (R. Grad et al., 2008).

Grad and Pluye realized that the IAM questionnaire could offer an educational opportunity through an app to support family medicine residents preparing for their board examination. They also thought that incorporating the IAM questionnaire in the App could potentially enhance reflective learning. The choice of the acronym was inspired from Descartes' quote: (Descartes, 1964): "I think, therefore I am".

3.1.2 The logo.

To prepare the App for its use by family medicine residents, some adjustments and modifications were made with the assistance of a designer to improve the aesthetics of the App. Given the clearly established purpose of helping clinicians to better manage a vast amount of clinical information, the logo that best represented this objective in the context of CE was a funnel. The funnel represents the filtering of information in a quick, efficient, and precise manner. The "Object oriented filtering" is a framework use in technology. Frameworks are packages needed by operating systems to allow a system (such as an app) to display files of information with functions. In the case of the Object oriented filtering framework, its design permitted to present multimedia files. In addition, this framework functions very much like the IAM App: it involves similar routing, editing, and synchronizing of clinical information (John & Milne, 1995). This is the reason why the funnel was chosen as the IAM App logo as illustrated in Figure 3.1.

3.1.3 The development of the App.

App design work began in 2012 for a mobile medical application competition at McGill. The IAM App was a finalist in this competition. Further interest in developing this

mobile tool arose following this event, and development began in 2013. It was thought the IAM App could support health professionals in meeting their need for lifelong learning through the delivery of brief clinical information on a mobile platform, through dedicated channels that would provide an alternative to email. Therefore, attempts were made to move the App forward and to go beyond the established niche of the IAM questionnaire in the domain of email alerts.

The idea that IAM questionnaire could also meet the educational needs of residents was developed subsequently. The research team thus decided to make an in-house application to support family medicine residents who must prepare for their board certification examination. The College of Family Physicians of Canada announced and published 99 priority topics, which constituted the scaffold for the content that was to be incorporated into the first channel on the App.

Following a needs assessment of what was required to build this App, the online prototype was structured and built. The prototype consisted of the login screen, the screen listing the 99 priority topics, the key features screen, and the clinical information screen.

The IAM App was made available for mobile devices that run iOS 5.0 + and Android (2.3 +). The mobile platforms require a software engine to render the web browsers; the IAM App uses an engine called “WebKit”, which is currently most commonly used. However, to target that browser, mobile applications require an injection of data. This is made possible using a language the browser can understand such as, the “Hyper Text Markup Language” (HTML). This is a standard language for the creation of web pages. The process of injection of data and use of a standardized language results in a display of data; however, this data display is only an imitation of how the data actually appears in an application. This App uses HTLM5 and has the

advantage of being very easy to program and also provides local storage, which means that data can be stored off the web server.

The IAM App runs on iPad and Android tablets supported by the open source framework, Cordova. The choice of this framework over the only other alternative-"PhoneGap"- was because of the advantages Cordova offers. For instance, Cordova is a "Cross-Platform Development tool", meaning that the developer develops an App for one platform and the same app can be re-compiled for the other platform. This aspect permits to create beautiful user interfaces. The competing way to develop these apps is using a "Native-Platform Development tool". In this case, for example iOS develops an app for iPhone and separately an Android developer, develops an app for Android. The latter development tool has the disadvantage that each developing environment has to be learned, and each one uses a different computer language thus, increasing development costs. In contrast, Cordova allows the IAM App to run on iOS, Android, Blackberry, and Windows mobile.

During the development process, a need to build multiple channels was anticipated. This step was carried out with the aim of using the same app as a platform for future projects. The framework used to design the App fell within a constructivist paradigm which allows the system to take into account what the learner knows.

Figure 3.1 IAM logo

3.1.4 Features and content of the App.

Five features were designed and developed within the IAM App. This section describes each of the features in terms of concept, development, rationale, location on the screen, and function.

3.1.4.1 Channels and log in.

After downloading the App the first page the user sees is the “Channels page”, in which the option to install a channel is available as presented in Figure 3.2.

The IAM mobile application (IAM app), was designed to present a number of channels of medical information. The current version of the product supports the 99 Priority Topics

recognized by the College of Family Physicians of Canada, in the training and competence evaluation of family medicine residents.

The content is supported on two channels, one dedicated to McGill University residents and the other for McMaster University, the two sites for implementing this project. The study at McMaster site was conducted independently and that data are not used in this thesis.

Figure 3.2 Channels installation page

Once the channel option is installed, the next page is the “Log in” page. It provides the channels available on the top and the log in blank boxes below. The McGill channel is labeled as “99 Weeks” as illustrated in Figure 3.3.

Once the channel is selected by tapping on it, the next step is to type a username and password. The user must subscribe to at least one channel. Thereafter, the “Channels” tab is available at the bottom of the App screen as presented in Figure 3.4. This tab is used to switch from one channel to another or to change user name and password. This can only be done with a network connection.

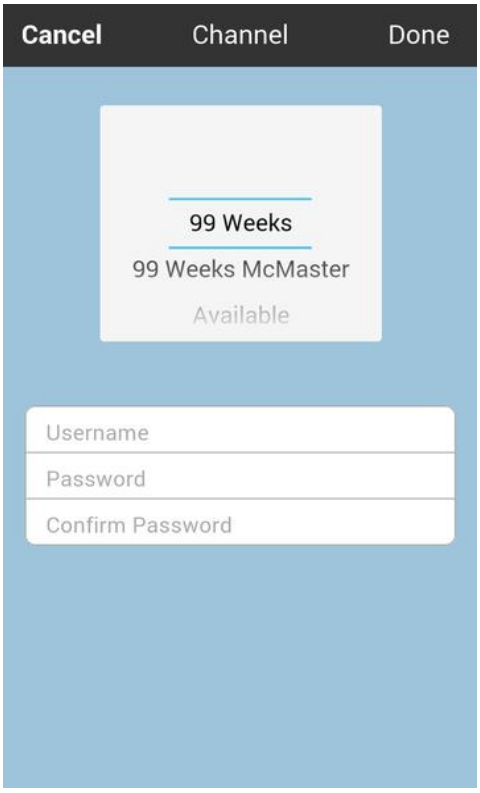


Figure 3.3 Log in page

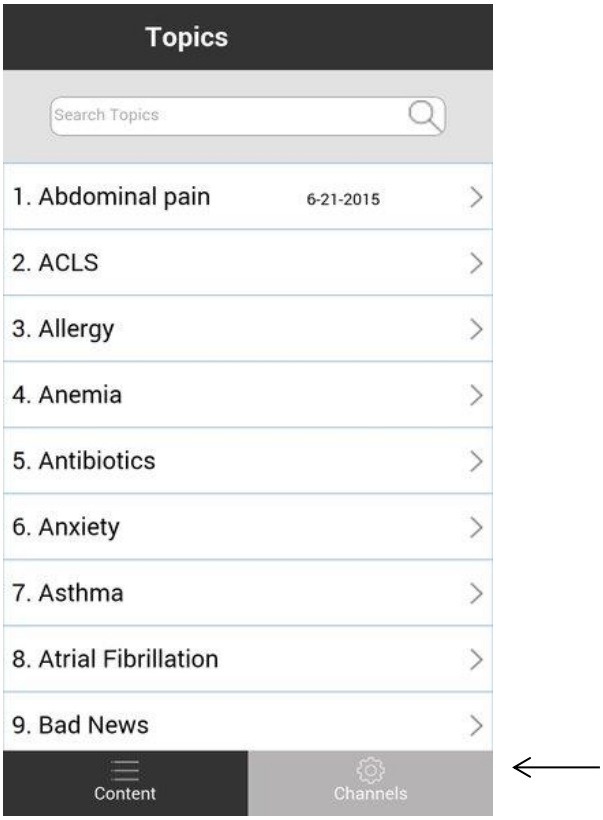


Figure 3.4 Channels tab

3.1.4.2 Presentation of information.

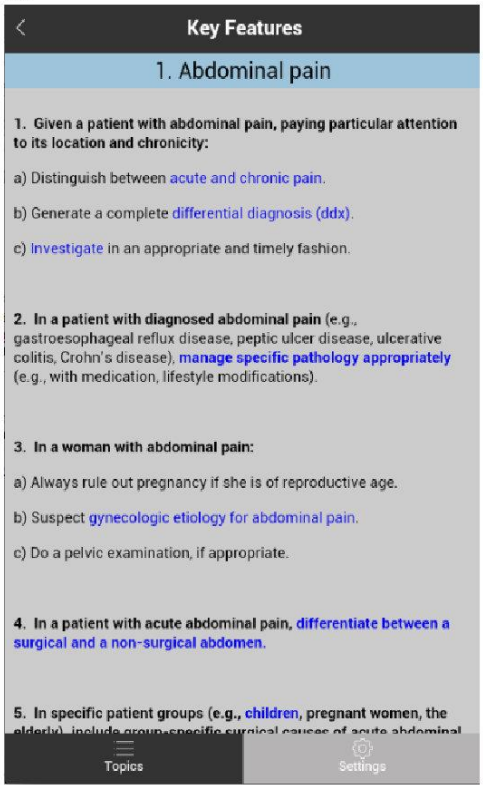
After login, the App presents information at multiple levels in the following order: "Topics", "Key Features", "Clinical Information" presented in Figure 3.5 (some have hyperlinks to access information from external websites) and "Earn Credits" as presented in Figure 3.6. The rationale was to provide a book format in which the user could find and search for information, and could read about the topic as much as he/she desired.

The Topics level presents the list of the 99 priority topics established by the College of Family Physicians of Canada. The Topics level or page is listed in a scrollable alphabetical table, which also accommodates a text search feature at the top of the screen.

a.


Topics
Search Topics
1. Abdominal pain 12-19-2013
10. Behavioural Problems 02-26-2014
11. Breast Lump 03-05-2014
12. Cancer 03-12-2014
13. Chest Pain 03-19-2014
14. Chronic Disease 03-26-2014
15. Chronic Obstructive Pulmon 04-02-2014
16. Contraception 04-09-2014
17. Cough 04-16-2014
18. Counselling 04-23-2014
19. Crisis 04-30-2014
2. ACLS 11-13-2013
Topics
Settings

b.


Key Features
1. Abdominal pain
1. Given a patient with abdominal pain, paying particular attention to its location and chronicity:
a) Distinguish between acute and chronic pain.
b) Generate a complete differential diagnosis (ddx).
c) Investigate in an appropriate and timely fashion.
2. In a patient with diagnosed abdominal pain (e.g., gastroesophageal reflux disease, peptic ulcer disease, ulcerative colitis, Crohn's disease), manage specific pathology appropriately (e.g., with medication, lifestyle modifications).
3. In a woman with abdominal pain:
a) Always rule out pregnancy if she is of reproductive age.
b) Suspect gynecologic etiology for abdominal pain.
c) Do a pelvic examination, if appropriate.
4. In a patient with acute abdominal pain, differentiate between a surgical and a non-surgical abdomen.
5. In specific patient groups (e.g., children, pregnant women, the
Topics
Settings

c.

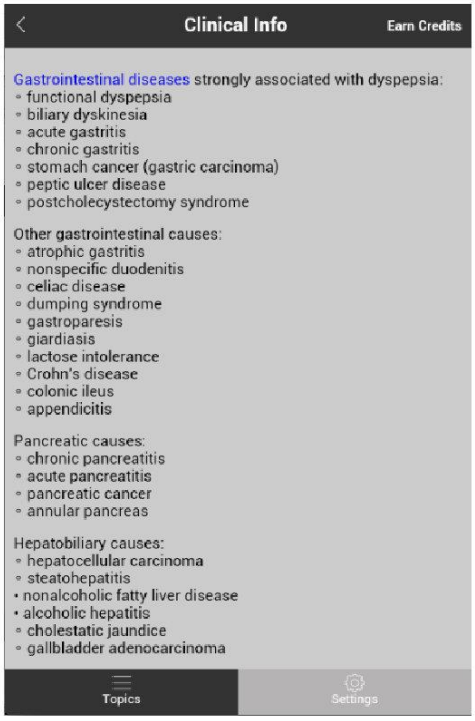
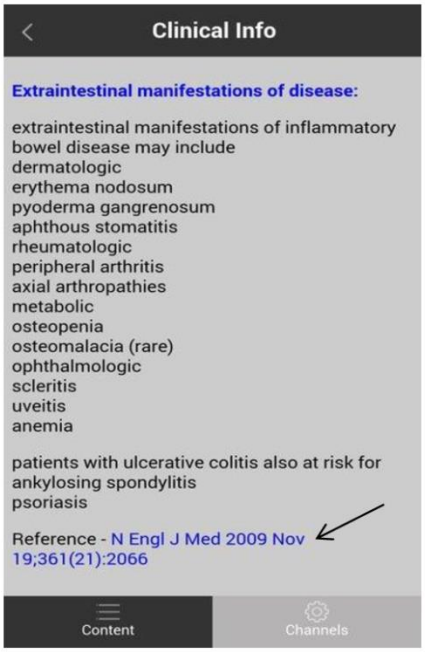
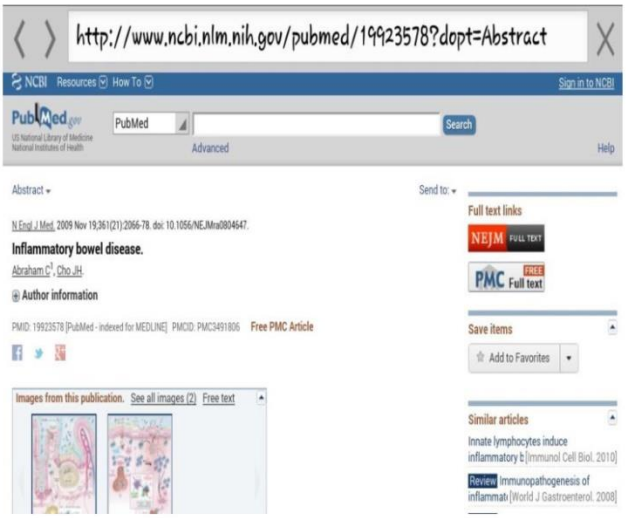

Clinical Info
Earn Credits
Gastrointestinal diseases strongly associated with dyspepsia:
◦ functional dyspepsia
◦ biliary dyskinesia
◦ acute gastritis
◦ chronic gastritis
◦ stomach cancer (gastric carcinoma)
◦ peptic ulcer disease
◦ postcholecystectomy syndrome
Other gastrointestinal causes:
◦ atrophic gastritis
◦ nonspecific duodenitis
◦ celiac disease
◦ dumping syndrome
◦ gastroparesis
◦ giardiasis
◦ lactose intolerance
◦ Crohn's disease
◦ colonic ileus
◦ appendicitis
Pancreatic causes:
◦ chronic pancreatitis
◦ acute pancreatitis
◦ pancreatic cancer
◦ annular pancreas
Hepatobiliary causes:
◦ hepatocellular carcinoma
◦ steatohepatitis
• nonalcoholic fatty liver disease
• alcoholic hepatitis
◦ cholestatic jaundice
◦ gallbladder adenocarcinoma
Topics
Settings

Figure 3.5 Levels of information 1. Topics: (a); Key features (b); Clinical information (c)

a.



b.



c.

Figure 3.6 Levels of information 2 (hyperlink and earn credits pages). In image (a) the arrow in the last line indicates an example of an external website. Image (b) shows the corresponding information to that external web site. Earn credits page (c).

Topics are ordered “logically” so that both digits and text appear where most people would expect them to appear (e.g., 1, 2, 3, 3a, 4a, 4b, 10, 11a, etc.). By tapping on any topic or on the next page arrow, the user is able to access the next level: “Key Features”.

The Key Features page presents a list of objectives established by the CFPC for each topic. The key features are shown in a scrollable web view. Links allow for accessing clinical information for selected key features. These links are segments of information highlighted in blue, as presented in Figure 3.7. Tapping a link brings the user to the next level, the “Clinical Info” page.

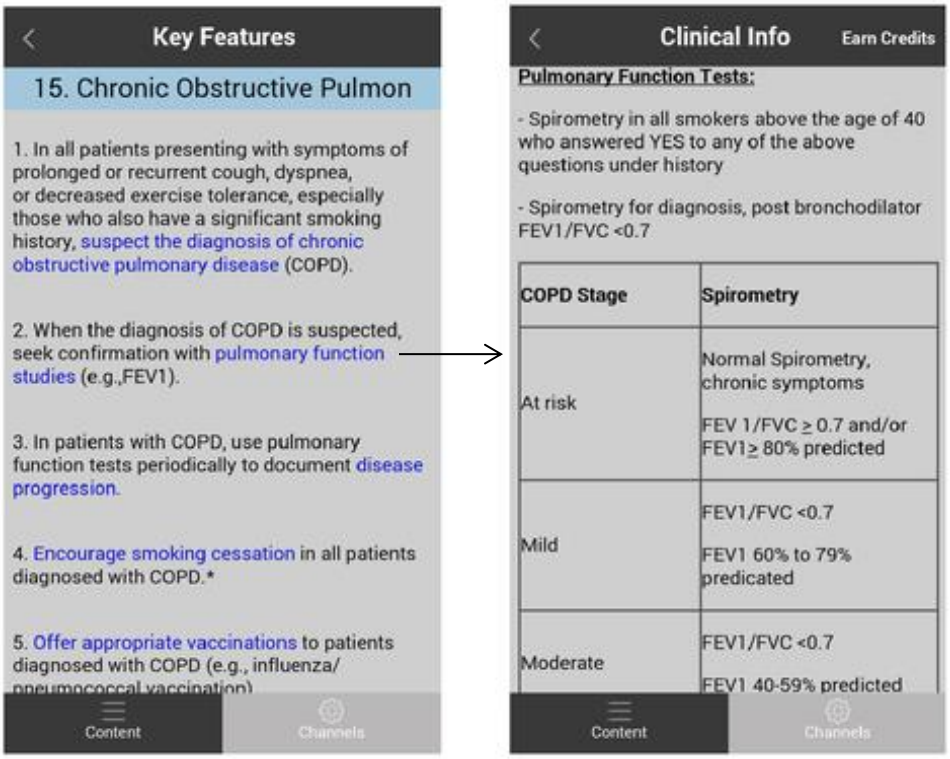


Figure 3.7 Key features with links to clinical information. By tapping on the key feature 15.2 “pulmonary function studies” (image on the left), the corresponding content opens (image on the right).

The content of the clinical information page is uploaded in a scrollable way. Some pages of clinical information contain additional information in the form of articles and synopses with links to external web pages and often the App will open these articles and synopses in a browser. The user can go back to the Topics page and/or key features pages by clicking the back arrow located at the top left of the screen, as presented in Figure 3.8.

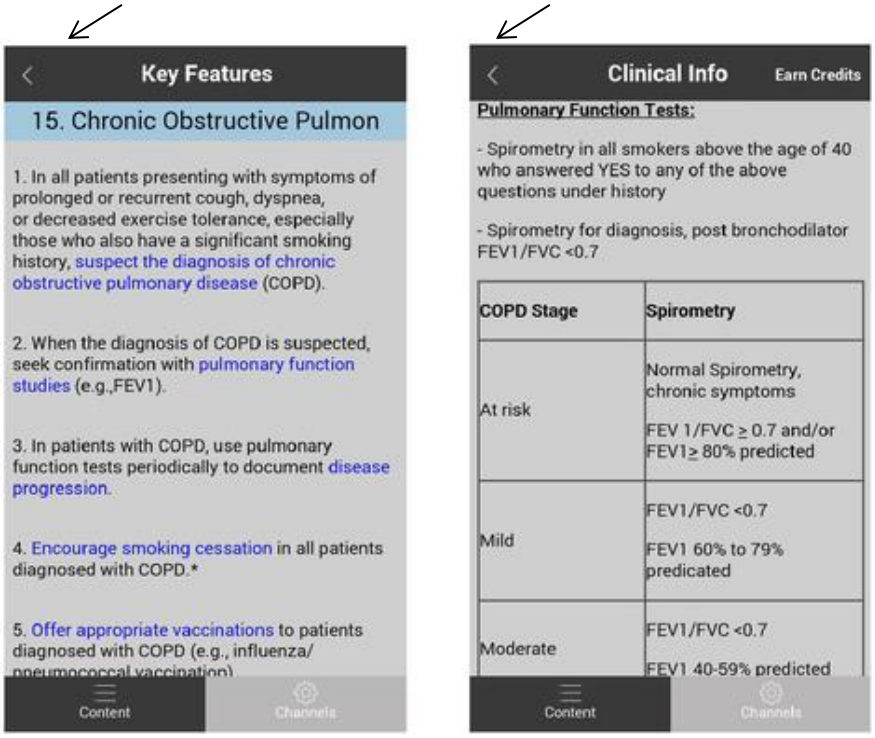


Figure 3.8 Back arrow

The last feature is the "Earn Credits" page. In the following section, I will describe how the page "Earn Credits" links the IAM questionnaire to specific pages of clinical information.

