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ORIGINAL RESEARCH

A Study of Mobile App Use for Teaching and Research in Higher Education

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Abstract
The exponential growth in the use of digital technologies and the availability of mobile software applications (apps) has been well documented over the past decade. Literature on the integration of mobile technology into higher education reveals an increasing focus on how mobile devices are used within the classroom environment, both physical and online, rather than on how mobile applications may be used for either teaching or the research process. Our study surveyed staff and higher degree research students at a New Zealand university using an online questionnaire to gain insight into the use of mobile apps for tertiary teaching and research, seeking information, particularly on which apps were used for which tasks and what obstacles hindered their use. The online survey used 29 questions and ran in 2016/2017. 269 participants completed the survey, nearly 20% of the potential sample. We found that mobile apps were used by academics and students for both teaching and research, primarily in the form of document and data storage and exchange, and communication. Very little app use was recorded for in-class activities (teaching) or in-field activities (research). Apps use resulted from personal motivation rather than institutional planning. Both students and academics reported that institutional support and flexibility would likely provide motivation and lead to increased app use for both research and teaching.

Keywords Mobile apps · Academic survey · Tertiary teaching and research · Information behavior · Twenty-first century abilities

1 Introduction

Mobile learning has been claimed as the future of learning (Bowen & Pistilli, 2012) yet surprisingly little specific empirical investigation of mobile application use in tertiary settings is available in the literature. While digital devices are prevalent in the higher education environment, the use and uptake of mobile apps for tertiary teaching and research by academic staff has only begun to be studied (Lai & Smith, 2018; Shraim & Crompton, 2015).

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1.1 Technology Availability to Students

The 2019 ECAR survey of Undergraduate Students and Information Technology found that students see technology as a means for better engagement with study material, instructors and peers in the classroom (Galanek, & Gierdowski, 2019). The 2020 survey found that 75% of students who connect to campus WiFi are using two or more devices (Gierdowski et al., 2020). The 2018 survey reveals 95% of students have access to smartphones and 91% to laptops (Galanek et al., 2018). The downloading of mobile software applications (apps) in recent years shows a similar pattern of increase, rising from 84 billion downloads from the Apple App Store/Google Play in 2016 to 105 billion in 2018 (Sensor Tower). The third most popular Apple App Store category in May 2019, was education at 8.52% (Statista, 2019). Studies of higher education students in Southeast Asian universities reveal even higher percentages, for example, 100% of Hong Kong undergraduates in a 2018 study possessed mobile phones, of whom 85% also used apps for their academic studies (Shuk Han Wai et al., 2016). Thus previously held concerns that not all students will have access to a smartphone is not supported by the wealth of recent research investigating technology availability (Anderson, 2015).

For some time there has been the suggestion that technological advancement of mobile devices and the increased availability of mobile apps may prove central to academic teaching and research (Hahn, 2014; Canuel & Chrichton, 2015; MacNeill, 2015). Specific empirical investigation that discusses mobile app use as opposed to mobile device or more generally information technology use in tertiary teaching or research is extremely limited. Of the few specific discussions of mobile app use in academia, we identify library studies that have been conducted on the selection, use or development of mobile apps (Wong, 2012; Hennig, 2014; van Arnhem, 2015). These studies have often had a focus on the delivery of information or data about library services. Practitioner research in library and education have also included work describing apps and app features for research or teaching—an example being apps for ethnographic field research (van Arnhem, 2015). Work has investigated undergraduate student perceptions of mobile apps and mobile devices. An early study of tertiary student use of mobile note-taking software by undergraduate students (Schepman et al., 2012) saw widespread positive perception and adoption of these mobile tools by students. Studies exploring the impact the integration of mobile computing devices is having on higher education teaching and learning reveal an increasing engagement with content, collaboration with classmates and information creation and sharing outside the formal learning spaces (Bell et al., 2019; Compton & Burke, 2018; Gikas & Grant, 2013). Systematic literature reviews (Burch & Mohammed, 2019; Singh & Hardaker, 2014) and reports or investigations of academics' perspectives of technology use in tertiary classrooms (Galanek & Gierdowski, 2019) provide insights into the broad picture but have provided little advice regarding app use for research or teaching.

1.2 Technology Use in Academia

Research on the integration of mobile technology in higher education is focussed on how mobile devices are used within the classroom environment, rather than on their application to the research process (Morris et al., 2016; Pedro et al., 2018; Schepman et al., 2012; Shuk Han Wai et al., 2016). MacNeill (2015) outlines techniques and strategies for the use of apps to support learning, teaching and research. The perspectives are self-reflective and provide insights into tools that have been trialled by the author

with recommendations for educators to dedicate time to explore the wealth of available applications for teaching and research inside and outside the classroom. In the higher education classroom, mobile devices in higher education can provide new opportunities for information gathering and use, content access, communication, collaboration and reflection (Beddall-Hill et al., 2011; Bowen & Pistilli, 2012).

Lai and Smith (2018) identify a paucity of research on technology use in higher education. We identified two previous surveys of mobile technology use in tertiary teaching and learning. They focussed either on how socio-demographic factors influenced the perception of teaching staff (Lai & Smith, 2018), or the perceptions of the pedagogical affordances for mobile devices in teaching (Shraim & Compton, 2015). The survey of 308 tertiary teaching staff by Lai and Smith (2018) found that while many of the respondents were positive about the benefits that mobile technology could provide for their teaching, many felt they lacked the confidence to apply the technology effectively. "When implementing a mobile application in curriculum, instructors need to clearly state the goals of using the application to make sure the students understand the purpose of using the application for coursework, how it is connected to the curriculum, and how it will improve their learning" (Chen et al., 2013, p.339). Other surveys of academics on their use of apps and mobile devices have focussed on teaching. The survey of faculty members use of mobile devices for teaching by Shraim and Crompton (2015) found that there are positive perceptions of the opportunities that mobile devices provide for teaching, but were focussed on the opportunities that the device itself provided (mobile connectivity, linking of formula and informal teaching, increasing enjoyment and connecting to real-world problems), rather than apps. The most important finding related to app use was the concerns that academics held about finding time to select appropriate apps and develop their teaching plans to incorporate them (Shraim & Crompton, 2015). Their scope was wider than app use, but only asked academics about their app use in their teaching, not their research.

Mobile devices provide opportunities to undertake research and fieldwork while enabling the collection, manipulation and sharing of data in real-time (Beddall-Hill et al., 2011). To date, the investigation of digital tools for research has focused on opportunities and challenges such as technical issues (e.g. battery life, data security or data inaccuracies) and considerations such as the preparation of future researchers to leverage the capacity of digital tools for research (Carter et al., 2015; Davidson et al., 2016; Garcia et al., 2016; Raento et al., 2009). The benefits of using mobile devices for research are described by Chen (2011), as including; immediacy of response, better enablement of longitudinal research, capturing of location information for context and the inclusion of an additional touchpoint to provide a more well-rounded research picture. Carlos (2012) suggests that mobile devices and mobile applications provide three main benefits for use in research: ready availability and familiarity, easy use, and always-on internet connections. A counter perspective is provided by McGeeney (2015) who observed a number of constraints for using mobile apps, compared to Web browsers. They found lower response rates, increased costs, and usability issues such as limited navigation and data entry options in mobile survey tools. Similarly, it is suggested that with mobile apps the time and effort required to learn how to use an app effectively can result in lower response rates than web-based data collection (Pew Research Center, 2015).