3.1.4.3 The IAM questionnaire.

The Information Assessment Method (IAM) questionnaire consists of questions and a free-text box for comments. The questions use a 'check all that apply' response format (see Appendix J). The purpose of this questionnaire is two-fold: a) to stimulate reflective self-learning (a process which residents will need in their future work as physicians), and b) to collect feedback on the clinical information presented to participants.

There are three ways the Information Assessment Method (IAM) questionnaire can be accessed in the App. First, using the "Earn Credits" button located at the top right of Clinical Info pages. Second, from start up, the App prompts the user to complete a number of questionnaires (or surveys). If the user answers "Yes", they are able to select from a list of topics previously accessed, and complete one specific Clinical Info questionnaire for that topic. In other words, each page of clinical information is associated with a specific key feature and will prompt a questionnaire. The user can refuse to complete any questionnaire by clicking on "No", and can return to it later. The questionnaire prompt appears the second and all subsequent times the user accesses a specific Clinical Info page. The questionnaires were set up to function in this manner, because it was assumed that the first time a user views a Clinical Info, the user is simply responding to the highlighted "Topic of the week", using the App for guided study. However, the second and subsequent times the clinical information is viewed, it may be an indication that the user is returning to the information for reasons related to his or her needs and or practice. The third way the IAM questionnaire can be seen in the App is when the user clicks on the "Reminders" tab, located at the top left of the Topics page, as presented in Figure 3.9. This tab is available only when the user visits a Clinical Info page more than once without completing a questionnaire for that page (or when a user has started but has not completed a questionnaire). In these cases, the questionnaires are added in the Reminders List.

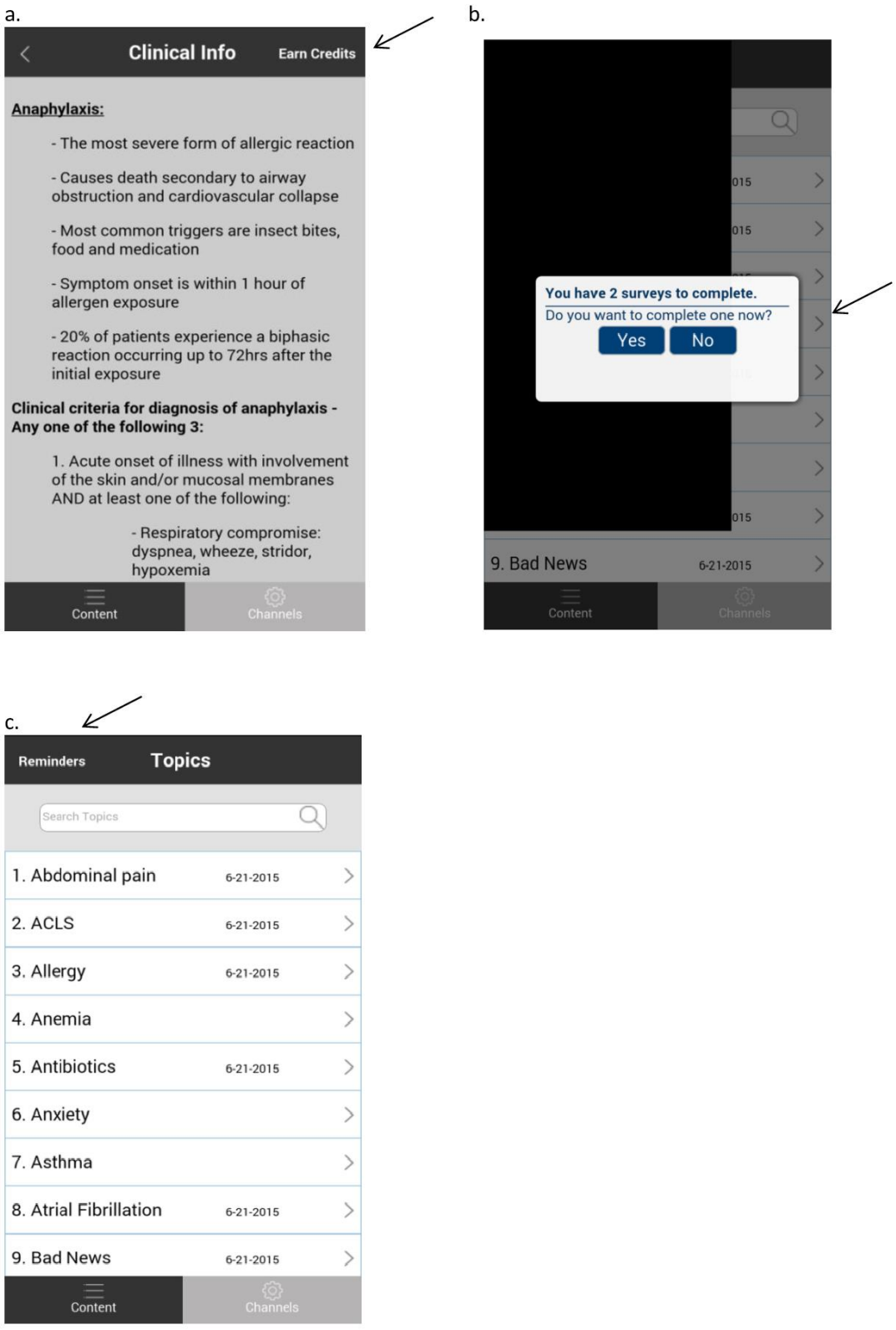


Figure 3.9 Access to the IAM questionnaire. Earns credit tab in clinical information pages (a); window that prompts when the App is opened (b); reminders tab in the topics page (c).

The questionnaire has multiple pages and these are dynamically enabled in response to the user's answers. The user simply clicks on a row in the list to select a response and clicks it again if they wish to uncheck it. In some cases there are sub-questions, which are hidden until the main question has been answered. This page is scrollable, and has "Next" and "Previous" buttons at the bottom of the page to facilitate navigation as illustrated in Figure 3.10. However, the user must respond to a question in order to be able to proceed to the next. If the questionnaire cannot be completed all at once, the answers will be saved and restored the next time the user enters the questionnaire for that particular Clinical Info.

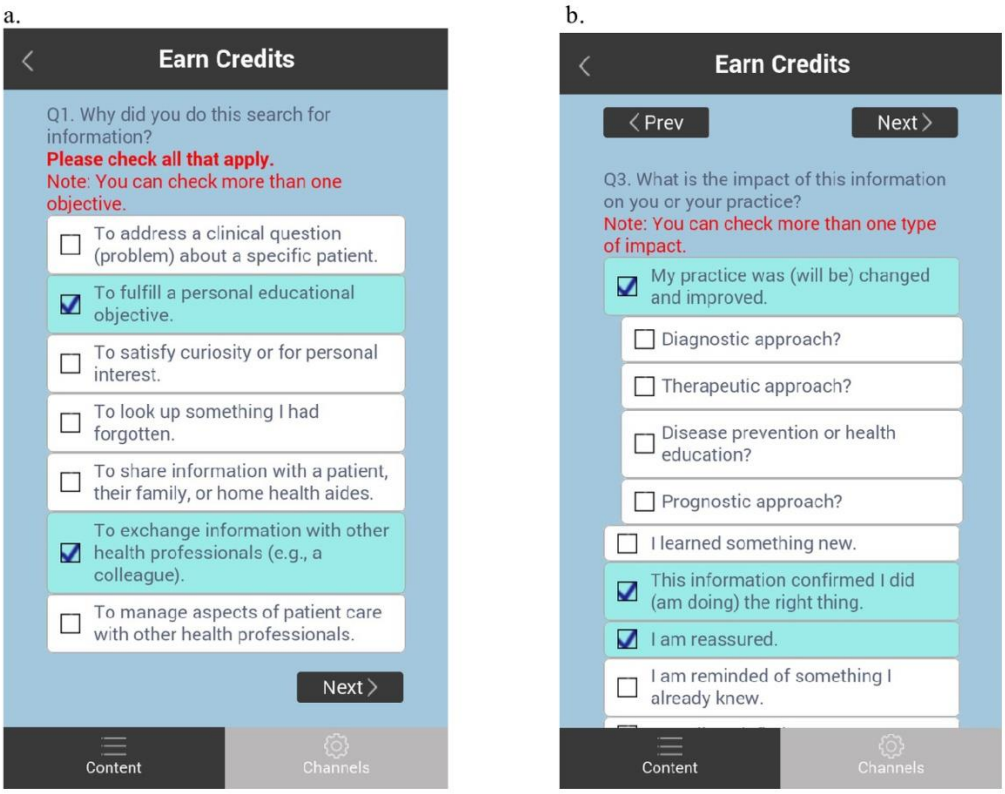


Figure 3.10 IAM questionnaire. First question with answer options (a) and sub-questions example (b).

At the end of the questionnaire the user will find a box where they can provide comments on the Clinical Info being assessed or on the questionnaire itself. It is not mandatory to leave comments in order to submit the questionnaire.

The final step is to submit the questionnaire by clicking the "Submit" button. Once the questionnaire has been successfully submitted it is not possible to return to it. If the user is offline, a thank you message for submitting the rating is displayed and the responses are recorded at the back end, the next time the user is online.

At this point, the system logs this event in a separate database. Only completed questionnaires are recorded in the system.

3.1.4.4 Clinical information content.

With regards to the informational content of each topic, initially, family medicine residents at McMaster University were invited to voluntarily choose one of the 99 topics and create a file containing the clinical information they considered essential to preparing for the board certification exam and responding to the objectives provided by the CFPC.

Subsequently, these clinical information files were made available to McGill residents through the App, progressively in 2 stages. The first stage involved the preparation and display of text content which included the following 5 steps. First, I revised the clinical content, references and their appropriateness according to the key features (objectives established by the CFPC). Second, I prepared the content by editing, formatting, and segmenting the information from the original word document, according to the key features. Third, I reorganized links previously created by the team in order to increase access to clinical content and match this content with key features. Fourth, I opened a new file in the back-end of the system of each segment or piece of information. Fifth, I linked the appropriate segment of clinical information to

the corresponding word or words from the Key Features page. This was done by using the Text Editor toolbox that permitted me to link and highlight a phrase or word (s) belonging to an existing file of clinical information. The above steps were repeated for each topic. This process provided the user with the option to click on a blue link and be directed to the respective information. In this way each topic was associated with a number of Key Features, as presented in Figure 3.11.

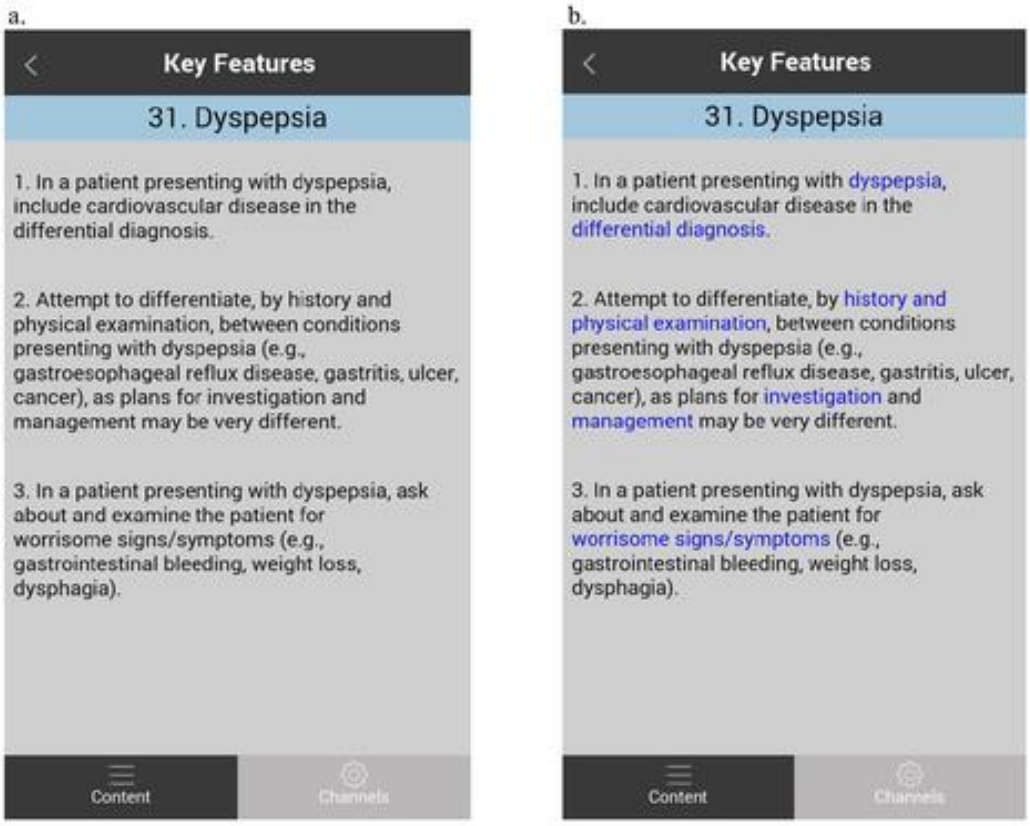


Figure 3.11 Assignment of content to key features. Previous view of key features with no associated content (a) and view of key features after formatting, editing, selecting and linking of content according to key features (b).

The second stage consisted of designing and uploading information in tabular format provided in the initial files as images. This step involved revising content, selecting the most

relevant tables, and editing and redesigning tables in a word document. Afterwards, I classified them according to key features and assigned the tables to the corresponding key features following the same procedures previously described. In this way, the App was updated with this content and fully populated by the end of December 2014. Clinical information in the App can be accessed online and offline. However, a network connection is required to access information from external hyperlinks.

3.1.4.5 Push notifications.

The Topic of the Week is advertised by means of Push Notifications, which must be enabled on the device. For iOS devices, instructions can be found at the following link http://ipod.about.com/od/iphonehowtos/ht/enable-push-notifications.htm. Study participants were asked to enable the iOS style for notifications called "Alerts". This was prompted by the assertion that when notifications are related to ongoing tasks or activities, user response is quicker (Czerwinski, Cutrell, & Horvitz, 2000). Participant residents were alerted on one topic per week on Wednesdays at 1 pm.

Push notifications are displayed on the device screen as "Topic of the Week", presented in Figure 3.12. The topic, date, and time of the push notifications are selected at the back-end of the system. If the user does not open the topic, the topic of the week remains highlighted in the "Topics" page as a reminder. A date is presented to illustrate when each topic was last accessed by the user, and to indicate topics that have never been accessed.

Android users must go into Settings / Sounds / Notifications and enable the notifications function. If notifications are not being successfully delivered to the Android device, this App can be used to fix the problem:

https://play.google.com/store/apps/details?id=com.andqlimax.pushfixer&hl=en

3.1.5 Functioning of the App.

The mobile App is available for iPhone (iOS 6.0 +) and Android (2.3 +). It is principally a phone App. Tablets are not specifically supported but the App will run on iPad devices in iPhone compatibility mode, and it has been tested on some Android tablets. A data account and an occasional network connection while the App is in use are required to log usage activity and to update the App with newly published clinical information, as well as to edit existing content, to change the password and to upload questionnaire responses. Apart from this, the App is fully functional offline.

The App runs on a particular device due to a relational database browser called "Structure Query Lite" (SQLite). SQLite permits browsing objects and structures. In this App, the information is developed on the server and stored on a relational database on the server called "My Structure Query Language" (MySQL).

A network is required by the App in order to synchronize the server with the device. This means that the device operates independently and synchronizes (that is, completes the updating process) in an opportunistic way. This way facilitates that the user does not notice when this process occurs.

The push notifications use a cross platform supported by plug-ins (these complement the software by adding features to the application. An App must support plug-ins to enable customization). Push notifications use two different processes: the Apple push notification is distinct from the Google push notification in that it uses different servers and different App programming interfaces.

The IAM App is maintained on two levels. First, the App is built on the "Linux, Apache, MySQL, and PHP (personal home page, server-side scripting language)" (LAMP) server. LAMP

is a powerful open technology stack preferable to Microsoft. The company that provides the service consistently maintains the server. They are responsible for applying operating system patches, detecting the latest operating system to defeat new viruses, etc. Second, as new versions of Cordova and iPhone OS are released, they update the App and reload them on the new versions.

In addition, when modifications or repairs are needed for the sake of operability, devices must download the App to refresh and synchronize these changes. Topics and Key Features are maintained on the server separately, making it possible to modify or update content at any time.

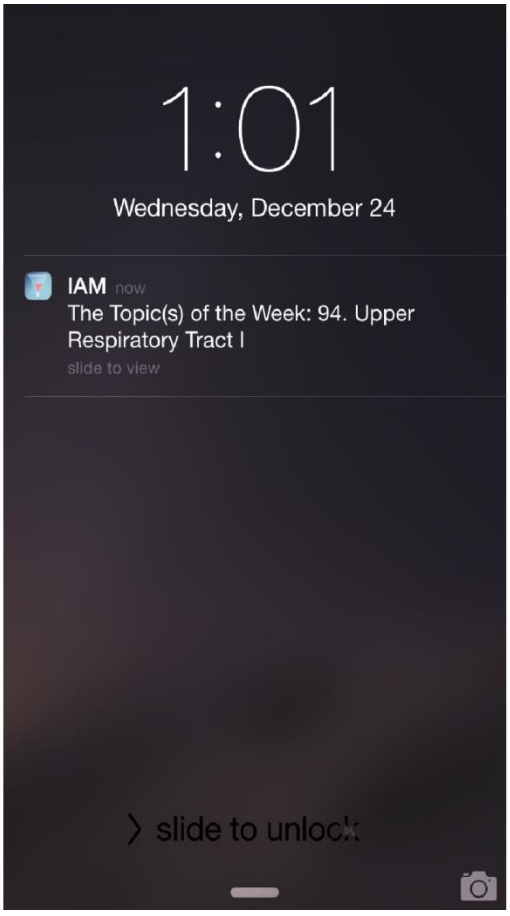


Figure 3.12 Push notification. Example of a push notification on the iPhone 6

3.2 Study Methodology

3.2.1 Research method.

This study used a qualitative descriptive method as it best supported the purpose, research questions, and the researcher's role in the study.

First, with regards to research questions, the literature supports the use of *"how"* or *"what"*, rather than "why" questions when the aim is to better understand what happens with regards to some specific event (Creswell, 2012; Patton, 2005). In this study we asked the following questions: "What is the usability of the IAM App among family medicine residents over a period of 6 months?" and "What is the role of the IAM App to prepare family medicine residents for the board certification exam?" These questions allowed us to explore participants' experiences with barriers that impeded App usage, and benefits of App use that would support its use and future implementation. Also, it allowed us to discover current needs in the context of residents' learning strategies and the way the App is used to prepare for the examination.

Second, qualitative research recognizes the researcher's role as an active participant in the study (Merriam, 1998). In this study, I, the researcher, was the key instrument in data collection and in interpreting data findings (Creswell, 2007). Third, qualitative research has been the main option to conduct research in a variety of academic and professional fields such as sociology, anthropology, psychology, education, management, nursing, program evaluation and technology research. "In any of these fields, qualitative research represent an attractive and fruitful way of doing research" (Yin, 2010, p.6).

Additionally, qualitative research has recently gained acceptability and in some areas. For example, qualitative research has been employed with increasing regularity in the field of technology. In the context of our usability framework, as described by Nielsen 1994, quantitative

and qualitative methods are options when the purpose is assessing user experience (Nielsen, 1994). Nielsen has argued that quantitative methods should be used with caution because quantitative usability assessment studies are conducted using an instrument of measurement; thus observation of the user is indirect and results can often be misleading. Qualitative methods allow direct observation of the user, and thus allow researchers to identify behaviors and attitudes. This permits researchers to adjust the research protocol and increases the chances of achieving the study's initial goals. The selection of the ideal research method depends on the phase of the study and its goals as presented in Table 3.1. Given this conceptual framework, since our study intended to provide information about how to optimize future versions of the App, a qualitative methodology (a formative approach) was deemed as appropriate.