1.3 Institutional Expectations and Support

Many Institutions and academic libraries encourage mobile device use in educational contexts (Canuel et al., 2016; Hanbridge et al., 2018; Morris et al., 2016). Academics are encouraged to provide learning experiences that include "mobile-friendly content, multi-device syncing, and anywhere/anytime access" (EDUCAUSE, 2019, p. 8). However, the 2019 Horizon Report has identified a need for sustained support and professional development to take advantage of the new teaching opportunities afforded by digital devices (EDUCAUSE, 2019). While academics are largely confident with mobile technologies, they need greater awareness of how these technologies can be incorporated effectively to take full advantage of the affordances mobile devices can offer in teaching ((Shraim & Compton, 2015). Several studies found that a lack of faculty training was a source for faculty dissatisfaction with classroom technology (Galanek & Gierdowski, 2019) and (mobile) IT integration into teaching (Burch & Mohammed, 2019; Shraim & Crompton, 2015). A number of academic libraries promote the use of mobile software to academics through digital or technological literacy training (Canuel & Chrichton, 2015; Hennig, 2014). However, research in the area of mobile application in academic libraries almost exclusively focused on the delivery of library services to mobile devices (Aher et al., 2017; Breeding, 2019; Singh Negi, 2014) or the integration of responsive design in web-based service (Kim, 2013; Tidal, 2017). A sample scan of university library websites indicates that it has become increasingly common for research university libraries to include guidance and instruction on the use of mobile apps for research. Such guidance usually takes the form of a brief preamble followed by a list of the various apps with a brief description of the features, functions and purpose of the app with links to the vendor website. Contextually, little indication is provided as to how or why such a list was curated or, more importantly, how the library supports the integration into learning of such mobile apps through training or instruction. A notable exception is the service offered by Stony Brook University Library, which assists in selecting and using mobile apps for research (Saragossi et al., 2018, p. 202).

1.4 Research Questions and Focus

We identified a number of shortcomings in the existing literature on app use in tertiary contexts. Research on technology use in teaching and learning rarely focuses on (the experience of) app use, but rather on device capabilities and opportunities of technology use. Previous surveys predominantly analysed the undergraduate students' perceptions of app use in teaching. Use of apps for academic research is little discussed beyond app use for specific projects, and general technology benefits or issues. While many tertiary institutions actively encourage academics to use mobile apps (and other technology) for teaching, the impact of such expectations on the academic experience is not well studied.

The research reported here attempts to understand more widely how apps are being used in tertiary teaching and research, including what are the perceived benefits and barriers. To provide insights into how mobile apps may be used by students and staff in teaching and research a university-wide survey on mobile app use in a tertiary setting was conducted. The survey design was guided by the following research questions:

RQ1: Are academics using mobile apps for tertiary teaching and research at University of Waikato?
RQ2: Which apps are used by academics for which teaching and research tasks?
RQ3: What is the experience of app use by academics: what obstacles/opportunities do they identify?

The survey was made available to staff and higher-degree students (collectively referred to as academics) across the University to capture their perspective on mobile app use for teaching and research.

This article presents our study data, and analyses these with respect to the three research questions posed above. The remainder of this article is structured as follows, in Sect. 2 we introduce our method, an online survey of staff and higher degree students at a New Zealand university. Section 3 provides results and analysis of the responses to this survey. We discuss the findings in light of our research questions in Sect. 4 and conclude this article in Sect. 5. Initial analysis results were presented elsewhere (Hinze et al. 2017a, b), and primarily focussed on the responses from higher degree research students. The results reported in this paper cover all responses to the survey including those of higher degree students and staff.

2 Method

We performed an online survey of staff and higher degree students of the University of Waikato in New Zealand. The survey was designed to get a university-wide view of how mobile apps were being used for teaching, research, and learning purposes. The survey was performed over two consecutive years in order to capture the widest sample of participants.

2.1 Context of Study Environment

This New Zealand University is typical of western universities offering qualifications across multiple academic divisions including, but not limited to; the arts, computing, education, management, and the sciences. The majority of staff and students work on campus yet mobile and electronic learning is supported at all learning levels. The university provides Google apps for email, file storage, and word processing. A number of digital resources and technologies are supported depending on the needs of researchers and teachers in academic disciplines. A well-resourced library supports students and staff with print and electronic holdings. There are no required or mandated mobile apps at this university.

2.2 Data Collection

A location-restricted online, self-administered survey tool was developed in the Qualtrics Survey Software. The survey was made available to participants at the University of Waikato in New Zealand from 3rd to 19th August 2016 and again from 31st August to 6th October 2017. The potential sample size was approximately 820 enrolled masters or PhD thesis students and 580 staff (including academics, researchers, and research administrators). All responses were anonymous.

2.3 Participant Recruitment

Higher-degrees students and staff from across the university were invited to participate. We engaged the University's research office to forward invitations to all departmental administrators, with whom we personally followed up with to distribute the survey invitation to all the University's academic staff and researchers via email. We further followed up these email

invitations with in-person invitations by one of the research team at Faculty and School meetings. The higher-degree students were engaged by the School of Graduate Research through email and social media. Our study had a potential pool of 1400 staff and higher-degrees students.

The survey was done in two stages (same target group, self-selected participants, initial and repeat attempt to engage participants), we present in this article the aggregated result of both stages. 288 survey entries were received, out of which 19 contained no further data and were excluded from the analysis. The survey was thus completed by 269 participants, or nearly 20% of the potential sample of university staff and higher-degree students.

2.4 Survey Tool

Our online tool was a 24-item survey that incorporated a combination of Likert scale tools, radio button responses, and free text questions. This tool was conceptualised in three sections which (1) requested demographic data, (2) surveyed previous experience and use of mobile apps, and (3) reviewed device and operating system use. The survey invited reflection by the participants on their use of mobile apps and whether they believed that their use or lack of use had influenced research or teaching practice. The survey also required participants to give information regarding their reasons for non-use in cases where participants indicated that they had not used, and were not intending to use, mobile apps. To review the survey questions please refer to Appendix 1.

2.5 Definitions Used in the Survey

In the survey we included the following definitions for clarity for the participants:

> Mobile app—is a software application developed primarily, although not exclusively, for use on small computing devices, such as smartphones or tablets. Examples include WhatsApp, Evernote, and Flipboard. Other examples might include mobile app versions of programs such as Dropbox or EndNote.
> Academic purposes—includes all teaching and/or research activities engaged in while a member of the University community.

2.6 Data Analysis

The results were analysed using default and cross-tabulation report functions provided by the Qualtrics software before manual manipulation, tabulation, and analysis using Excel. We have undertaken basic descriptive statistical analysis (means testing and T test for cohort comparison) and provide tables, graphs, mean values and probability values (where appropriate) along with our reporting in the Results section.

3 Results and Analysis

We present our results structured by the three research questions. After demographic information in Sects. 3.1, 3.2, 3.3 address the first question (*are academics using mobile apps for tertiary teaching and research)*, while Sects. 3.4, 3.5 address the second question

(*which apps are used for tasks*), and finally Sects. 3.6, 3.7, 3.8 address the third question (*academic experience of app use: obstacles and opportunities*).

3.1 Demographic Attributes

The university staff and postgraduate students at the time of the two instances of the survey was reasonably stable at about 1400 (580 academic staff and 820 higher-degree research students), which forms the potential participant pool. 269 of these 1400 responded to our invitation, with most of our study participants being academic staff (N = 163), followed by doctoral students (N = 83), see Fig. 1.

Out of the 269 participants, 141 were female (52%) and 125 were male (46%); 2 did not specify gender (1%), and 1 selected other.

63% of the participants were younger than 40 years old, see Fig. 2. The participants represent a range of schools and faculties, as shown in Fig. 3. The other university areas mentioned by participants were administration and technical support. Five participants selected two options.

3.2 Use of Mobile Apps

With 172, the majority of the 269 participants (64%) had used mobile apps for academic purposes such as teaching or research, see Fig. 4 for details. We note that the percentages among Academic staff and doctoral students were comparable at 67% and 69%, respectively, while only 25% of Master's students had used apps for research. Four participants provided no data (Fig. 5).