Table 3.1

Product Development Phase

	Phase		
	Strategize	Execute	Assess
Goal	Inspire, explore and choose new directions and opportunities	Inform and optimize designs in order to reduce risk and improve usability	Measure product performance against itself or its competition
Approach	Qualitative and Quantitative	Mainly Qualitative (formative)	Mainly Quantitative (summative)
Typical methods	Field studies, diary studies, surveys, data mining, or analytics	Card sorting, field studies, participatory design, paper prototype, and usability studies, desirability studies, customer emails	Usability benchmarking, online assessments, surveys, A/B

Note. Adapted from "When to use which user-experience research methods", by C. Rohrer, 2014, retrieved from http://www.nngroup.com/articles/which-ux-research-methods/

Another aspect influencing the decision to pursue different methods in the area of technological research is the need to impact social disciplines. One explanation for this is that using conventional research methodologies does not allow for the integration of theories with user studies. Qualitative research can fill this gap, providing a better assessment of interactions between the user and technology systems. This builds a better understanding of underlying needs and allows improved recommendations in the context of service provision (Wilson, 2000). One example can be found in a study of online banking system usage in Thailand. This research studied factors encouraging and discouraging customers from accepting online banking

(Rotchanakitumnuai & Speece, 2003). The researchers argued that a qualitative approach gave them a broader perspective to explore the perceptions and viewpoints in early stages of customer research. This resulted in the identification of phenomena, attitudes and influences through use of this modality (Healy & Perry, 2000).

Moreover, the tendency to use qualitative research rather than quantitative research methodology has grown in the field of research technology due to persistent dissatisfaction with the results of the traditional quantitative approach. It seems that qualitative studies help decrease this dissatisfaction; case studies are particularly effective (Benbasat, Goldstein, & Mead, 1987).

Evidence suggests that qualitative approach is the best means to contextualize and understand the present study's research questions; it fosters a better understanding of the participants' (residents') lived experiences and their understandings of how to use or not to use the App, as well as benefits and barriers that influence usage and the App's role in the context of preparing for a high-stakes examination.

This study, based on the constructivist paradigm, gives participants the opportunity to express their views, concerns, expectations and needs. By using rich and critical description, it provides an in-depth, detailed report of participants' perceptions and experiences using the IAM App.

3.2.2 Philosophical foundation.

Social constructivism serves as the interpretative framework of our epistemology, that is, the philosophical assumption or belief that forms the basis of this project. The connection between the assumption and the framework suggests that reality is "co-constructed between the researcher and shaped by individual experiences" (Creswell, 2012, p. 36).

Constructivism highlights the importance of building meanings to conceptualize

representations and explanations. Researchers need to use new data and new interpretations to construct meaning based on social interpretations (Stake & Kerr, 1995). Also, the researcher's role in the constructivist approach is interpreting and gathering data, which supports the belief that knowledge is constructed rather than discovered (Stake, 1995b).

The research in this thesis is based on residents' interpretations of the IAM App in the context of daily work, and factors that influence patterns of usage. In other words, this research is about how residents created their own meanings for the App and the ways they decided to use it. Residents constructed reality based on their particular experience. They interacted with this technological system and made decisions based on their learning needs and perceptions; this reflects the constructivist epistemology.

With regards to the analysis, the constructivist framework allowed me to examine and understand residents' perceptions and experiences with the App in their learning environments. Examining lived experiences in-depth through open-ended questions (Crotty, 1998), I focused on the understanding and rebuilding of meanings that individuals create for the phenomenon studied (Gubrium, 1997).

3.2.3 Research design.

This qualitative study used a case study design. This section will describe the rationale for choosing case study methodology. This study included convenience sampling, semi-structured interviews, systematic and concurrent data collection, and cross analysis procedures.

3.2.4 Case study.

The first part of this section summarizes the rationale for using case study methodology and why that methodology is appropriate for this study. The second part uses the framework proposed by Yin (2013), which describes the 5 components of an effective case study design:

research questions, the purpose of the study, unit of analysis, the logic linking data to that purpose, and criteria for interpreting findings.

The case study was the qualitative method selected because this study's goal was to understand a real-life phenomenon in depth in contextual conditions (Yin, 2013). Case studies offer unique advantages: "compared to other methods, the strength of the case study method it is its ability to examine, in-depth, a "case" within its "real-life" context" (Green, Camilli, & Elmore, 2012, p. 111).

In this study, the unit of analysis corresponded with the group of residents identified according to usage tracking. I selected interviewees based on individual differences in usage patterns identified through tracking of page hits.

I employed the strategy of theoretical propositions that consists in selecting and excluding certain data during the data collection phase (Yin, 2013). This strategy guides the study analysis. In other words, having certain perspectives in mind focuses the researcher's attention on specific aspects of the data.

3.2.5 Research site.

This study took place at a McGill University teaching hospital. There were no barriers in locating the site as Dr. Roland Grad, the principal investigator of the larger project entitled "Can a mobile application for smartphone improve examination scores?", a clinician researcher and supervisor of residents, acted as the facilitator at the research site.

This study was conducted in accordance with the ethical principles set out in the declaration of Helsinki. Ethical approval was obtained from the McGill University Institutional Review Board (IRB). The IRB provided ethical approval #A11-E25-05A for the collection and analysis of data (See Appendix A for Institutional Review Board approval).

A private office was used to store confidential documentation and to conduct the interviews. The study was carried out in 7 months. It began on October 6th 2014 and ended on April 30th 2015. At the time of the study, a considerable number of residents were training at the hospital. Since the overarching goal of the project lead is to later test this App's impact on examination scores, and the study consisted of providing residents with a new tool to prepare for their examination, this was a motivating factor for them to participate.

Moreover, this study resulted in substantial benefits to my professional development. As a graduate student, conducting this study was an enriching and encouraging learning experience. As a physician, managing the clinical information was a great opportunity to build upon my knowledge and integrate the content and references used in the Canadian Health Care System. As a future clinician educator, I greatly appreciated the opportunity to be involved in assessing the foundation of the IAM App, which will be considered for future study. Also, learning about the opinions of residents from different years of training in Family Medicine provided me with new insights and ideas to continue contributing to this specialty.

3.2.6 Participants.

The strategy for selecting participants for this study is referred to as a "convenience sampling". It was used primarily because the participants were already accessible at the research site. This is a type of nonprobability sample widely used in qualitative and quantitative research for the following reasons: it is time and cost-effective, easy, quick to administer, inexpensive and usually assures a high participation rate (McMillan & Schumacher, 2010). Some weaknesses of this sampling method include subject bias and a potential lack of generalizability. To deal with subject bias, the role of the clinician researcher facilitator of the study is to supervise residents

during clinical encounters; however, this person is not involved in the examination process, either in preparation or in determining or communicating exam results.

To respond to the lack of generalizability, it is important to mention that residents are distributed in clinical sites based on the same initial selection process. Residents are assigned equally in terms of their training level and all meet the same requirements in residency length and in opportunities in each setting. These limitations were considered and had implications on the interpretation of findings, limiting their generalizability.

Forty-three family medicine residents from the family medicine clinical teaching unit at the Jewish General hospital were invited to participate. Twenty residents volunteered. No inclusion or exclusion criteria were used other than owning a smartphone with the iPhone (iOS 5.0 +) or Android (2.3 +) platform.

Of the twenty residents who agreed to participate, 8 were in first year and 12 in second year postgraduate training. A total of 17 participants were Canadian medical graduates, and 3 were international medical graduates.

A total of 15 interviews with residents were conducted along with continuous data analysis in order to understand and identify usage patterns and construct the meaning of participants' experiences with the App. The selection of participants for interview was done using "purposeful sampling". Participants were selected from the Herzl Family Medicine Practice clinic. Being the principal investigator one of the supervisors of the residents at the Herzl clinic, recruitment and support throughout the study were facilitated at one site compared to residents from multiple sites. Also, the fact that the principal investigator previously knew these residents, gave residents more confidence to express their opinions, thus adding to the understanding of App use. By definition, Maxwell explains that purposeful sampling is the best

strategy for deliberately selecting activities, persons and specific settings to provide specific information not obtained from other sources (Maxwell, 2012). In other words, purposeful sampling is another type of nonprobability sampling, used when some elements are representative of or provide information about the topic of interest (McMillan & Schumacher, 2010). Purposeful sampling shares the advantages of convenience sampling, and also ensures that the information can be generalized to similar subjects. However, it will represent only a portion of the population with unique characteristics. The strategy to deal with this aspect was is to select different subjects by usage patterns and by level of training. Notwithstanding, results will still need to be interpreted with caution.

In order to enrich the case description, 1 or 2 residents were chosen according to usage patterns or behaviors, adding up to a total of fourteen participants and were interviewed throughout the study.

3.2.7 Procedures.

This study was funded by a McGill Research Residual Fund held by RG (Fund number 121010).

3.2.7.1 Recruitment process.

The recruitment process was conducted by the project's lead investigator, who informed residents about the study at various meetings beginning in September, 2014. After these meetings, residents were invited to participate via email beginning October 6, 2014. One of the chief residents assisted in the recruitment process, providing information to peers face-to-face. The last resident included in the study provided consent on December 3, 2014. A total of forty-three residents were invited and a total of 20 residents consented to participate.

The recruitment invitation email was sent to 43 participants. This email contained an explanation of the App's main purpose and a description of the context in which it was created related to the 99 priority topics. The email also contained information about the study's ethics approval by the Institutional Review Board of the McGill Faculty of Medicine, and confidentiality issues. Specifically, participants were informed that their names, usage patterns and topics accessed would be tracked in the system. They were assured that only aggregate results would be presented and that confidentiality would be maintained. Other information provided in this email included the conditions of participation (e.g. a signed consent, form, having a smartphone, willingness to try using the App and permission to analyze their usage data), and information about weekly alerts (participants were expected to enable the receipt of alerts about clinical information linked to a specific topic). Participants were also assured that by not providing consent, they were in no way jeopardizing their academic standing.

In this email participants were also informed about two follow-up steps. First, they were asked to provide a short "yes" or "no" answer by email to indicate whether they were interested in participating. Second, if they agreed to participate, the consent form was sent to them (See Appendix B for invitation Email. Participants were asked to sign the consent form and return it to the principal investigator (See Appendix C for consent form).

Finally, participants were informed that once the consent form was properly filled out and received, an email would be sent to them with a username, a temporary password and instructions on how to download the IAM App to their iPhone or Android device (See Appendix D for the instructions to download the App). Usage data were collected on a password-protected server (99prioritytopics.ca) and residents were notified that their usage would be recorded in the

system. Participants did not receive further assistance or resources during this process in order to allow researchers to later assess the user experience with the App.

3.2.7.2 Development of the study.

This study began on October 6, 2014 and the first push notification for the topic of the week, was sent on October 8, 2014 at 1 p.m. The alert or notification mechanism was used to track how frequently residents read and re-read clinical information. This provided the opportunity to remind them about a topic to study based on the spaced learning framework. The system was set up to send weekly notifications every Wednesday at 1 p.m. because the academic half-days take place at this time. These are protected mandatory 3-hour teaching sessions offered by most Canadian Family Medicine programs. It was assumed that delivering the notification at that time and day, would be less intrusive and convenient to support the teaching sessions. Development of the study and decisions are described (See Appendix E for the Milestones table).

3.2.8 Data collection.

According to Yin's (2013) recommendations, this study used a database from the log in the system which recorded usage of the App. In this context, usage refers to page hits on the Clinical Info pages. Documents were produced to assess usage frequency per month, topic, subtopic, and per user; tabular excel documents from IAM questionnaires in which frequency of response was tabulated once for the 6 month study period; and notes were taken on each interview.

To meet the requirement of maintaining a chain of evidence, this study employed a combination of data collection methods including: follow-up open-ended individual interviews based on log files, and IAM questionnaires.

3.2.8.1 Interviews.

This section first provides a rationale for the use of interviews, followed by a description of procedures, sample size and sampling method, and finally an explanation of the rationale for the type of interview conducted and the scheduling. Interviews were selected as the primary data source (Merriam, 1998).

With regards to the type of interviews open-ended semi-structured interviews were employed, because they help to highlight specific topics to be covered (Kvale, 1996) and gather specific information (Merriam, 1998).

To construct interview guides, the questions included thematic and dynamic dimensions. "Thematic" refers to relevance to the topic or research theme of interest, and "dynamic" refers to questions intended to promote positive interaction between the interviewee and the interviewer. This was employed because it maintains the conversational flow while encouraging interviewees to express their feelings and experiences (Kvale, 1996). In addition, probing questions were used when necessary to trigger and encourage participants to elaborate on answers or clarify comments.

All interviews were conducted face to face except the last interview. As it was impossible to communicate face to face with this participant due to her location in the far north, the interview guide was submitted by email, and the responses obtained via email. The same procedures for data coding was applied to all responses included in the analysis.

A sample between 2-5 participants was chosen for the interviews, based on evidence that a total of 4-7 participants would be sufficient to identify numerous usability issues (Nielsen, 1994).

With regards to purposeful sampling, log files provided information on usage patterns, thus the most representative participants were selected for interview. Based on the goal of

understanding user experience throughout the study, the scheduling of interviews was determined as follows:

Once participants were approved, I audio recorded the interviews to ensure proper data collection and accurate transcription(Merriam, 1998). In addition, I took handwritten notes to highlight aspects of particular interest for analysis after the fact. Before beginning each interview, I provided participants with information about myself to gain their trust and establish rapport (M. Q. Patton, 1980). I reminded them of the purpose of the interview, mentioned the procedures, and provided a brief outline of how the interview session was to unfold. Participants were also reassured about confidentiality.

The overall interview goal was to gather information on participants' experiences during IAM App usage. In order to define the interview scheduling it is necessary to provide a cursory description of the concept of user experience and the factors influencing it.

User experience is defined as "a momentary, primarily evaluative feeling (good-bad) while interacting with a product or service" (Hassenzahl, 2008, p. 1), which translates in a consequence of users' internal state (such as expectations, needs, motivation, mood), the characteristics of the new system (such as purpose, complexity, usability, functionality), and the context in which this interaction occurs (for instance, organizational or social setting, significance of the activity or willingness to use the system) (M. Hassenzahl, 2008).

Empirical studies in the field have researched the aspects that modulate user evaluation of a product and their perceptions. It is argued that there are four sources of diversity in user experience: individual, product, situation and time (Karapanos, 2013). Ultimately, these aspects interact to define user experience and satisfaction with a product. Individual differences refer to each user's preference and individual needs (Karapanos & Martens, 2007). The product relates to

a system's quality and features, which may or not may fit in different contexts (Jordan & Persson, 2007). The situation is when different circumstances influence adherence to a system or product (M. Hassenzahl, 2008; Mahlke & Lindgaard, 2007). For example, the same mobile phone can be used to explore screen lock images or to make an emergency call. However, the most relevant aspect for the purpose of the present study was the time factor. As has been asserted elsewhere, experience with a new system changes over time (Fenko, Schifferstein, Huang, & Hekkert, 2009; Karapanos, Jain, & Hassenzahl, 2012; Venkatesh & Bala, 2008; von Wilamowitz-Moellendorff, Hassenzahl, & Platz, 2006). Research has shown that users give different weights to different qualities during different phases. During their first interaction with a product, users might focus more on its usability and after some time, they may become more interested in functionality or communication. For example, a study conducted for a period of 5 weeks showed that product experience changed significantly, especially in the first couple of weeks of system usage (Karapanos, 2013).

Therefore, our interview protocol was scheduled for implementation at 3 time periods. The first one took place on 2 weeks after the beginning of the study (October 19, 2014), the second interview took place 1 month and 2 months after the beginning of the study (November 2, 2014 and December 10, 2014 respectively). The final interview was completed 7 months after the beginning of the study (between May 8, and May 13, 2015). The transcription process began after the completion of each interview. Reading and listening to audiotapes was simultaneously performed in order to ensure transcript accuracy.

The interview protocol included a short questionnaire to obtain participants' demographic information. The questions covered age, their device name, operating system and data plan, as well as whether or not they had installed the IAM App on their smartphone.

The interview protocol was developed in 3 main phases: First was the "Initial interaction phase", which was conducted 2 weeks following the beginning of the study (See Appendix F for the interview guide 1). Second, the "Functionality phase", which was conducted 4 weeks following the beginning of the study (See Appendix G for the interview guide 2). Because usage patterns were considered more representative at two months following the beginning of the study and confirmed by usage patterns of some participants, an additional interview was conducted in which participants were interviewed in two streams: continuers and non-users (See Appendix H for the interview guide 2.1).

For the first and second interviews, the term "continuers" refers to those participants who used the App and for whom page hits (or at least one page hit) were recorded in the system within the last 2 weeks (at least at the clinical information level). The term "non-users" refers to those participants who did not use the App, for whom no page hits were recorded in the system. The term "discontinuers" refers to those participants who did use the App, but after a period, stopped usage and no page hits were recorded in the system within the last 2 weeks.

The third phase was called the "Relative experience phase". Interviews were conducted 7 months after the beginning of the study (See Appendix I for interview guide 3). Because data gathering became longitudinal after time had elapsed from the beginning of the study, the user types for the third phase were the same except that the period of time related to usage activity was 2 months instead of 2 weeks.

The reason of establishing a cut off of 2 months was due to the length of clinical rotations, which last 4 weeks. We considered that because some clinical rotations have more work load than others and 4 weeks would not have been enough time for users to show their use of the App. Therefore, we decided to allow for more time by adding 4 additional weeks. Figure

3.13 describes the interview process, including the focus, procedures, and number of participants at each interview phase.

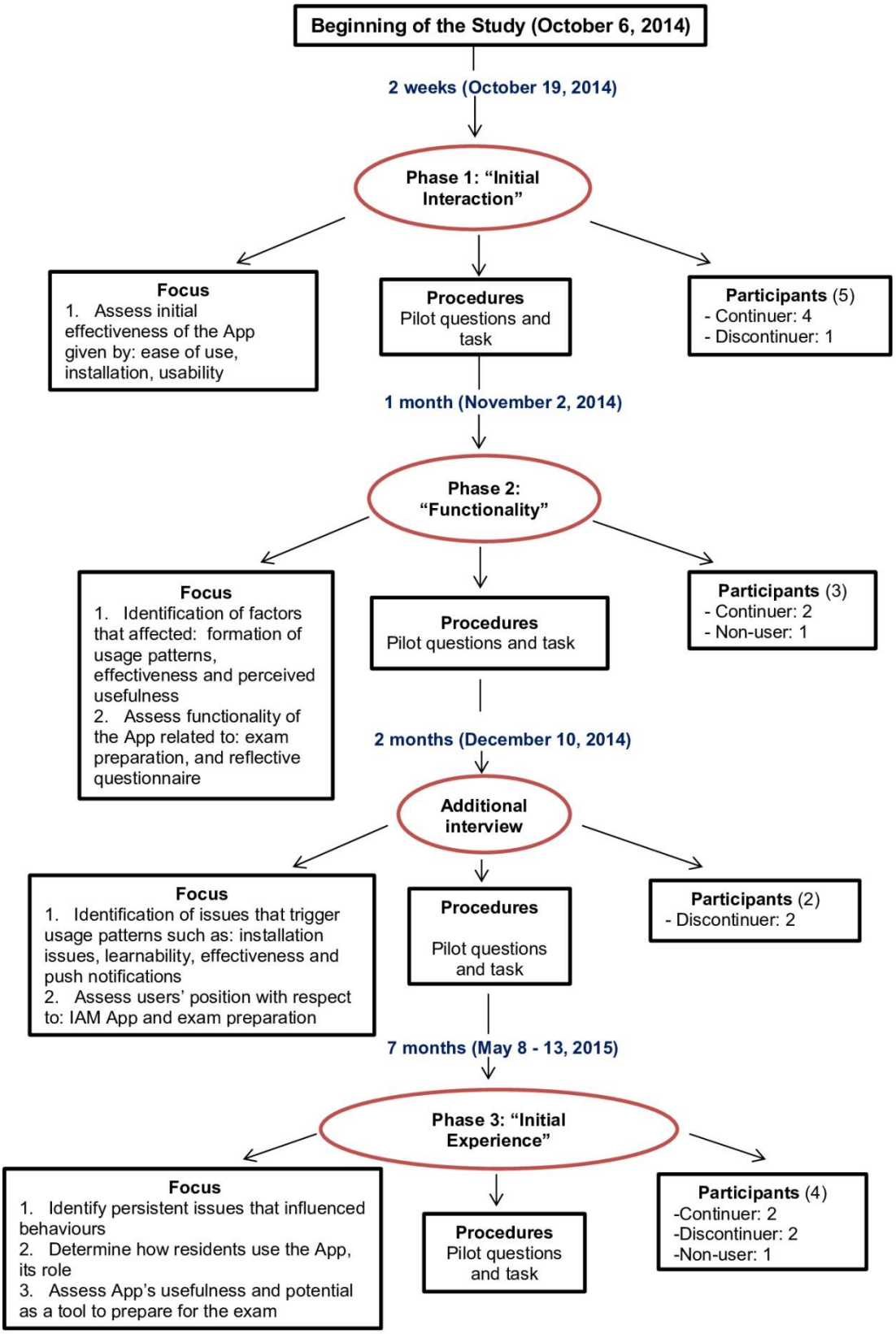


Figure 3.13 Interview process

During the interviews, participants were invited to highlight any issues they encountered with regards to App functioning, navigation, errors or other issues that might have affected individual usage. Following the completion of interview questions, a task was included in the first and second phase. The task consisted of each participant being asked to search for one priority topic from the "Topics" page. Information was recorded, including data on the time required to perform the task and method used (scrolling vs. search box). Related comments were recorded in written notes and in a computer file. In the case that spacingone of the non-user participants failed to install the App, the task was not performed.

3.2.8.2 Log files.

Log files served to track usage. As mentioned in the first section of this chapter, a hit was recorded each time a user opened the App at the level of clinical information. Every hit was logged as a separate entry in the server's access log file. This information was logged at the web site www.99prioritytopics.ca on a password protected server. The back-end system allowed the download of usage records at any time to an excel spreadsheet which provided a complete set of data log file. These data logs included information on participants' name and the specific topics and clinical page information they accessed, including frequency, date and time.

Once records were downloaded, the data were stored in a single Microsoft Excel spreadsheet containing the complete set of data logs. The final data set was collected on May 3, 2015, providing information dating to April 30, 2015. A frequency count was conducted and the total number of page hits per user, per topic, per day of the week, and ratio of number of topics per user per day were descriptively analyzed.

3.2.8.3 The IAM questionnaires.

The IAM questionnaire was included in the App as a feedback tool and reflective instrument (See Appendix J for the IAM questionnaire). Data from the IAM questionnaires were downloaded at the end of the study following the same procedure as that for log files on page hits. Data were stored using Microsoft Excel to create a single spreadsheet containing the complete set of questionnaire data, information on participants' names, the topics and clinical information pages from which IAM questionnaires were completed, the date and time and responses per each question and sub-questions. Records were downloaded at the end of the study. Frequency and type of responses were counted and analyzed.

3.2.9 Data analysis.

This study employed a strategy focused on theoretical propositions, because the research questions were based on these propositions. Also, because propositions shaped the data collection process, they were given priority in the analysis (Yin, 2013).

The final analysis was still an ongoing process instead of a particular moment when the analysis took place (Stake, 1995a). From the first interview to the last, analysis followed each interview and was the means to verify usage patterns that were previously identified via tracking of page hits and experience with App use. Also, content analysis was based on interview comments made during the task and notes taken during direct observation. This led the researchers to adjust data collection and revise the themes or propositions needed for subsequent data collection (Strauss & Corbin, 1998).

The MAXQDA qualitative analysis software was used to store transcripts and coding processes due to its ease of integration (compatible with windows and Macintosh, easy to use and get started, with several options for managing documents). This program permits weighting codes to measure the significance of specific pieces. MAXQDA also offers options for memo

writing, highlighting quotations, data retrieval and development, and display and modification of code. In addition, this program permits code sorting, combination, and creation of concept maps. Data merging is another advantage since it allows other researchers to code data for inter-coder agreement purposes and then merge analyses (Creswell, 2012).

Inter-coder agreement was conducted by two coders. The second coder was a recently graduated student in Educational Psychology- learning sciences education with sufficient experience in coding qualitative data and the first coder was the author of this thesis. We followed these steps: first each of the two coders coded each of the first 10 interviews independently. The second coder and I compared the codes to calculate a reliability coefficient. For this purpose, we used the formula of total number of agreements/total number of codes and after counting of codes and agreements, the coefficient was of 65%. We discussed the disagreements and adjusted descriptions accordingly, reaching a coefficient of 85%. The final step was to recode another set of data to merge both works followed by a final revision.

For the last interview 40% of data was coded (out of 5 participants, 2 sets of transcripts were coded). First, each coder coded independently each of these 2 interviews. Second, the second coder and I compared the reliability coefficient. We followed the same procedure as above using the same formula. The coefficient was 67%. We discussed the disagreements and adjusted descriptions accordingly, obtaining a final agreement of 93%. The final step was to recode another set of data to merge both works followed by a final revision.

The analysis process followed the 5 steps described by Creswell.

Step 1: Organization and preparation of data. Transcripts of each participant were read and listened to simultaneously in order to get a sense of the data, obtain the maximum

understanding of comments from participants' perspectives, and immerse oneself in the data. Creswell (2012) refers to this as: "Preliminary exploratory analysis".

Step 2: Coding of text: this was done by locating the text segments and assigning labels with respective meanings different from participant's codes (in-vivo codes were not used). The underlying meaning for each code was written using a memo located next to the comments.

In this way, the data were coded. Thematic analysis was employed to identify patterns previously structured within the data and common themes. The advantages of this approach in this study were flexibility, ease of use by summarizing key features of a large body of data, highlighting similarities and differences across the data set, generating unanticipated insights, and allowing researchers to draw a map of themes (Braun & Clarke, 2006).

Step 3: Grouping of similar codes: we were able to reduce the list of label segments and to decrease overlap and redundancy.

Step 4: Preliminary organization: this was done by double checking the data to assess whether new themes had emerged.

Step 5: Themes or categories in which similar codes are grouped together: this followed a reduction of codes into themes, in order to provide a detailed description of a few themes instead of a general description of many themes (Creswell, 2012). The process ended with inter-coder agreement, consisted in a second coding process (Creswell, 2012, p. 36), conducted by someone with a Master's degree in Educational Psychology - Learning Sciences education from McGill University. I selected this person because of her extensive experience in coding qualitative research for dissertations, her master's thesis and her current involvement in conducting other research studies. Also, this person did not have previous knowledge or exposure to the area of

this study, thus she did not have the potential of having a biased opinion. On the contrary, her perspective added different insights to the analysis.

Next, themes that emerged were analyzed at 3 levels of user: continuers, discontinuers and non-users. Therefore, as various cases were found, a cross-case analysis was conducted. Cross-case, cross-site or multiple-site case studies relate to the same concept and imply analysis based on multiple examples. This type of analysis allows generalizing across several representations of a particular phenomenon (Green, Camilli, & Elmore, 2012), thus overcoming one of the threats or criticisms of using case studies (Yin, 2013).

3.2.10 Research steps.

The research followed a protocol to ensure that the data gathered from interviews was consistent with our research goals.

1. Participants were invited to the interviews by the principal investigator and one of the participants (a chief resident); all residents received information about the study, its goals, and confidentiality.

2. Open-ended semistructured interviews were conducted in 3 main phases. Participants were selected according to usage patterns and received $50 compensation for their participation.

3. Interviews lasted about 20 minutes each and were audio-recorded and transcribed within 5 days of completion of each interview.

4. Contact with the research team was constant to verify data and share insights from the interviews.

5. Data were coded for emergent themes followed by the inter-coder agreement process.

3.3 Goodness and Trustworthiness

The role of the researcher is to provide details so that the reader can ascertain the trustworthiness of findings. The quality of any research design is determined by the following aspects trustworthiness, credibility, confirmability and data dependability (Kirst, 1990). According to this evidence, Yin presents 4 tests that can be used to assess the quality of a case study. These tests were used for this research; they are construct validity, internal validity, external validity, and reliability (Yin, 2013).

To ensure construct validity, multiple sources of evidence were drawn upon. Drafts of the case study report of my findings were reviewed by peers and colleagues as they emerged. This review involved experienced researchers in the field of educational psychology and medical education. This was carried out during the data collection process and analysis. Pattern matching was used during data analysis to increase internal validity. External validity was ensured by relying on theoretical guidance because this is a case study; this test took place during the research design phase. Last, reliability was provided by developing the case study database during the process of data collection. Inter-coder reliability was used and the goal was to reach 80% agreement between independent judges in coding the text (Creswell, 2012, p. 36).

Additionally, with regards to dependability I provide a milestones document (Merriam, 2002; Wolf, 2003), which consists of a detailed explanation of the study decisions, data collection and data analysis process (see Appendix E).

This study also used other aspects recommended in the literature to ensure credibility and trustworthiness: reflexivity, engagement, and maximum variation. Reflexivity represents the researcher's critical self-reflection with regards to bias, relationship to the study and factors that might affect the research. Creswell argues that qualitative research has changed, moving towards interpretative lenses emphasizing researchers' reflexivity (Creswell, 2012, p. 36). The second

aspect is engagement, which is related to reasonable time to collect data; in this study data were collected at different points in time in a feasible and flexible way. The last aspect is maximum variation which relates to the diversity in sampling and seeking of the most representative cases to increase the findings' range of application by research consumers (Merriam, 2002).

In this study, purposeful sampling of interview participants was conducted in order to achieve maximum variation.

3.4 Researcher Positionality.

In qualitative research, the researcher is the primary instrument for data gathering and analysis. On the one hand, this benefits the collection and production of meaningful information. However, as researchers are human, each researcher will also introduce limitations in terms of errors or bias. Although humans have personalities and individual skills necessary to conduct this type of research and these skills have great value, researchers are fallible, as is any other research instrument (Merriam, 1998).

In the interest of disclosure and ethics and to avoid unintentional influences on the interpretation of results, the following discussion outlines my personal position with regards to this study.

I have worked in the academic environment with other residents in the same setting. During this time, I have had the opportunity to exchange ideas with them related to their work environment and learning needs. This has provided me with a broad understanding of their context. During this period, I have also engaged in a community with the same interests, needs and habits in terms of using medical apps in the clinical context, among others. This identity was shaped and expressed around the use of apps (Gardner & Davis, 2013), and gave me an insight into the data.

Further, I have worked as a physician in the field of general medicine in a variety of settings; this experience has provided me with a full understanding of the field, and of the challenges and limitations for which residents aim to prepare in the best way possible. They hope to be able to demonstrate full competency through the board certification examination. Therefore, it is easy for me to understand that test anxiety, expectations, as well as their appreciation and conscientious evaluation of novel tools all have potential to prepare them for a complex high-stakes examination.

In addition to my professional background, my experience with high-stakes exams in Canada (exams that are very similar to a portion of the board certification examination), increases my understanding of residents' learning needs and obstacles, and fuels my expectations as a future trainee in this context, which might constitute a bias.

3.5 Summary.

This chapter first outlined the origin of the IAM App and gave a detailed explanation of its design, development and features. These were described in detail to make results understandable for the reader. This section was followed by an explanation of the epistemological grounding and methodology used in this study, along with explanations of the research pathway and decisions that anchored the analysis process.

Each section and decision was supported by a rationale, to illuminate variations in personal experiences, App usage and the dual-complexity of integrating technology into medical education. Measures to ensure the robustness of the methodology were discussed next.

Finally, research positioning was discussed to avoid unethical and unintended interpretations of the results. The next chapter will provide results of the study. In Chapter 5, I will discuss findings, limitations, strengths, and recommendations for further research.

CHAPTER 4

Research Findings

The research findings are described in four sections: the first section provides background information on participants. The second and third sections provide descriptive results based on analysis of usage behavior data and results from the IAM questionnaires respectively; The fourth section provides findings from interviews, which includes synthesis of the themes that emerged, and results of task performance. A conclusion is provided at the end of this chapter.

It is important to mention that during the first 3 months of the study (October to December, 2014), the App's content was not fully available. Although, it wasn't until the beginning of January that the App was fully populated with content, a number of page hits were recorded in the 3 prior months. However, total accesses dropped from 68 page hits in December to 49 page hits in January. Throughout the second half of the study (January to May, 2015), the content was stable. It is also important to consider that by the second half of the study, residents were closer to the examination date, and so their App use may have varied due to this factor. Thus the first section's aim is to provide a descriptive analysis of the tracking data obtained.

4.1 Demographic Information

The participants in this study were 20 family medicine residents from first and second year postgraduate levels, 8 first year and 12 second year residents; 17 participants were Canadian and 3 were international medical graduates. Seventeen participants made page hits during the study. Out of those, 7 belonged to first year and 10 belonged to second year postgraduate training. A total of 3 participants did not have any page
hits recorded in the back-end system. Out of those, 1 belonged to the first year postgraduate training and two to the second year. Table 4.1 reflects this demographic information.

Table 4.1

Demographic Information

	PGY1	PGY2
Total Participants (20)	8	12
Participants with Page Hits (17)	7	10
Participants with no Page Hits (3)	1	2

Note. PGY = postgraduate year of training, 1 and 2 respectively; CMG = Canadian Medical Graduate; IMG = International Medical Graduate.

4.2 Results of Usage from Log Files

This analysis was conducted to determine whether any particular factor motivated users to have more page hits than others. Examples could include topics, days of the week or proximity to exam dates. A total of 933 page hits were recorded over the course of the study. Descriptive statistics of total number of accesses per month and per user are found in Table 4.2 in descending order.

Table 4.2

Total Number of Page Hits per Month and per User

Month	Number of Page Hits	Percentage	*Mean*	*SD*
March	236	25%	454.8	47.8
February	210	23%	35	65.86
October	171	19%	15.54	14.02
April	142	15%	23.67	24.67
December	68	7%	8.50	4.93
November	57	6%	6.33	8.16
January	49	5%	8.17	7.51
Total Page Hits per Month	933	100%	133.28	70.83
Total Page Hits per User	933	100%	54.88	116.35

Note. SD = standard deviation

4.2.1 Overall app usage behavior.

Once the App had been provided, residents not only had access to the material anytime and anywhere. Seventeen residents (17/20 = 85%) had page hits. The number of page hits varied from 1 to 226 page hits per user (M = 55, SD = 116.3). Page hits over the 7 month study were consistent. With regards to the length of the study (7 months), 8 participants' page hits occurred between 3 months and 7 months (47%) and 9 participants' page hits occurred between 1 and 2 months (53%).

The two months that showed the most page hits were February and March as illustrated in Figure 4.1. It is important to remind the reader that examination dates took place between April 30 – May 3, 2015.

Figure 4.1 Page hits per month

A higher number of page hits was seen in October 2014 compared to the 3 subsequent months. The usage increased throughout the study and by the month of April it dropped slightly.

4.2.2 Residents' behaviors on pages hits.

Of 17 residents who used the App 9 (53%) used the App for 2 months or less, and 8 residents used the App for 3 months or more (47%). Usage frequency varied according to the level of training as described in Table 4.3.

In general, while 6 residents (35%) used the App for only the first 3 months of the study, 11 residents (65%) used the App to the end of the study. Based on these differences we were able to classify these users into two groups: early users and constant users. The former refers to those users who had page hits only from October, 2014 to December, 2014 and the latter refers to those users who had page hits from October, 2014 to March and April, 2015.

Table 4.3

Usage Frequency by Year of Residency

Year of Residency	Usage Frequency		**Total**
	2 ≤ months	**3 ≥ months**	
PGY 1	4 (44%)	3 (38%)	7 (41%)
PGY 2	5 (56%)	5 (62%)	10 (59%)
Total	9 (53%)	8 (47%)	17 (100%)

Note. PGY= postgraduate year

To find out the number of page hits that each user was recording per month, we calculated the ratio of number of pages per user per month. From October to December the ratio was 7.84; and from January to April the ratio was 9.95.

4.2.3 Usage behaviors on days.

Usage was analyzed by day of the week during two periods and overall. During the first half of the study (October to December, 2014) usage was higher on Sunday, followed by Friday, and Thursday. Saturday showed a decline in use. During the first half of the study, Sunday, Friday and Wednesday were the days with more page hits. During the last half of the study, usage increased for every day overall. However, the highest usage was found to occur on Wednesday, followed by Tuesday, Thursday, and Sunday, ending in a decline by Monday.

Table 4.4 shows the frequency of page hits per day of the week and Figure 4.2 illustrates the same data graphically in two study periods (October to December and January to April). The overall usage was higher Sundays, followed by Friday and Wednesday and lower Tuesday, followed by Saturday and Monday as illustrated in Figure 4.3. According to the clinical schedule residents work the same amount of hours during week days. The schedule on weekends is rotatory and requires only few residents on call. Likely, the majority of residents found more free time to use the App on Sundays, compared to other days.

Table 4.4

Frequency of Usage Behaviors per day of the Week

Period	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Page Hits
Oct – Dec 2014	40 (13%)	32 (11%)	30 (10%)	42 (14%)	61 (20%)	20 (6%)	71 (24%)	296
Jan– Apr 2015	47 (0.7%)	101 (16%)	121 (19%)	101 (16%)	98 (15%)	69 (11%)	100 (16%)	637
Total Page Hits	87	133	151	143	159	89	171	933

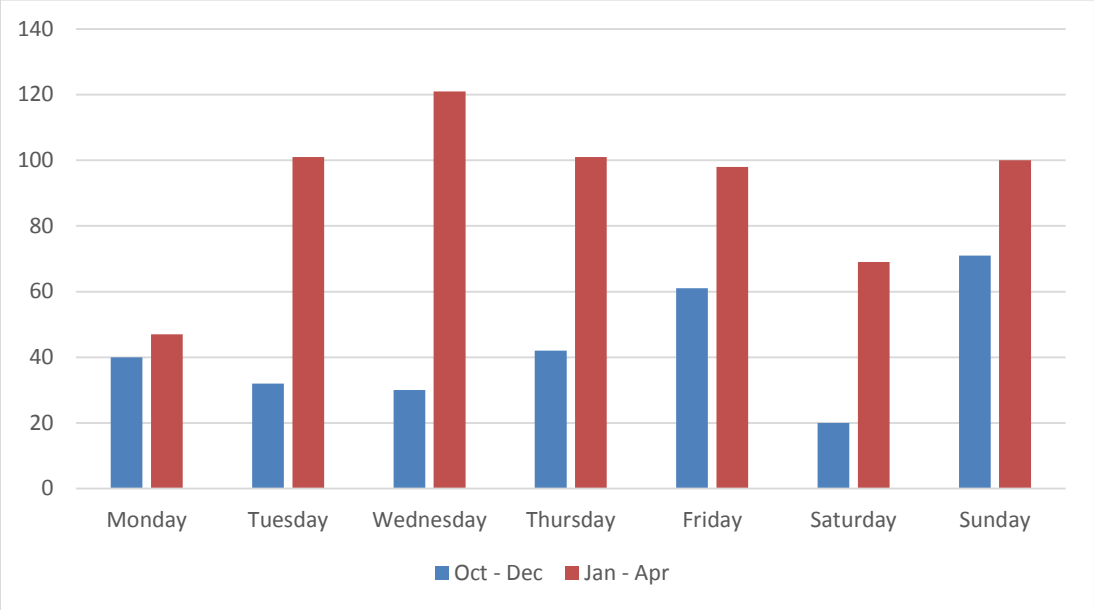


Figure 4.2 Page hits per day of the week during 2 study periods

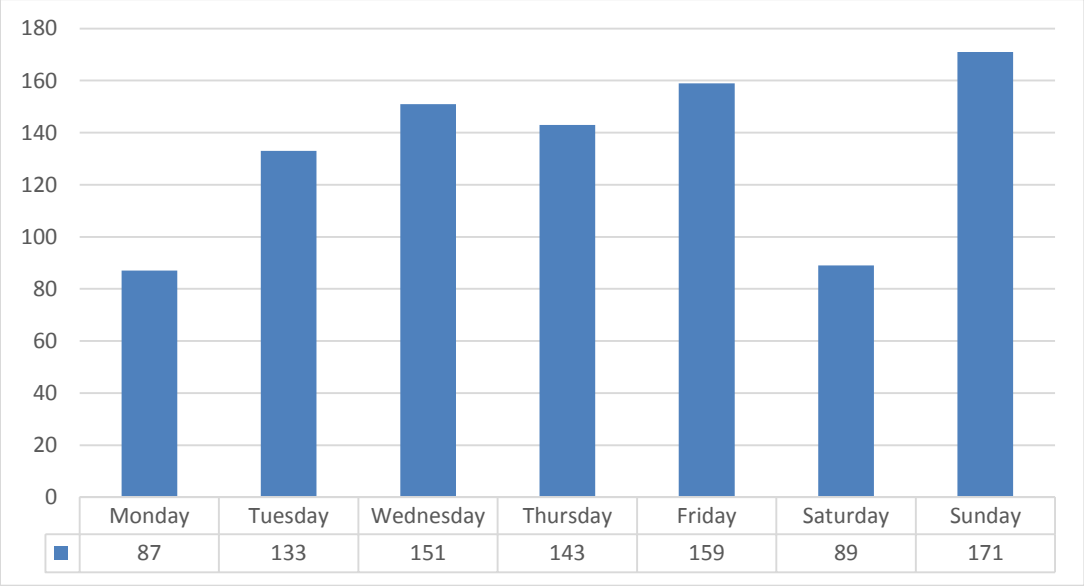


Figure 4.3 Total of page hits per day of the week

4.2.4 Residents' behaviors on topics.

From a total of 99 topics available, 69 were visited (70%) and 30 were not visited at least at the level of any Clinical Info page (30%). The number of topics accessed per month ranged from 8 to 33. The lowest number was recorded in October and November 2014, and the highest in March and April 2015, as presented in Table 4.5.

It is important to note that the number of topics include those accessed previously as well as new topics. The number of topics visited increased beginning in February 2015 (22 topics), and into March 2015 (29 topics) and April 2015 (33 topics). It seems that as the exam dates approached, interest in accessing new topics rose continuously among residents.

Table 4.5

Number of Topics Visited Monthly

Month	Oct-2014	Nov-2014	Dec-2014	Jan-2015	Feb-2015	Mar-2015	Ap-2015
Number of Topics Visited	8	8	12	12	22	29	33

The list of the top 10 and top 20 most visited topics are provided in Figure 4.4 and Figure 4.5, respectively. According to these results, the following patterns were identified from the top 10 most visited topics.

1. They are extensive topics. This means that the clinical information encompasses several differential diagnoses. They have more red flags compared to other topics. They include a broad treatment plan and 8 out of 10 medical conditions (topics) sometimes require emergency treatment.

2. Seven out of ten medical conditions can be seen at various ages, such as abdominal pain, anxiety, headache, asthma and diabetes among others.

3. The 10 topics include medical conditions common in a variety of populations ranging from children to elderly populations.

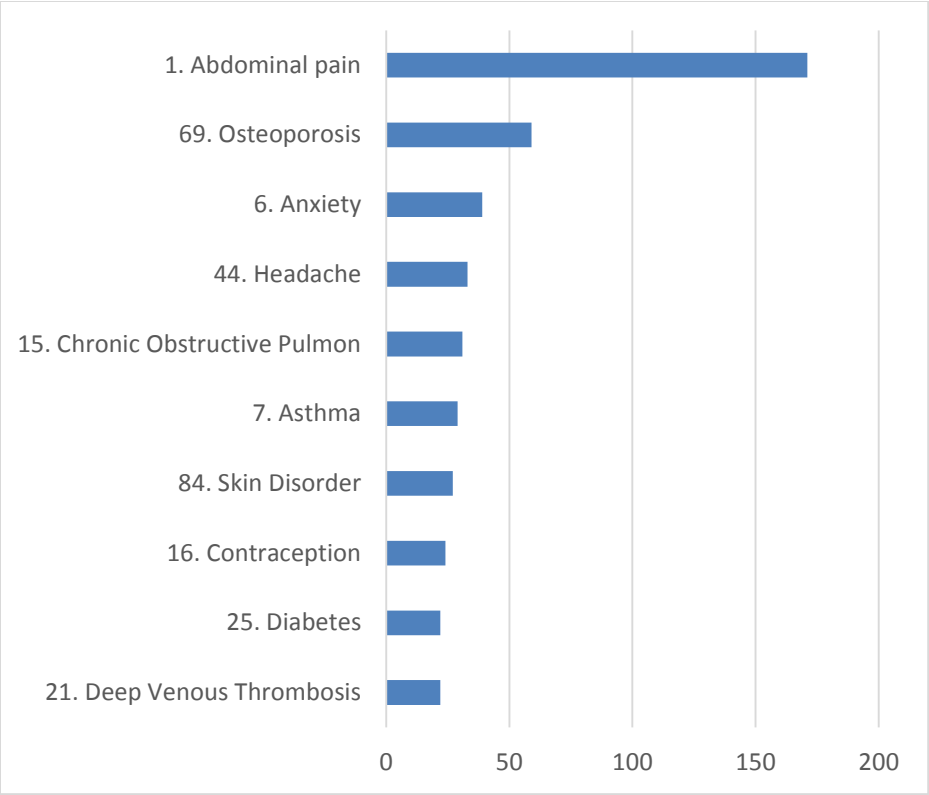


Figure 4.4 The top 10 topics visited. The numbers on the Y axis (next to the topic) corresponds to their place in the 99 priority topics' list. The numbers on the X axis indicate number of page hits.

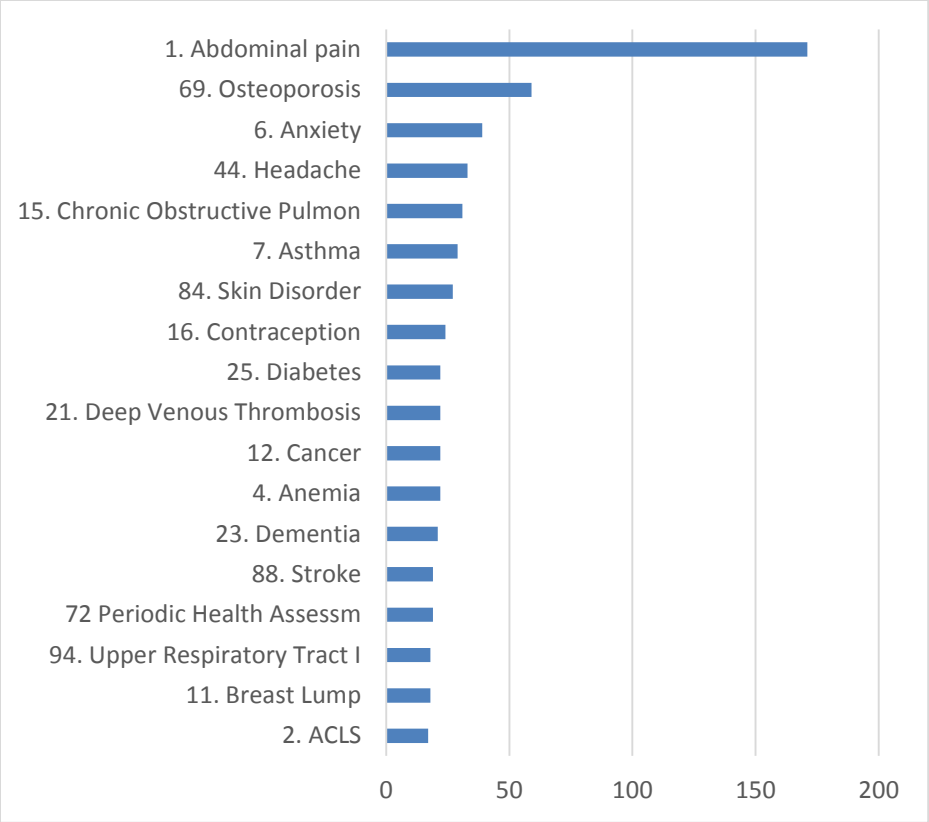


Figure 4.5 The top 20 topics visited. The numbers on the Y axis (next to the topic) corresponds to their place in the 99 priority topics' list. The numbers on the X axis indicate number of page hits.

The frequency visits to topics by medical specialty is presented in Table 4.6. The frequency visits to topics in the area of primary care and other unclassified topics are provided in Table 4.7.

With regards to the least accessed topics, the following patterns were observed:

1. These topics are less frequent in clinical practice, thus less likely to be a subject of exam questions.

2. The content for several of these topics had not been uploaded by the time residents were interested in finding this type of information.

2. Other topics had few if any links due to the nature of the topic. For example, grief, family issues, immigrants, disability, sexual assault, etc.

Table 4.6

Frequency of Visits to Topics per Medical Specialty

Discipline	Topics' Frequency	Specialty	Topics' Frequency	Discipline	Topics' Frequency
Psychiatry	8	Infectious diseases	7	Cardiovascular system	6
Respirology	6	Neurology	6	Gynaeco-obstetrics	5
Endocrinology	5	Gastrointestinal	2	Hematology	2
Oncology	2	Pediatrics	2	Urology	2
ENT	1	Dermatology	1		

Note. ENT = ear, nose and throat

Table 4.7

Frequency of Visits to Topics in Primary Care

Topic	Frequency	Topic	Frequency	Topic	Frequency
Periodic health assessment	19	Fatigue	11	Lacerations	10
Chronic diseases	6	Counselling	6	Bad news	6
Insomnia	5	Smoking	5	Elderly	4
Difficult patient	1	Gender specific issues	1	Low weight	1

4.3 Results of the overall usage of the IAM questionnaire.

The total number of questionnaires sent to residents was 916. A total of 25 questionnaires were completed by 9 residents and submitted. The number of questionnaires submitted by residents ranged between 2 and 8. A total of 12 topics (17%) corresponded to the questionnaires submitted. The number of questionnaires per topic ranged from 1 to 7. Table 4.8, presents this information. With regards to the blank box to write comments (last page of the questionnaire), one constructive comment was received.

Table 4.8

Number of IAM Questionnaires per Topic.

Topics Number and Name	Number received
1.Abdominal Pain	7
15. Chronic Obstructive Pulmonary Disease	3
54. Ischemic Heart Disease	3
11. Breast Lump	2
6. Anxiety	2
69. Osteoporosis	2
7. Asthma	1
12. Cancer	1
47. Hypertension	1
52. Infertility	1
77. Prostate	1
94. Upper Respiratory Tract Infection	1

The pattern that this list presents is related to fairly extensive topics, which are both prevalent and highly relevant during training. Also, the topics are diverse, which means that each

topic tends to represent a medical specialty. For example, abdominal pain is a big part of gastroenterology and surgery; chronic obstructive pulmonary disease and asthma are a big part of respirology; ischemic heart disease is part of cardiology; hypertension is part of internal medicine; anxiety is part of psychiatry; infertility is part of gynecology; and prostate is part of urology.

Table 4.9 presents each question with its answer options and sub-questions in descending order and at the end provides the feedback received (To see the complete IAM questionnaire, see Appendix J).

Table 4.9

Item responses to 25 IAM questionnaires

Main Question	Answer Options	Total
1. Why did you do this search for information?	1.1To fulfil a personal educational objective.	22
	1.2 To satisfy curiosity or for personal interest.	9
	1.3 To look up something I had forgotten.	8
	1.4 To exchange information with other health professionals (e.g., a colleague).	2
	1.5 To manage aspects of patient care with other health professionals.	1
2. Did you find relevant information that partially or completely met your objective (s)?	2.1 Yes (1)	25
3. What is the impact of this information on you or your practice?	3.2 I learned something new.	12
	3.5 I am reminded of something I already knew.	10
	3.1 My practice was (will be) changed and improved.	5
		4
	3.1.1 Diagnostic approach?	2
	3.1.2 Therapeutic approach?	2
	3.1.3 Disease prevention or health education?	7
	3.3 This information confirmed I did (am doing) the right thing.	5
	3.4 I am reassured.	
4. Did you (will) use this information for a specific patient?	4.1 Yes	3
	4.1.1 I managed (or will manage) this patient differently	1
	4.1.2 I used (will use) this information to justify a choice	1

	4.1.3 I did not know what to do, and I use (will use) this information to manage this patient.	1
	4.2 No	22
	4.3 Possibly	0
5. For this patient, did you observe (or do you expect) any health benefits as a result of applying this information?	5.1 Yes	2
	5.1.1 This information helped me to improve (will help to improve) this patient's health status, functioning or resilience (i.e., ability to adapt to significant life stressors).	1
	5.1.2 This information helped to prevent (will help to prevent) a disease or worsening of disease for this patient.	1
	5.2 No	1
Feedback comments	"Benzos are not the first line" (topic 6)	1

The IAM questionnaire permitted users to assess the content of the App, as a function of the questionnaire's purpose, relevance, trustworthiness, educational roles and support. All respondents rated the clinical information as relevant (25 responses/25) and listed their purpose as being mainly educational (22 responses/25). These aspects corresponded to questions 2 and 1.1, respectively.

Furthermore, although the number of completed questionnaires was low, it was still possible to identify themes according to the questions and the frequency of responses, as depicted in Table 4.10. and Figure 4.6.

Table 4.10

Themes from the IAM Questionnaires' Responses

Theme	Answers	Response Rate (/25)
1. Relevance of the App	2. Yes (Found the App relevant)	25
2. Trustworthiness in information	5.1 Yes (Benefits from this information)	23
	Other answers related to this theme:	
	5.1.1, 5.1.2	
3. Educational purposes	1.1To fulfil a personal educational objective.	22
3.2 Building new knowledge	3.2 I learned something new.	12
3.3 Recall information	3.5 I am reminded of something I already knew.	10
	Other answer related to this theme:	8
	1.3	
3.4 Satisfy curiosity	1.2 To satisfy curiosity or for personal interest.	9
4. Reassurance/Support	3.3 This information confirmed I did (am doing) the right thing.	7
	Other answers related to this theme:	
	3.4, 4.1.3	

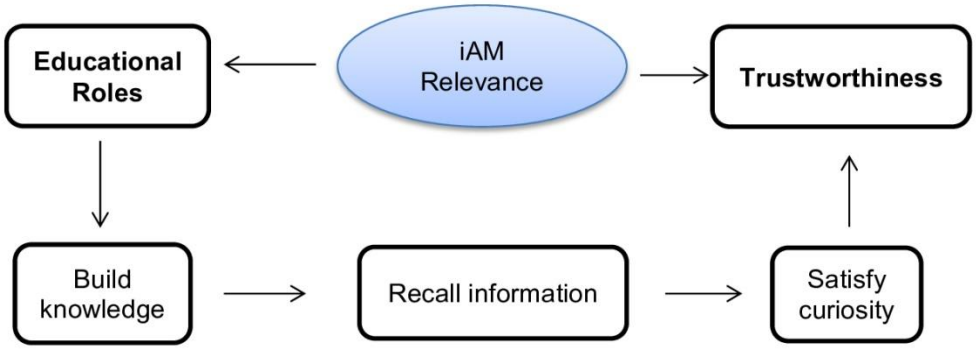


Figure 4.6 Representation of themes from responses to the IAM questionnaires

Because log data do not have the potential to show why people use the system the way they do, semi-structured interview data, and task performance data were analyzed to gain insight into this question.

4.4 Interview Results

This section begins by giving the background of the interviews conducted, followed by a description of themes for each of the cases identified, results of the task performance conducted after some interviews, and suggestions which emerged from participants' comments.

4.4.1 Background.

In total, 15 interviews were conducted. Thirteen participants were interviewed once, and 2 participants were interviewed twice (first and last interview). Of the 13 participants, 6 were in their first postgraduate year and 7 in their second year; they ranged in age from 27 to 32 years. Demographic information of participants who were interviewed is presented in Table 4.11.

Table 4.11

Demographic Information of Interviewees

Total	Age Average	Postgraduate Year		Device name		iOS	Data Plan		App Installed	
		(PGY1)	(PGY 2)	iPhone	Android		MB	GB	Yes	No
13	28	6	7	11	2	7-8* 4**		1-6	12	1

* Iphone
**Android

Note. IOS = Internetwork Operating System; MB = megabytes; GB = Gigabytes.

During open-ended interviews, participants described their initial experience, perceptions, and barriers they encountered in using the App. They also commented on the way they used the App and its overall usefulness, and provided recommendations for further improvement.

As mentioned in this chapter's introduction, at the time of the study, some of the App's content was uploaded, and some was still under construction; as a result, some of the key features lacked links to allow residents to access the next level of the App (clinical information). During the first two interviews, some participants referred to these links and in a few cases associated them with technical problems. For example, some key features lacked links to clinical information, and other key features provided links to clinical information that sometimes displayed a table frame with no content as the content had not yet been uploaded. Participants interpreted both situations as technical failures. This was explained to participants during the interview and the associated comments were not used as excerpts.

4.4.2 Synthesis of case-cross analysis.

This study aimed to explore residents' experience and perceptions as they used a mobile

phone application to prepare for the family medicine board certification exam. The following research questions informed this study:

1. What is the usability of the IAM App among family medicine residents over a period of 7 months?

2. What is the IAM App's role in preparing family medicine residents for the board certification exam?

Participants were grouped into three categories according to their usage patterns, thus, in the cross case analysis, the unit of analysis was the type of user: continuer (6), discontinuer (5) and non-user (4). The distribution of each case according to year of residency training is found in Table 4.12.

Table 4.12

Cases According to User Type and Year of Residency

User Type	Postgraduate Year (PGY) PGY1	PGY2	Total
Continuers	3	3	6
Discontinuers	2	3	5
Non-users	2	2	4

Note. PGY1 = first postgraduate year of training; PGY2 = second postgraduate year of training.

The following themes emerged from the 3 cases (continuer, discontinuer and non-users): factors that impacted the use of the App, role of the App, motivation to use the App, use preference and acceptability.

In addition, from the case of continuer users 3 themes were unique for this group: threats to use the App, IAM questionnaire barriers, and role of alerts.

Participant responses, classified by case, often addressed various aspects. Sometimes indicated convergence and other times divergence. Qualitative data of the themes across the cases with their corresponding excerpts can be found in Table 4.13.

4.4.2.1 Theme 1: factors that influenced the use of the app.

The factors that influenced the use of the App among continuer users were related to conditions that maintain and increase the use of the App. Continuers were particularly interested in having access to clinical information (Participant 1) and push notifications (Participant 12). To quote the residents themselves:

"I want to go access information when I need it. For this app also my comment will be, I would like to have access to all the information". (Participant 1)

"I think the clinical information is what gives value to this app. But from the other side, it's really nice to have those objectives". (Participant 1)

"I double checked my settings which said that the app is authorized to send me alerts". (Participant 12)

Continuers valued the content the App provided. Some of them noted that some links did not provide more clinical information, and they assumed the content was in the process of being uploaded. This is one example:

"I didn't know yet that it was gonna be so, I started to kind of clicking around and there was nothing up yet. 'Cause I did start looking at it after… There was the first link, the abdominal pain that was uploaded. But it was fairly easy". (Participant 2)

In terms of push notifications, continuer users were not receiving the push notifications, as was the case for most participants at the beginning of the study. They expected to receive push notifications and some comments suggested that their intent to use the App might have been related to the push notifications.

"I mean I like the idea of this app. It seems like a really good idea and I'm really excited to be able to get it. I didn't get the weekly reminders, but I think once I start getting those, I would probably use that to start studying around each topic". (Participant 6)

However, not all saw this in the same way. One participant's comment was:

"Probably not 'cause an app is telling me that this week it's this topic, which is arbitrary, doesn't make much sense to me". (Participant 7).

The push notifications were not received by all continuers. To some extent, this may have influenced the use of the App by the continuers however the content was likely the factor that fueled App use among continuers. This continuer said:

"First of all the alerts, 'cause by the time I got the app I was too far in for the weekly alerts to start. The other thing is the clinical information inside the app, not every topic had it and if there was more of that, it would be much more useful, if there was more to find… that would be a much more useful resource". (Participant 12)

In contrast, the factors that influenced the use of the App by the group of discontinuers and non-users and were considered as barriers to the point that they completely stopped using the App were: user interface issues, technical issues and lack of support.

With respect to user interface issues, the first issue that emerged was related to the channels. Discontinuers commented on channels (Participants 4 and 14) and also to the links highlighted in blue in the Key Features Page (Participants 5 and 15).

"I did have to try multiple times. I wasn't initially sure about the channel, the channel 99 I think, versus the other one". (Participant 4) This participant meant compared to McMaster channel.

"I guess I have a question about what the channels really are and if that is something that would be applicable to what we're using this app for, because it's such a prominent button on the bottom of the screen. I didn't know if it's something I should be trying to figure out what it's used for or if it's just background setup information. If that's the case maybe an actual button for it may not be necessary. I don't know". (Participant 4)

This issue might be related to the way the channels were labeled; one channel indicates the setting—McMaster)—whereas the other says "99 Weeks", which is related to McGill. Second, once the user enters the Topic page level, the tab on the lower right corner was labeled "Channels"; however its icon corresponded to the "settings" icon.

When this discontinuer was asked how she understood the highlighted text she answered: *"I just thought it was highlighted like really important stuff. So I don't know".* (Participant 5)

And a non-user expressed:

"I remember it was a list of information, like the key features and I guess… I think it must have been on black text or something where it just didn't occur to me that it was clickable, so I probably wouldn't… I guess if it was a different color or something it might have occurred to me to click on it, but it's like a hot link that would take me to a different page". (Participant 15)

The next issue that emerged had to do with technical issues, such as failure of push notifications, the App closing once it was opened, and some external links failing to work. Discontinuers commented:

"So when I stopped getting those push notifications, at some point I kind of lost track of when I was looking at it, and it wasn't as useful to me then, to kind of continue my studying" (Participant 14)

"I don't get the notifications, weekly notifications, I don't know for what reason". (Participant 9)

"So I was waiting and waiting and I don't think I got a weekly update. So I'm not sure if I missed it or…" (Participant 5)

"I think it's a very good app, it's useful. Maybe send out an email if… I don't know if it's freezing. Like if you notice people are using it and then they stopped for a month…" (Participant 10)

"I didn't really use it that much because it wasn't working. I, myself, would have been interested in using it if it was working". (Participant 13)

"I also tried to get into like the ACLS several times, the guidelines, and every time I try I don't get to the…hyperlinks." (Participant 14)

User interface at the beginning of the study was a factor that may have decreased the use of the App, followed by some technical issues. It seems that the most relevant technical failure was related to the lack of receiving the push notifications. Furthermore the case of discontinuers seemed to be likely to stop the use of the App, when they faced these issues.

In addition, the last factor that seemed to prevent these participants from continuing to use the App was likely a perceived lack of support related to system failure and device platforms.

"…but it was only like a couple of weeks before the actual exam where Dr. "A" showed me I should just delete it and redownload it". (Participant 15)

"My device is not very conventional. It's a jailbroker let's called for my own purposes, for modifying things. Usually it doesn't influence any apps. It just allows to modify other things on the system. But in this case, for some reason, I can't enable notifications for this app in particular. I don't know why". (Participant 9)

Other factors that affected the use of the App among non-users and prevented them to use the App, in addition to technical issues and lack of support, was the launching process.

"I remember trying to log in afterwards, once I had gotten more into my studying and I couldn't, it had crashed or it was blank or something like that. And that's why I deleted it. It wasn't just because I hadn't initially participated, because I still would have taken advantage of the fact that I had the app and I could have used it to track my studying. It was the fact that it was blank". (Participant 15)

The last part of the preceding comment suggests that another important aspect that might predict potential non-users of a system in advance is/have prevented users from using the App at deeper levels (Clinical Info Page) is the lack of support at early stages. Prompt communication might prevent this kind of issue.

"I probably would have emailed Dr. "A" and just confirmed that this was happening, but because I had tried a few times and I thought I wasn't part of the study anymore… I just kind of assumed: I probably just don't have access to this anymore. I assumed it was because I wasn't part of the initial interview". (Participant 15)

One non-user showed a degree of techno-phobia. For this participant, likely the type of support required was personal assistance to solve this problem.

"I don't know…I think what prevented me from installing it was the daunting task of putting it on my phone, because I'm really not good with technology". (Participant 8)

Even though this non-user intended to start to use the App, and assistance was provided during the interview, usage did not happen.

In conclusion, for continuers content was the main aspect that increased the use of the App. Although the 3 cases were not receiving the push notification at the beginning of the study, this issue was not a limitation for continuers to continue using the App. Likely, receiving the notifications later on, was the factor that maintained the App use during the study.

In contrast, for the cases of discontinuers and non-users, the lack of push notifications (one of the many technical issues), was one of the main barriers to affect their use of the App. Also, lack of support was reported by discontinuers and non-users, although the type of support varied in both cases. Some residents needed more instructional support specific to the functioning of their smartphones platforms and others regarding constant updates of the software. For example, non-users demonstrated that if potential users encounter a technical issue or lack of support early on, they were more likely not to use a system.

If I had known that there were those features, I definitely would have been very motivated to click on them. I guess maybe a pop up or something, just letting me know…".
(Participant 15)

4.4.2.2 Theme 2: role of the app.

All 3 cases agreed that the App had the role to deliver content at intervals, resulting in spacing learning over time. The comments of continuers (participants 1, 7) discontinuers (participant 9) and non-users (participant 8) presented below support this aspect:

"OK. So you guide the speed… the delivery". (Participant 1)

"I would click on it and I'll read the topic of the week definitely, I guess for my own kind of study purposes, now a topic a week is nice now, but closer I get to the exam, it's gonna be a topic a day". (Participant 9)

"Just more of a consistent way of just signalling all the topics in advance". (Participant 8)

All cases perceived the App's value to deliver content at intervals, which was manifested by the need to have a long term learning tool.

Additionally, continuers and discontinuers perceived that the App might have a role as a reflective tool based on the content provided and through suggested features. For example, continuers suggested that incorporating exam questions would help them think about their knowledge and their own learning after reading a topic. They explained why these additional functions in the App might enhance their thinking about their learning and help them identify their knowledge gaps.

"Yeah it would be good 'cause then you have a reference to see what did I get out of it? Did I get what I needed to… did I pay attention to it, is there more I should be reading about this". (Participant 6)

Whereas discontinuers foresaw the utility of the App as a reflective tool through a notepad feature:

"The other thing I could see, is if there would be a way to write just personal notes. Let's say you're viewing a topic, if there would be a way to just add like little notes about something. And sometimes it's clinical pearls that you saw going to a conference, you just also wanna add a little note there. Or you're reading about something, you know something that you must not forget, like a big, big red flag or maybe you can write down". (Participant 14)

It seems that these users inquired about whether it would be possible to have an additional tab or function for a notepad space, to be used to log personal notes and thoughts that might include reflective notes.

However, each case identified additional roles. For example, continuers suggested that the App might serve as an advance organizer, or to prepare for other high-stake examinations and support their study groups.

First, the App might initiate and help residents to organize, plan, and schedule their own preparation process:

"If I were to base my preparation on this app, 'cause it's always nice to have one structure and you just follow with information". (Participant 1)

"I think it will help give me structure and make sure I hit the key points I should". (Participant 7)

"I was hoping that it would function as… Two things: I was hoping for a guide, and I was hoping for something to tell me what I needed to know. I see it makes a great guide and there's lots of links in there". (Participant 7)

Second, continuers also considered the App to be potentially supportive of their studying for other high-stakes exams:

"…at the end and we're gonna have to do MCC II as well, plus the final exam at the end. So in terms of MCC II there's a station about physical exam as well… So if the purpose is really to help prepare, I mean maybe a section about physical exam, like let's say you go to hypertension and then you have a link to physical exam about hypertension, like you go through the list of OSCE style, how we would go about doing an exam for hypertension". (Participant 3)

In fact, the App was used among peers:

"We could sit down as a group and see really what the key points that we have hit more and make sure that when we go through a set of material we make sure to hit those points". (Participant 12)

In contrast, discontinuers described its role in clinical practice and as a feedback aid.

First, it seems that these users found the App might be able to support specific needs during patient encounters:

"What I find in the app useful for, is in terms in interviewing on what subjects should I touch. Like is there anything I missed during my interview or is there anything else I should have asked for complaint. If I'm looking at the clinical features, it's very helpful for that". (Participant 14)

Second, the same participant found that the App might help clinical teachers during patient encounters to discuss a case and provide feedback to residents:

"I would actually think that would be useful for teachers, like our supervisors as well in terms of if you review a case with them, for them to double check what else could you have asked the patient, what else could you have done in a visit about that problem, in terms of asking questions or investigate or think about investigating". (Participant 14)

In the end, although discontinuers stopped the use of the App at some point during the study, they foresaw different potential roles for the App.

In the case of non-users, they did not comment on a different role for the App. Even though these users could not have had much knowledge about the App's function, or much experience with it, they understood its main educational purpose and confirmed that the App has potential to space learning and deliver content over an extended period of time.

4.4.2.3 Theme 3: motivation to use the App.

The main motivation for all 3 cases seemed to be related to the timing of the exam. For example, one continuer user's answer to the question concerning what had encouraged him to use it more was:

"To have the app come earlier, like in R1, I think I would have been more prone to sit down and look at the weekly topic". I do not really have anything and I feel pressed to start studying now, but this is like here this weekend maybe I'll just take the extra time to look at this topic 'cause it's there". (Participant 7)

A non-user shared the same opinion:

"To study later probably not. Not when it comes down to crunching at the end". (Participant 8)

This participant meant that they would prefer to use the App in advance instead of having to study all the content when examination dates were closer.

In contrast, a representative comment from discontinuer users was:

"I am still kind of far away from like actively studying. But I think when the time comes". (Participant10)

It seemed that each case had different timing plans to prepare for the test. Some used the App earlier and others later with respect to the time they would be prepared for the exam.

4.4.2.4 Theme 4: use preference.

Three themes punctuated the user preferences: how the users used the App in relation to traditional learning materials; what content was mostly used; and what was the preferred approach (individual or collaborative) to prepare for the exam.

With respect to the usage of the App in relation to other learning resources, continuers (participant 1) and non-users (participant 6) both preferred to use the App as a primary resource

to study, followed by other learning resources. They explained:

"I would always go first to your source and then fuel from all the sources when this is insufficient". (Participant 1)

"It has… from what I've seen a lot of information, so it can kind of guide you how to study, but then you might need a few little extra resources to kind of add to what the app gives you". (Participant 6)

A non-user also commented in the same way regarding the use of the App:

"If it doesn't provide me the adequate information, I'll know that I have to look it up somewhere else, but at least it gives me an outline". (Participant 8)

For these users the content the App provided seemed enough, to start preparing for the exam and furthermore, to facilitate content selection from other learning resources.

In contrast, discontinuer users preferred to use the App as a secondary resource after using other learning resources:

"Certain topics I was going through, so the way I was using it as I was studying was let's say we got a push notification, then that week I would look up this or read more about this specific entity in terms of my learning. Then, I would kind of glance over the key clinical features to kind of decide what's more or less important". (Participant 14)

"*I think at first I was just reading the "A" Notes, but then I kind of realised that it might cover some topics…with the App".* (Participant 13)

The second aspect related to use preference had to do with the preferred levels of information in the App. Users relied on both the Key Features Page and the Clinical Info Pages. For example continuer users preferred to focus mainly on the Clinical Information level as a guide to prepare for the exam, according to the content found and required:

"I focused most of my time on the one that had data there. I didn't keep going and looking at the objectives 'cause I had seen some of the stuff previously, like what the ninety-nine topics were. So I didn't feel at that point that I wanted to overwhelm myself with objectives lists. So I just focused more on the data that was there, that had been uploaded". (Participant 2)

However, discontinuer (Participant 14) and non-users (Participant 15) focused mainly on the Key Features Page level as a way to organize and track their learning. These were their comments, respectively:

"Yeah, I was looking at the Key Features for most topics". (Participant 14)

"*So I was using it mainly for key features".* (Participant 15)

It seemed that these users' goal was to ensure that they assessed the objectives established by the CFPC (this is the type of content uploaded in the Key Features Page).

The third aspect related to user preference concerned the approach to preparing for the exam (individual and collaborative). In all 3 cases, participants considered to use the App for individual purposes. Comments made by a continuer (Participant 6), discontinuer (Participant 13) and non-user (Participant 8) are presented below:

"I think the app would guide me". (Participant 6)

"I didn't study in groups so I think there were some people studying in groups so they at least could tell what a few of the people did, but I was more on my own". (Participant 13)

"I'd like to know what I need to know". (Participant 8)

However, continuer users also found that the App might have a collaborative learning purpose in their approach to exam preparation as some planned to use the App in study groups.

"The first thing that struck me when I saw the information available on the app was that it would be really useful to use it in context of a study group more than studying alone".

(Participant 12)

In conclusion, whereas continuer users demonstrated that they were more autonomous in using the App and discovered different ways to use it, discontinuer users and non-users seemed to prefer to use the App independently to prepare for the exam. A discontinuer user (Participant 14) and a non-user (Participant 15) felt they did not make the most of the App:

"I think there's definitely a role for the app in terms of preparation. And I think more than what I have done". (Participant 14)

"Yeah and I don't think I ever did… like hit any of those". (Participant 15)

4.4.2.5 Theme 5: acceptability.

All three cases provided descriptions related to acceptability of the App. Aspects such as ease of use, effectiveness, aesthetics, portability and satisfaction were highlighted by participants. These aspects are part of the usability framework explained by Nielsen (2004).

For example, continuer users reported on the App's ease of use, installation, launching, and intuitive navigation.

"Every time there was a link, it went very smooth". (Participant 3)

"*I don't have any issues using it. It's really very simple, very easy to understand, to get everything. I had no problems at all".* (Participant 6)

"It's an intuitive app with all the topics and just reading and following… It was pretty straightforward" (Participant 9)

Discontinuers expressed:

"I think it's a very good app, it's useful". (Participant 10)

"I think overall it's a useful tool to have". (Participant 13)

A non-user discussed:

I think this was a very useful app for keeping track of which topics you have studied and which ones were left. (Participant 15)

Other comments were related to aesthetics:

"I find the App very clean. I really, really appreciate that. Few medical apps that I installed that were not clean, that were not user-friendly you didn't know where you were going. Their information looked really great, but it was too hard to navigate". (Participant 12)

"I liked the design of the app". (Participant 7)

Continuers valued the App's design when they compared it to other available apps. They also commented on its portability.

"Your phone is always with you too. I guess you always have access to the information you want". (Participant 6)

Continuers discussed the App's facility to find clinical information in a timely manner and under different circumstances.

"*It's handy when you're at the hospital. I mean we have access to A, B databases and other things on a hospital computer. But when you're not here or you wanna look for something else and you don't have access to one of those computers".* (Participant 12)

"It's very accessible and you can use it even if you have a few minutes to sit down 'cause your phone is always with you. I guess you always have access to the information you want".

"I liked the accessibility of the information surrounding the 99 topics". (Participant 6)

Also for discontinuer users portability seems to be an important aspect:

"It's much more available. I have the phone with me all the time and it's a good way to keep that there, at the fingertips. It's great". (Participant 9)

The fact that their phones are available to them all the time allowed participants to use the App in any particular circumstance and helped them to meet individual goals. This seemed to be particularly important when time constraints were factored in.

"I would say like 90% of the time, I am busy doing something...". (Participant 10)

Residents encounter different medical problems anytime, anywhere, they need tools to help them resolve issues on the spot. Also, under different circumstances, they try to make the most of any moment to review or just read clinical information to build knowledge or prepare for their exam.

"I was actually sitting in the emergency room at the Children's Hospital, 'cause I had to take… my son was very sick, and I was sitting there reading through the 99 topics 'cause I'd lost a study day and it was luckily… I was thrilled that the app was with me and I could at least get something done in the emergency room". (Participant 12)

With regards to other aspects mentioned, all cases expressed satisfaction and pleasure while using the App. Continuer users expressed:

"In general, I appreciated the app. I used it to study for my exam". (Participant 11)

"I enjoyed using it". (Participant 12)

"Thank you for creating this app and giving us the opportunity to use it". (Participant 11)

Discontinuer users also share the same opinion:

"I think it's a very good app…" (Participant 10)

And non-users also indicated that they would likely embrace this tool:

"The idea of the app was great". (Participant 13)

To sum up, all cases had a good experience with the App, regardless of the factors that influenced their use. All cases shared some components of theme 5 and differed in other

aspects.

In conclusion, several roles of the App emerged from these cases which enriched the results and strengthens the future potential of this App. In general, all user groups demonstrated high levels of motivation to use the App.

Among all cases, residents were open in describing the learning resources they were using or planned to use during their preparation for the examination. Residents used traditional learning materials and usually made reference to notes, books, and online resources. They demonstrated that the App could support those traditional learning resources in different ways, regardless of whether the App was used as a primary or secondary resource. Also, regardless of the way they used it or would use it, they all had individual approaches to learning and scheduling the right time to start their preparation for the exam.

Table 4.13

Qualitative Data Excerpts by Themes across Cases

Theme	Continuer users	Discontinuer users	Non users
1. Factors that influenced the use of the App	*"First of all the alerts, 'cause by the time I got the app I was too far in for the weekly alerts to start".* *" The other thing is the clinical information inside the app, not every topic had it and if there was more of that, it would be much more useful, if there was more to find… that would be a much more useful resource".*	*"I was using it at first, was really for me the alarms and push notifications to kind of guide me, like this week I'm gonna read about this. And it reminds you about reading about something. So when I stopped getting those push notifications, at some point I kind of lost track of when I was looking at it, and it wasn't as useful to me then, to kind of continue my studying"* *"Maybe send out an email if… I don't know if it's freezing. Like if you notice people are using it and then they stopped for a month…"*	*"I remember trying to log in afterwards, once I had gotten more into my studying and I couldn't, it had crashed or it was blank or something like that. And that's why I deleted it. It wasn't just because I hadn't initially participated, because I still would have taken advantage of the fact that I had the app and I could have used it to track my studying. It was the fact that it was blank".*
2. Role of the App	*"I think it will help give me structure and make sure I hit the key points I should".* *"We could sit down as a group and see really what the key points that we have hit more and make sure that when we go through a set of material we make sure to hit those points".* *"I know as we do our rotations, there is a lot more than we wanna read about based on the cases we see, but just to have one topic for the week*	*"What I find in the app useful for, is in terms in interviewing on what subjects should I touch. Like is there anything I missed during my interview or is there anything else I should have asked for complaint. If I'm looking at the clinical features, it's very helpful for that".* *"I think there's definitely a role for the app in terms of preparation. And I think more than what I have done".* *"I would actually think that would be useful for teachers, like our supervisors as well in*	*"Support the learning, in advance. To space out my learning".*

	to kind of also focus on, I think that would be a good way to study".	*terms of if you review a case with them, for them to double check what else could you have asked the patient, what else could you have done in a visit about that problem, in terms of asking questions or investigate or think about investigating".*	
3. Motivation to use the App	*"To have the app come earlier, like in R1, I think I would have been more prone to sit down and look at the weekly topic"*	*"I am still kind of far away from like actively studying. But I think when the time comes, I will start to use it"*	*"To study, probably not. Not when it comes down to crunching at the end. But just more of a consistent way of just signalling all the topics in advance".*
4. Usage preference	*"I would always go first to your source and then fuel from all the sources when this is insufficient".*	"*I think at first I was just reading the "A" Notes, but then I kind of realised that it might cover some topics…with the App".*	*"I would look at the actual 99 topics to see what they actually… so I could have a better idea where I should focus on".*
5. Acceptability of the App	*"I liked the design of the app".* *"In general, I appreciated the app. I used it to study for my exam".* *"I enjoyed using it".* *"Thank you for creating this app and giving us the opportunity to use it"*	*"It's much more available. I have the phone with me all the time and it's a good way to keep that there, at the fingertips. It's great".* *"I think it's a very good app, it's useful".*	*" I think overall it's a useful tool to have"* *"The idea of the app was great".*

4.4.3 Task performance results.

The task consisted in retrieval of clinical information on a random topic. The time taken to complete the task was recorded along with the resident's preferred search method. The aims

were to assess whether they had recognized the two techniques available to search for a topic in the App, to identify which method they preferred, to find technical or interface issues, and to observe how they interacted with the App. This task was conducted at the end of the first and second interviews and 10 participants were selected to perform the task.

The topic to search for interview phase 1 was hypertension and for interview phase 2, (additional interview) was prostatitis. Table 4.14 summarizes the results by user type, preferred search method, and average time spent on this task. First choice refers to the first method the user chose to perform the task. The second choice was the alternative option compared to the first method used.

Table 4.14

Task Performance, Searching Method

User Type	Scrolling as First Method of Searching	Scrolling Method Average	Search Box as First Method of Searching	Search Box Average
Continuer Users (5)	3	6.3 sec	2	8.5 sec
Discontinuer Users (4)	2	5.7 sec	2	14.5 sec
Non-Users (1)	1	12 sec	0	0 sec*
Total	6	8 sec	4	11.5 sec

* Not performed due to technical issues with this participant's device at the time the task was begun using the alternative method.

A total of 6 users preferred scrolling down as their first method to search for a topic, with an average task completion speed of 8 seconds. A total of 4 users preferred to use the search box as their first method to search for a topic, with an average of 11.5 seconds. The majority of users preferred to scroll down instead of using the search box. Some participants experienced the

search box option differently. Although several users had noticed the search box previously but not used it, some chose it as their first option to complete the task expecting it to be faster than the scrolling method. They relied on the shortcut feature in the search box:

"I have never used this search before". (Interview 1, participant 4)

"I would probably have just scrolled it and then it would have been faster" (Interview 1, participant 5)

"I knew that scrolling would probably be faster". (Interview 1, participant 2)

"It would have been even faster using the box, 'cause I would have just typed the first five letters then it gets to it". (Interview 1, participant 2)

This task gave the residents the opportunity to become aware of the limitations of these methods for searching for a topic, and to find the technique that suited them best. It also allowed us to identify a feature of the search box that could be improved according to residents' needs and expectations.

Regardless of users' first choice when searching for a topic, all users spent less time when they scrolled down compared to typing in the search box. In all cases the task's duration time increased when it was performed using the search box. This could be due to these users' adaptation to using digital resources to find clinical information, as this user stated:

"That would help, because I'm spoiled in that sense 'cause on "A" database that's like my gold standard. Even when I text, I'm so used to autofill, like I'm not used to typing in complete words. (Interview 2, participant 8)

"I'm so used to Google where I type three letters and it pops up the word I want. I don't know if that's a possibility, but if I type HYP, it doesn't pop up". (Interview 2, participant 10)

Another reason might have been the degree of their familiarity with smartphone services

which would have allowed them to transfer the knowledge of using smartphone features to the way they used the App:

"Sometimes when you have your contacts on your phone, you can scroll between A, B, C, D, and go like that a bit faster". (Interview 3, participant 14)

Regardless of the method they used, the most important factors for residents were practicality and the speed with which they could find clinical information.

4.4.4 Participants' suggestions.

Throughout the interview, several suggestions emerged, primarily related to the App's features. These recommendations were selected according to the comments and the perceived relevance for participants and they provide important information to improve future versions of the IAM App. Table 4.15 summarizes suggestions made by the three types of user in 3 parts: the first column lists the feature of the App related to the suggestion. The second column contains the suggestions drawn from the interviews. And the third column provides excerpts that support each suggestion.

Table 4.15

Summarized suggestions for the IAM App

Feature	Suggestion	Excerpt
Tabs	- Size of the tabs located at the bottom of the screen	*"I do think the buttons are quite large. I think that it's unnecessary for them to be as large. I actually clicked on them to see "Oh, am I supposed to be using them because they're so large?"* (Discontinuer user)
	- Channel tab might be labelled "Settings" in keeping with the icon	*"I wasn't sure if it's because the bottom bar of the channels versus topics, if that was more of an issue".* (Discontinuer user)
Tracking Usage Activity	- This process might be made transparent for the user (the App will not close or return to the main menu after a period of inactivity)	*"I didn't like the way the app times out. So the way the app works is when your screen goes… if you're sitting and reading something and if it's lengthy and it's longer than your blackout time on your screen, and then you turn your screen back on, it automatically takes you back a page".* (Continuer user)
Alerts	- Tracking access date	*"It was interesting to have the date when I consulted certain topics".* (Continuer user)
Questionnaires	- Decrease the frequency of the questionnaires by prompting after completing the topic	*"I would prefer to answer those questions right after I've looked through the topic. So I would give you a more valuable feedback".* (Continuer user)
	- Indicator to track the number of questionnaires to complete	*"I think the top right had earned credits and maybe the top left could have the questionnaires you still have to do".* (Continuer user)
	- Feedback comments might be tracked anonymously	*"I don't think I filled out any comments. "So, maybe under abdominal pain I should have included a comment".* (Continuer user)
Content	- Percentage or indicator of the amount of content revised per topic	*"If there is a day marked there that means that I fully completed reading that topic, rather than just starting and briefly have seen it and not… didn't read the whole thing".* (Discontinuer user)

	- Opportunity for residents to participate in content building or updating process	*"I think the residents have a place to write information".* (Discontinuer user)
	- Opportunity to have access to images	*"It brought up a lot of the imaging modalities that are the most useful for them" (*referred to residents practicing ultrasound techniques). (Continuer user)
	- Consider increase amount of content"	*"With more clinical information links inside, so it would unfold more like a textbook that you could read through rather than go through it and then start reading through 4 other resources to get your answers".* (Continuer user)
Other Functions		
-Shortcuts	- Preferable for search box to function with shortcuts	*"So to make this easier for me, I'm so used to Google where I type three letters and it pops up the word I want".* (Discontinuer user)
-Technical Issues	- Possibility of reporting technical failures.	*"Just a screen shot and saying "link not working" if that will be sufficient…"* (Continuer user)
-Exam Questions	- Opportunity to test their knowledge	*"So like you have the content tab and channel tab. You can add like a quiz tab or a test tab, generate quiz or test, you can load the database of questions and then randomly select questions for different topics".* (Discontinuer user)
-Notepad	- Notes space to take personal notes and register information that would help them to organize their learning	*"It would tell me other forms of notes sets to tell me… not just what topics I need to know, but what the information within those topics that I need to know is".* (Discontinuer user)
-Indicator	- Notification or mark of any change made.	*"On each page, like at the topic or the bottom could just say last updated, with the date…"*(Discontinuer user)

4.5 Summary

This chapter has provided the results of two components. First, the tracking data from log files (usage and questionnaires) and second, interview results (cross-case analysis, and task performance). The tracking data analysis found that different factors motivated residents' App use: uploaded clinical content, proximity of exam dates (which suggests when residents increased their exam preparation), the day of the week that reflected most frequent access of the App (Friday, Sunday and Wednesday), and the most and least common accessed topics.

The data from IAM questionnaires revealed that several factors negatively influence their use. However, questionnaires showed that the App might have in the future other educational roles. Interview results identified three categories of cases: continuers, discontinuers and non-users of the App and themes corresponding with usage patterns. The themes themselves were unique, however, the content of each theme changed from one case to another. The common themes included the factors that influenced the use of the App, role of the App, motivation to use the App, use preference and acceptability of the App. In addition, multiple suggestions emerged throughout the interview phases.

This information will be considered in order to improve future versions of the IAM App. Task performance showed that familiarity and quick access were determinants to choose one or the other searching method.

CHAPTER 5

Discussion

This chapter starts with the discussion of results in relation to our research questions, followed by description of the lessons we learned from our findings. Strengths, limitations, and suggestions for future research are discussed, and a conclusion is provided.

5.1 Discussion of Results

To sum up, results based on tracking data showed that participants could be identified as continuers (those who persisted in using the App), discontinuers (those who started using and stopped), and non-users (those who never tried to use the App). Also, 5 themes emerged from interviews: factors that influence the use of the App, role of the App, motivation to use it, use preference and acceptability of the App. These themes provided us information on the factors that increase and decreased the use of the App, usability issues, and several suggestions to improve the App.

With regards to our research questions, the first research question addressed the usability of the IAM among family medicine residents. Results showed that participants could be identified as continuers, discontinuers, and non-users. To the best of our knowledge, few usability studies have identified usage patterns. For example, one study on the use of smartphones identified only users and non-users of smartphones (Verkasalo, López-Nicolás, Molina-Castillo, & Bouwman, 2010). Also, there were differences among residents' use of the App, which could be influenced by residents' postgraduate year of training (first year vs. second year), their workload, and learning autonomy, remoteness of location of their practice, notification traffic, or wireless connectivity. To our knowledge, no usability study on mobile apps has discussed factors that impact users' decisions to continue, discontinue, or not to use a

system in the context of medical education. Therefore, our study's findings contribute to the broader understanding of usage behaviors with respect to the use of a mobile app, and add to the existing literature by identifying and defining three different usage patterns.

Results also showed that individual needs, time frame and learning strategies, were the main factors influencing App use. However, proximity of exams dates was the most important factor in sustaining App use. Residents' comments on these aspects, demonstrated their capacity to reflect on their learning needs, and plan when and how they would schedule their preparation. Our findings confirm previous research on self-directed learning among family physicians. One study found that family physicians are more likely to be self-directed learners compared to other populations (Fox & Bennett, 1998).

Our finding that failure to delivering push notifications and lack of technical support, negatively impacted residents' decisions to continue or start using the App. This finding reinforces the notion that push notifications are beneficial. Despite the literature's inconsistency with regards to the negative and positive consequences of push notifications, this study supports the evidence which argues that notifications from mobile devices have positive effects when those notifications are of the interventional type (Spiller, Vlasic, & Yetton, 2007) . This means that timely notifications that are relevant to users' tasks can contribute to work quality, learning, reorientation of attention, and motivation. By contrast, intrusive notifications that are irrelevant to users' primary activities have been proven to disrupt user activity and divert their attention (Czerwinski, Cutrell, & Horvitz, 2000).

We found only one participant perceived the delivery of push notifications as constraining to their freedom by suggesting what to study. This justifies further research into the role of push notifications and into individual perceptions of the use of handheld devices. It is also

important to note that even though most of our users were familiar with apps use in clinical practice, and they belong to the generation of "digital settlers" who have embraced and quickly adapted to changes in technology (Robin, McNeil, Cook, Agarwal, & Singhal, 2011), they still encountered issues that they could not resolve on their own. While our study provided some insights with regards to App use, it did not shed light on other factors. For instance, we still do not know what is the optimal frequency to deliver push notifications or how and when it would be ideal to provide users with technical support.

One of the questions posed to the residents elicited several suggestions for improving interface issues, a point underscored in existing studies on mobile apps' usability (Buchanan et al., 2001). This aspect of our study offers a fresh perspective, thanks to residents' insights on the usability issues that mobile device users are currently facing.

Another unexpected finding was the lack of feedback provided by residents through the use of the IAM questionnaires. This suggests a new area to explore, namely how to improve or incorporate features into apps to obtain user feedback. Besides this, to our knowledge, no mobile app has been documented as having a feature that offers a structured opportunity for users to freely express their opinions about the information they have read.

The second research question addressed the future possibilities for the IAM App in preparing family medicine residents for their board certification. The results of this study are timely and informative in terms of exploring different services that mobile apps might offer in the context of medical education.

Another finding that frequently emerged from interviews was, that the App facilitated the selection of topics and levels of information that residents preferred to read for the exam. Research on the services provided by mobile apps has been extensive (Ozdalga, Ozdalga, &

Ahuja, 2012), but only a few have been used in medical training to promote continuing medical education. For example, a systematic review found only 4 mobile medical training apps by 2012: two apps were designed to provide knowledge about specific medical conditions and provided CME materials. The other two were designed to improve performance scores in resuscitation skills in a simulation environment (Mosa, Yoo, & Sheets, 2012). Moreover, these apps were only available for iOS smartphones.

By contrast, in our study the IAM App was used to prepare for a high-stakes exam; it was conducted in a real life context, the App was made available for multiple operating system platforms, and our results provide new insights from the perspective of postgraduate medical training. This study is also in alignment with the intention to promote CME. Although, the tab at the top right of the App, was labeled as "Earn credits", it did not provide real CME materials, due to this study's purpose. Future studies might consider integrating this feature.

One piece of information that emerged from several interviews, and which was rarely found in the literature, was the integration of the App into both traditional learning resources and different study approaches (individual and collaborative learning). This finding supports previous research involving family physicians. For instance, one study found that family physicians use multiple sources of information to best meet their learning needs (Barrett, 2014). Additionally, these results support studies on the effects of mobile apps to support learning. For example, one study on the use of PDAs among medical students demonstrated that when using a mobile device, learning occurred through repetition, consolidation of knowledge, and reflection (Davies et al., 2012). Sandars (2009) defines reflection as, "a metacognitive process that occurs before, during and after situations with the purpose of developing greater understanding of both the self and the situation so that future encounters with the situation are informed from previous

encounters" (Sandars, 2009). Steward et al. (2000) showed that reflection can enhance quality of care by improving therapeutic relationships. This aspect positively impacted patient satisfaction and chronic disease (Stewart et al., 2000). Therefore, reflection is an essential aspect to foster during medical training. This finding is confirmed by our results on the App's potential to provide the opportunity to space learning over time, and its potential to encourage reflection. In fact, this study's unique additions to the literature include the incorporation of the IAM questionnaire as a tool to stimulate reflection.

In general, residents' initial experience using the IAM App was positive. The App was considered intuitive, useful, and easy to use. This finding confirms previous evidence that usefulness, ease of use, aesthetics, effectiveness, and satisfaction are essential to system acceptability (Nielsen, 1994). Trainees and healthcare providers have regularly used and overwhelmingly accepted handheld devices in clinical practice as shown by previous studies conducted on PDAs (Kho, Henderson, Dressler, & Kripalani, 2006; Omori, Wong, & Nishimura, 2013).

However, due to limitations of the PDAs previously documented (Kho, Henderson, Dressler, & Kripalani, 2006a), some studies called for urgent initiatives to continue research on the use of smartphones to promote learning (Burdette, Herchline, & Oehler, 2008; Davies et al., 2012). The present study contributes to our understanding of the new roles of mobile apps in learning, as an adaptation guide, and other educational benefits that have been foreseen for PDAs in medical training (Kho et al., 2006).

This study targeted family medicine residents. These residents are the largest single group of physicians in North America and studies regarding their learning needs and urgency to support their preparation (Committee, 2004) have been limited and few.

5.2 Lessons learned

This study provided several contributions at the following levels:

Information systems technology

The first lesson that must be considered is the cost of this type of technology. Not only, is an initial investment required, any modifications or add-ons will result in additional costs. Also, costs grow as additional design and technical expertise is needed during the development process. However, one way to overcome this barrier is to design an App based on a flexible software system that allows using the App for other purposes.

Another aspect that we learned, was that the App's display screen colors, discrete tabs and function features (in terms of screen space), small tabs, few colors and features that are displayed only when the user needs them, led the App to be considered "user friendly" by residents.

Although modern technology, particularly related to targeting different platforms will favor the use of this App, we realized that a strong network connection is an important factor for the optimal functioning of the App. For instance, during the first interview sessions, the coverage of Wi-Fi in hospital was adequate for some users but not for others. The increasing use of smartphones indicates wider acceptance of mobile technology. However, the capacity to provide and improve connectivity is not keeping pace with the needs of health professionals.

Postgraduate medical education

We learned that understanding residents' particular needs, as opposed to the needs of other potential users of this App, will contribute to creating new instructional approaches in Family Medicine and to building new mobile apps to support teaching and promote life-long learning. Another aspect we learned is that clearly, users need a better means to provide feedback

through the App. For example, only one resident provided a constructive comment through the IAM questionnaire. It might be that this approach was not the best way to obtain written feedback from residents. The suggested action would be to track feedback comments anonymously. In this way, we might ensure a safer environment for residents to provide comments.

Overall, we foresee that residents have a heavy burden of clinical duties and are under time pressure. Thus, it is important to take into account that residents work flow and environment present some challenges to the App's use.

5.3 Strengths, limitations and future research

Strengths

This is the first medical App designed with the ultimate goal of helping residents prepare for the board examination. In addition, unlike other medical applications or mobile learning technologies, this App achieved the purpose of serving as a reflective tool, using the questionnaire as the mechanism for this. This constitutes one of this App's greatest values, due to the importance of reflection in the medical profession (Nguyen, Fernandez, Karsenti, & Charlin, 2014).

In terms of technological infrastructure, this App demonstrated that it can accommodate the latest mobile operating systems and furthermore can be adaptable to mobile platforms used by residents. This aspect facilitates possible future demands related to the App, such as maintenance, version updates, content uploads or features modification. Also, the back-end of the App is easy to use and reliable, and allows downloading data for analysis of page hits.

In conclusion, this research provided a rich picture of how mobile apps in medical education could be used and assessed. Also, this study gave us greater insight into the collective

needs and internal factors that might facilitate or challenge the use of general apps and the future of the IAM App.

Limitations

As a foundational study several limitations were encountered. First, the App did not run properly on the version 3.0 Android platform and some iPhone versions at the beginning of the study. Because, the back-end of the system did not log error events related to technical failures, we captured these issues through participants' verbal reports during interviews.

Second, because this project's principal investigator was present during interviews, (experimental effect), the presence of the experimenter could "influence participant responses by conveying expectations about desirable responses" (Shadish, Cook, & Campbell, 2001, p. 73). Third, participants were recruited from a single training site. This threatens the external validity of this study (participant selection). However, the sample was representative of other training sites, two or three observers conducted data collection and residents changed the location of their clinical practice every 4 weeks.

The last limitation consisted on that the small number of completed IAM questionnaires, reduced data collection on the reasons to use the App. Likely, the questionnaires' frequency, affected the use of the questionnaires.

Future research

Future research on this project has already begun, with adjustments and modifications of the IAM App in terms of design, content updates, and test questions. This next step will include the educational effects of push notifications on family medicine residents at two universities (McGill and McMaster). They will be studied over a period of two years, and the overarching goal is to measure learning outcomes using board examinations scores.

5.4 Summary

Primary care physicians are asked to become competent in a short period of time. Multiple educational approaches supported by mobile apps have the potential to improve learning retention, to promote life-long learning, and thus to help to ensure patient safety.

Residents in our study voiced high levels of stress regarding the short time they had to prepare for the exam, whereas others expressed the pressure they felt to continue building knowledge as quickly as possible. Although residents are open to try new learning tools that can support them during their study process, it is important to continue exploring the role for technological tools that align residents' needs, exam preparation, and program curricula. Although residents spoke positive about the IAM App, thoughtful design is essential for scalability. Also, organization support from bodies that represent family physicians, such as the CFPC, maybe needed to ensure the App's long-term sustainability.

Building an extensive body of evidence to support family medicine residents, and medical education in the digital era will allow family doctors to meet the needs of their patients and optimize medical training.

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Appendix A: Institutional Review Board approval

McGill

Faculty of Medicine
3655 Promenade Sir William Osler #633
Montreal, QC H3G 1Y6

Faculté de médecine
3655, Promenade Sir William Osler #633
Montréal, QC H3G 1Y6

Fax/Télécopieur: (514) 398-3870
Tél/Tel: (514) 398-3124

May 26, 2014

Dr. Roland Grad
Department of Family Medicine
Jewish General Hospital
3755 Cote Ste-Catherine
Montreal, Quebec H3T 1E2

RE: IRB Study Number A05-E48-14B
Usability testing of a mobile app for information delivery, information retrieval and data collection

Dear Dr. Grad,

Thank you for submitting the above study for IRB review.

As this study involves no more than minimal risk, and in accordance with Articles 2.9 and 6.12 of the 2nd Edition of the Canadian Tri-Council Policy Statement of Ethical Conduct for Research Involving Humans (TCPS 2) and U.S. Title 45 CFR 46, Section 110 (b), paragraph (1), we are pleased to inform you that approval for the study, study instruments and consent form (April 2014) was provided via an expedited review by the Co-Chair on May 26, 2014 valid until **May 2015**. The study proposal will be presented for corroborative approval at the next meeting of the Committee and a certification document will be issued to you at that time.

A review of all research involving human subjects is required on an annual basis in accord with the date of initial approval. The annual review should be submitted at least one month before **May 2015**. Should any modification to the study occur over the next twelve months, please advise IRB appropriately.

Yours sincerely,

Carolyn Ells

Carolyn Ells, PhD
Co-Chair
Institutional Review Board

cc: A05-E48-14B

Appendix B. Invitation email

From: Roland Grad, Dr.

To: Participants' addresses
Subject: Invitation IAM project

Dear All,

We would like to invite you to participate in a project that has been approved by the McGill Institutional Review Board (IRB). Please find below further details.

Background:

The IAM app is designed to help residents improve their clinical knowledge. Before our app can be widely used, we wish to see how residents actually use it. If you agree to participate, the app will send you a weekly alert to clinical information linked to a specific topic like asthma. In total, 99 alerts will be sent, each alert linked to one priority topic as defined by the College of Family Physicians of Canada.

If you agree to participate, we will provide an educational app for the iOS or Android smartphone. We will automatically gather information about which topics you read by tracking page hits.

Your participation requires the following:

1. Your signed consent. Once we receive your consent, the app can be emailed to you.

2. Installation of the app on your smartphone.

3. A willingness to try using the app.

4. Permission to let us analyze your usage data to identify usage patterns.

Your name will be collected along with your usage data, however, only aggregate results will be presented. You may be contacted by the study team to troubleshoot any app usage issues. This study has been reviewed and approved by the Institutional Review Board of the McGill Faculty of Medicine.

There are two steps to follow at this point:

Step 1: A simple 'YES' reply to this email will allow us to send you the consent form.

Step 2: Once your signed consent form is received at my office, the app will be made available.

Many thanks for considering this invitation to participate.

Best,

Roland Grad.

Appendix C. Consent form

Research Consent Form
McGill University

Principal investigator: Roland Grad MDCM MSc
Project title: *Usability testing of a mobile app for information delivery, information retrieval and data collection*

Investigators

Roland Grad MDCM MSc CCFP FCFP
Associate Professor, McGill University
Herzl Family Practice Centre
Centre Médecine Familiale Herzl
3755 Cote Ste Catherine Road
Montreal, Quebec H3T 1E2
Tel 514 340 8222 x5851
Fax 514 340 8300
roland.grad@mcgill.ca

David Li Tang PhD
Postdoctoral fellow
Lady Davis Institute
David.l.tang@mail.mcgill.ca

Introduction
This is a usability study of a newly developed smartphone tool (hereafter called the IAM app). This study will inform the development of a protocol for a future trial of the effect of this app on resident knowledge.

In 2010, the College of Family Physicians of Canada elaborated the 99 priority topics for the purpose of defining competence in Family Medicine as measured by their board certification examination. In addition to the weekly academic half-day that offers group lectures or workshops, through the IAM app we seek to stimulate self-learning by delivering one priority topic per week, following the method of spaced online education. This usability study aims to improve the IAM app by examining residents' use of the app to access the 99 priority topics. In addition, through individual interviews, we seek to better understand the resident experience with this tool in the context of their daily work.

Study Procedures
You have been asked to participate because you are a family medicine resident at McMaster or McGill University. We plan to track how frequently you access pages through the app to read and re-read clinical information. Factors affecting the effectiveness and ease of using the app will also be examined. Our focus is on real-world use, reasons for use, and usage patterns.

Three phases of testing are planned: 1. On adoption, 2. After two weeks of use among new users and 3. After six months have elapsed. You will be contacted for a brief telephone interview at each phase, the content of which will be based in part on your use of the app.

Potential Harms
There are no known harms associated with your participation in this research.

Potential Benefits
Study results will benefit the development of a protocol for a cluster randomized trial involving Canadian Family Medicine residents. This trial will seek to determine the effect of the app on resident knowledge.

Withdrawal
Your participation in the present study is voluntary. You can withdraw from the study at any point in time without any negative consequences.

Compensation
You will be compensated for your participation in the interviews. The amount of compensation will be calculated based on an hourly rate of $50.

Confidentiality
If you agree to participate, your total confidentiality and anonymity in the study is guaranteed. Only investigators will have access to primary data. All study information will be used for academic purposes only. Unless authorized in writing, publication of the results of this study will be done anonymously for both the individuals and organizations involved. The results will be published in a journal with a focus on medical education. On-going and final reports will be available to participants.

Consent
The study has been explained to me and my questions have been answered to my satisfaction. I agree to participate in this study. I do not waive any of my rights by signing this consent.

Contact
If you have any questions or concerns regarding your rights or if any adverse event should arise, please contact the PI (roland.grad@mcgill.ca).

Signature

_____ _____
Participant, Date Witness, Date

Appendix D. Instructions to download the app

From: Roland Grad, Dr
To: Participants' addresses
Subject: welcome to our usability study

Dear All

Thanks for signing up for the usability study. The app is private, and only distributed to authorized users. So it is not available on the App Store or Google Play. Instead, we are using private over-the-air installation from a webpage with login access protection.

To install the IAM app:

1. *From your smartphone*, please go to www.99prioritytopics.ca

2. Log in with the username and password that was emailed to you.

3. Download the app to your device. It will install automatically.

4. You will be asked to subscribe to a channel - choose '99 Weeks'.

5. Re-enter your username and password. You will then see a list of topics and their 'key features'.

I attach a few screenshots from my iPhone - just to show you what to expect.

Best,

Roland Grad

Appendix E. Milestones

Timeline	Task
2012 – 2013	Started design and development of the app.
April, 2014	Submitted research proposal to Institutional Review Board (IRB), McGill University.
May, 2014	Received IRB approval.
June – August 2014	App development and testing.
September, 2014	Established face to face communication to invite residents to the study.
October, 2014	Conducted follow-up with residents informed about the project and sent information about the study by email.
October 8, 2014	Study began. Sent the first push notification.
October 19, 2014	Conducted the first open-ended face-to-face interview and transcription.
November 2, 2014	Conducted the second open-ended face-to-face interview and transcription.
December 10, 2014	Conducted additional open-ended face-to-face interview and transcription.
December, 2014	Revision, edition, formatting, uploading and linking of pages of clinical information was completed.
May 6, 2014	Last push notification. End of the study.
April 30 – May 3, 2014	Board certification examination in Family Medicine.

May 8 – 13, 2015	Conducted the last open-ended face-to-face interviews and transcription.
May, 2015	Started data analysis and inter-coder reliability process. Sent documentation to renew IRB approval.
May 26, 2015	Received approval continuing review form from IRB.
June 3, 2015	Received written responses to interview questions from one participant invited to the final interview session.
June, 2015	Finalized data analysis. Principal investigators to review study findings.

Appendix F. Interview guide 1

A. Demographic Information

1. Your age?
2. Device name
3. OS
4. Data plan
5. Is the IAM installed on your device?
    - No
    - Yes

B. Research Question 1: What is the usability of the app among family medicine residents, following the first interaction with the IAM app?

Easiness of Installation:

1. How was your experience with the installation process?
    - Probe: Please describe
2. Did you encounter any difficulties in launching the app?
3. What is your opinion of the response time?
    - Probe e.g. too slow?
4. With regard to installation, would you change anything in this process?
5. Is there anything else (with regard to installation) that you would like to add to what we have discussed so far?

Learning how to use the App:

1. How was your initial experience with learning to use the app?
    - Probe: Can you describe how you started to use the app?

2. Did you encounter any difficulties in using the app?

3. Are there any features you would change?

• Probes: Is there anything about this app you would change? Likes and dislikes?

4. Do you know something about the questionnaire on the app?

5. Is there anything else (with regard to learning how to use the app) that you would like to add to what we have discussed so far?

C. Research Question 2: What is the role of the IAM app to prepare for the Family Medicine board certification exam?

Exam Preparation:

1. Are you now preparing for the CFPC certification exam?

- If yes: Can you elaborate on the strategies that you have used (are using)?

Probes: •Which educational resources did you (do you) find to be helpful and why?

•Are there any resources that you find to be unhelpful?

2. Do you presently use apps for educational purposes?

- If yes: How would you compare this app with the IAM app?

Task Completion:

We have a task for you: we would like you to find a topic and we will time you. How long it takes them to find the following topic: Hypertension.

Probe: Did you use the search box to find this topic or did you find it by browsing the list?

Appendix G. Interview guide 2

A. Demographic Information

1. Your age?
2. Device's name
3. OS
4. Data plan
5. Is the IAM installed on your device?
    - No
    - Yes
6. What clinical rotations are you on right now?
7. What clinical rotation did you do last?

Stream 1: Users (clinical information level)

B. Research Question 1: What is the usability of the app among family medicine residents, following the second phase: functionality?

1. Now that you have the app for several weeks can you describe any issues that you encountered?
2. Is there anything about the clinical information you would add or change?
3. Have you completed the questionnaire when prompted?

- If not:
    - Why not?
- If yes:

•Is there anything about the questionnaire that concerns you?

C. Research Question 2: What is the role of the IAM app to prepare for the Family Medicine board certification exam?

1. Are you now preparing for the CFPC certification exam?

- If yes:

•What study strategies do you use? Why?

•In your opinion, how could this app support your exam preparation?

- If no:

•What strategies will you be using? Why?

•In your opinion, how could this app support your exam preparation?

Task Completion:

We have a task for you: we would like you to find a topic and we will time you. How long it takes them to find the following topic: Hypertension.

Probe: Did you use the search box to find this topic or did you find it by browsing the list?

Stream 2: Non- users (did not accessed the clinical information level)

C. Research Question 1: What is the usability of the app among family medicine residents, following the second phase: functionality?

1. Have you installed the app?

- If yes:

•Did you encounter any difficulties in launching the app?

•How was your experience with learning to use the app?

•What pages have you explored?

•Would you add or change something with respect to the process of installation or learning to use the app?

Continue with question 2.

- If no:

• Why you have not installed it?

• Do you plan to install it / to use it?

Yes: Why?

No: Is there a reason why you would not use it at all?

• What would encourage you to install it? / To use it?

•Is there any reason for which you would not use it at all?

2. Have you completed the questionnaire when prompted?

- If yes:

•Is there anything about the questionnaire that concerns you?

- If no:

•Why not?

D. Research Question 2: What is the role of the IAM app to prepare for the Family Medicine board certification exam?

1. Are you now preparing for the CFPC certification exam?

- If yes:

•What study strategies do you use? Why?

•In your opinion, how could this app support your exam preparation?

- If no:

•What strategies will you be using? Why?

•In your opinion, how could this app support your exam preparation?

Task Completion:

We have a task for you: we would like you to find a topic and we will time you. How long it takes them to find the following topic: Hypertension.

Probe: Did you use the search box to find this topic or did you find it by browsing the list?

Appendix H. Interview guide 2.1

A. Demographic Information

1. Your age?
2. Device's name
3. OS
4. Data plan
5. Is the IAM installed on your device?
    - No
    - Yes
6. What clinical rotations are you on right now?
7. What clinical rotation did you do last?

B. Research Question 1: What is the usability of the app among family medicine residents, following the second phase? Issues that impacted usage patterns in different types of users.

Installation and Learnability of the app:

1. We'd like to learn about the installation process. How was your experience with this?

    Probe: Please describe
2. Did you encounter any difficulties in launching the app?
3. With regard to installation, would you change anything in this process?
4. Is there anything else (with regard to installation) that you would like to add to what we have discussed so far?
5. How was your initial experience with learning to use the app?

Probe: Can you describe what you did when you first used it?

6. In learning to use the app, have you encountered any difficulty?

   Probe: If you had some difficulty, how did you work around it?

7. Have you checked out these pages?

   - Show picture 1 (Key Features), then picture 2 (Clinical Info) then picture 3 (the questionnaire)

8. Is there anything else (with regard to learning how to use the app) that you would like to add to what we have discussed so far?
9. Trouble learning?
10. Trouble remembering how to use it?
11. Are you using the app?

    - If not:

    •Why?

Notifications:

1. Do you see notifications about the topic of the week?

   - If yes:

     •Does the weekly alert have any effect on you or on the way you use the app?

   - If no:

     •Are you using the latest version of the operating system?

2. Does this app fit with your plans to prepare for the exam?

   - If no:

     •Why?

C. Research Question 2: What is the role of the IAM app to prepare for the Family Medicine board certification exam?

1. Does this app fit with your plans to prepare for the exam?

    Probe: Why?

Task Completion:

We have a task for you: we would like you to find a topic and we will time you. How long it takes them to find the following topic: Hypertension.

Probe: Did you use the search box to find this topic or did you find it by browsing the list?

Appendix I. Interview guide 3

A. Demographic Information

1. Your age?
2. Device's name
3. OS
4. Data plan
5. Is the IAM installed on your device?
   - No
   - Yes
6. What clinical rotations are you on right now?
7. What clinical rotation did you do last?

GROUP 1: Non Users (Residents who never used the app)

B. Research Question 1: What is the usability of the app among family medicine residents, following the study: Initial experience?

Postgraduate Year 1	Postgraduate Year 2
We track page hits; this provides us with information about individual usage of the app. However, we can only track hits from the clinical information pages and beyond. Let me show you… So, in your case it seems that you did not open any clinical information pages. Is this right?	
YES (did not use it)	
1. Did you install the app?	
YES: What have you explored in the app?	**NO:** Could you tell us about your reasons for not installing the app? Go to Q. 3.
2. What were your reasons for not using the app? **Probe:** Could you describe?	
3. Is there something that would have encouraged you to install the app? To use the app?	
YES: Can you elaborate on that?	**NO:** What are the reasons for this?

C. Research Question 2: What is the role of the IAM app to prepare for the Family Medicine board certification exam?

4. Are you using any knowledge resource to guide your learning around the 99 priority topics? **YES: Which ones?**	**4. Did you use other resources to prepare for the exam?** **YES: Which ones?**
5. Do you see a role for apps to prepare for exams in family medicine? **YES:** What type of role do you see?	**NO:** Why not?
6. Do you think there is a role for residents to contribute to the content provided by this app?	
7. Before we end, do you have any final comments?	**Probe:** Is there something you would like to see in this app?

NO (they used it):

All right. So, in this case we would like to know more about this.

1. Can you tell us, how did you use the app? **Probe:** Show me an example of a topic you check

2. We noticed you never read beyond the key features level, did you know you could go further?

YES: Could you tell us about your reasons for not using the app beyond that level?

NO: How the app could have helped you to inform you about the possibility to go beyond that level?

4. Is there something that would have encouraged you to use the app beyond that level?

YES: Can you elaborate on that? **NO:** What are the reasons for this?

5. Do you see a role for apps to prepare for exams in family medicine?

YES: What type of role do you see? **NO:** Why not?

6. Do you think there is a role for residents to contribute to the content of the app?

7. Before we end up this interview, do you have any comments? **Probe:** Is there something you would like to see in this app?

END OF GROUP 1

GROUP 2: DISCONTINUERS (Residents who used the app and stopped)

B. Research Question 1: What is the usability of the app among family medicine residents, following the study: Initial experience?

Postgraduate Year 1	**Postgraduate Year2**
We would like to show you your page hits; this provides information about your usage of the app. However, we can only track hits from the clinical information pages and beyond. Let me show you… So, in your case the file shows that you started to use the app on (date X) and by (date Y) you stopped. Is this right? **YES:** continue **NO:** Show me what you did	

C. Research Question 2: What is the role of the IAM app to prepare for the Family Medicine board certification exam?

1. Could you tell us about your experience with the app? **Probe:** In general how did you find the app?	
2. Are there any factors that prevented you from using the app? **Probe:** Specific rotations, opinions of other people?	
3. Is there anything that would encourage you to use it again? **YES**: Can you elaborate on that? About the alerts, did you receive them? **NO:** End	
4. Did the app change the way you study? **YES: In what way?** **NO: What were your reasons?**	**4. What do you think about the role of the app in helping you to prepare for the exam?** **Probe: In what way you used the app during your preparation?**
5.Are you using any knowledge resource to guide your learning around the 99 priority topics? **YES: Which ones?**	**5. Did you use other resources to prepare for the exam?** **YES: Which ones?**
6. How would you compare this app with those learning resources?	
7. With regards to the IAM questionnaire, what was your experience? **Probe:** Role of the IAM questionnaire to provide feedback on pages of clinical info and / or to stimulate reflection (TBD)	
8. Do you see a role for apps to prepare for exams in family medicine? **YES:** What type of role do you see? **NO:** Why not? 9. Do you think there is a role for residents to contribute to the content provided by this app? 10. Before we end t, do you have any final comments? **Probe:** Is there something you would like to see added to this app?	

GROUP 3: CONTINUERS (Residents who continued using the app)

B. Research Question 1: What is the usability of the app among family medicine residents, following the study: Initial experience?

Postgraduate Year 1	**Postgraduate Year 2**
We would like to show you your page hits; this provides information about individual usage of the app. We have a file for each user and based on this we can determine who used it or not. However, we can only track hits from the clinical information pages and beyond. Let me show you… So, in your case, the file showed that you started to use the app from (date X), you continued using it and the last time you use it was on (date Y). Is this right? **YES:** continue **NO:** Show me what you did	

C. Research Question 2: What is the role of the IAM app to prepare for the Family Medicine board certification exam?

1. Could you tell us about your experience using the app? **Probe:** In general how did you find the app? 2. What encouraged you to use the app during this time? **Probe:** Can you elaborate on that? What about alerts?	
3. Did the app change the way you study? **YES: In what way?** **NO: What were the reasons?**	**3. What do you think about the role of the app to prepare for the exam?** **Probe: In what way you used the app during your preparation?**
4. Are you using any knowledge resource to guide your learning around the 99 priority topics? **YES: Which ones?**	**4. Did you use other resources to prepare for the exam?** **YES: Which ones?**
5. How would you compare this app with those learning resources?	
6. With regards to the IAM questionnaire, what was your experience? **Probe:** Role of the IAM questionnaire to provide feedback on pages of clinical info and / or to stimulate reflection (TBD)	
7. Do you see a role for apps to prepare for exams in family medicine? **YES:** What type of role do you see? **NO:** Why not? 8. Do you think there is a role for residents to contribute to the content provided by this app? 9. Before we end, do you have any final comments? **Probe:** Is there something you would like to see added to this app?	

Appendix J. IAM Questionnaire

1. Why did you do this search for information?

   Please check all that apply.

   Note: You can check more than one objective.

   ○ To address a clinical question (problem) about a specific patient.

   ○ What was your question?

   ○ To fulfil a personal educational objective.

   ○ To satisfy curiosity or for personal interest.

   ○ To look up something I had forgotten.

   ○ To share information with a patient, their family, or home health aides.

   ○ To exchange information with other health professionals (e.g., a colleague).

   ○ To manage aspects of patient care with other health professionals.

2. Did you find relevant information that partially or completely met your objective (s)?

   ○Yes

   ○No

   Thank you for your feedback

3. What is the impact of this information on you or your practice?

   Note: You can check more than one type of impact.

   ○ My practice was (will be) changed and improved.

   ○ Diagnostic approach?

   ○ Therapeutic approach?

   ○ Disease prevention or health education?

   ○ Prognostic approach?

- ○ I learned something new.
- ○ This information confirmed I did (am doing) the right thing.
- ○ I am reassured.
- ○ I am reminded of something I already knew.
- ○ I am dissatisfied.
- ○ There is a problem with the presentation of the information.
    - ○ Too much information?
    - ○ Not enough information?
    - ○ Information poorly written?
    - ○ Too technical?
    - ○ Other?

- ○ I disagree with the content of this information.
- ○ This information is potentially harmful.

    - ○ Why is this info potentially harmful?

4. Did you (will) use this information for a specific patient?

    ○ Yes

    ○ As a result of this information I managed (or will manage) this patient differently.
    ○ I had several options for this patient, and I used (will use) this information to justify a choice.
    ○ I did not know what to do, and I use (will use) this information to manage this patient.
    ○ I thought I knew what to do, and I used this information to be more certain about the
    management of this patient.

○ I used this information to better understand a particular issue related to this patient.

○ I used (will use) this information in a discussion with this patient, or with other health professionals about this patient.

○ I used (will use) this information to persuade this patient, or to persuade other health professionals to make a change for this patient.

○ No

○ Possibly

5. For this patient, did you observe (or do you expect) any health benefits as a result of applying this information?

○ Yes

○ This information helped me to improve (will help to improve) this patient's health status, functioning or resilience (i.e., ability to adapt to significant life stressors).

○ This information helped to prevent (will help to prevent) a disease or worsening of disease for this patient.

○ This information helped to avoid (will help to avoid) unnecessary or inappropriate treatment, diagnostic procedures, preventative interventions or a referral, for this patient.

○ This information helped to decrease this patient's worries about a treatment, diagnostic procedure or preventative intervention.

○ This information helped to increase this patient's knowledge, or their family or home health aides' knowledge.

Comment on this information

Submit