Of the 172 participants who had used mobile apps for academic purposes, the age cohort that showed the strongest engagement were the 21–30 year-olds (71%). This was followed by the group of 31–40 year-olds (64%). If broken down by gender, 62% of the 141 female participants and 67% of the 125 male participants had used apps for academic purposes ($p = 0.3975$, i.e., there was no significant gender difference in app use), see Fig. 6.

Out of the participants who had used apps for academic purposes, most (19%) were in the Faculty of Computing and Mathematical Sciences, followed closely by both the Faculty of Education (18%) and science and engineering (18%); details are shown in Fig. 7.

We surveyed the 172 participants who had used mobile apps for academic purposes to inquire which types of devices they used mobile apps with (multiple selections were

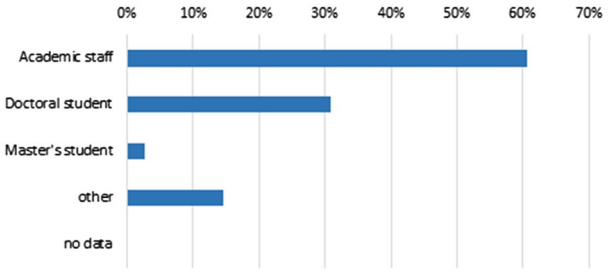

Fig. 1 Participant roles (multiple selections possible)

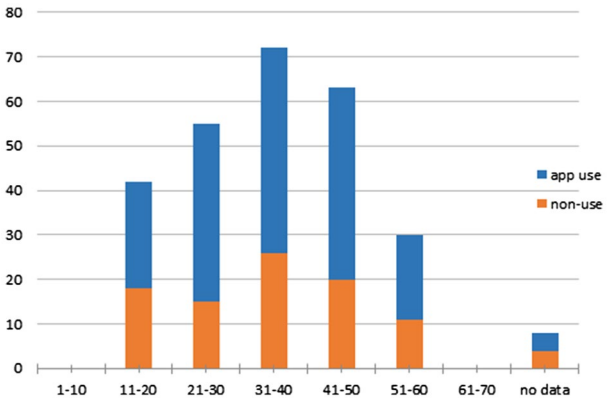

Fig. 2 Participant age

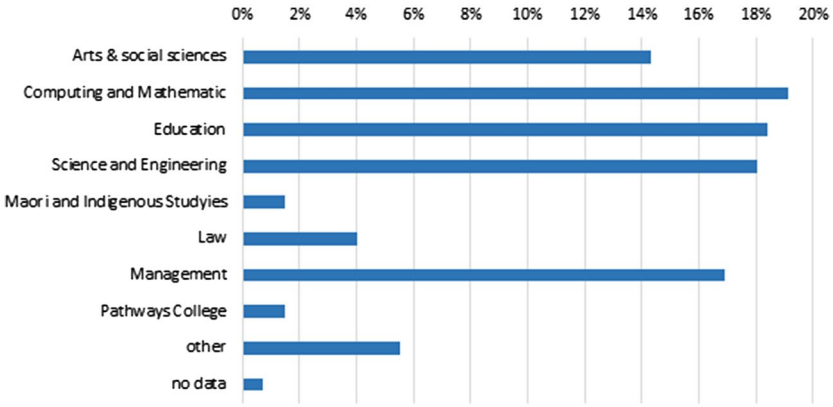

Fig. 3 Participants by school/faculty (multiple selections possible)

possible). 303 responses were collected. The majority (79%) used smartphones, followed by iPad and Android tablet devices (together 70%), details see Fig. 8. The named other devices were laptops and PCs, and one sporting device.

90 of the 172 app users gave details about operating systems with 114 selections; for details see Fig. 9. Under 'Other' participants listed ChromeOS and Microsoft system (surface tablet). As expected based on mobile phone ownership data, Android and iOS emerged as the preferred operating systems.

Finally, we also asked if participants had been involved in the development of any mobile apps that might be used for academic purposes, and to explain their purpose. We received 60 answers: 50 no, 5 n/a, and the 5 positive answers: driving support (1), for teaching (2), indigenous language learning (1), and a personal digital library (1).

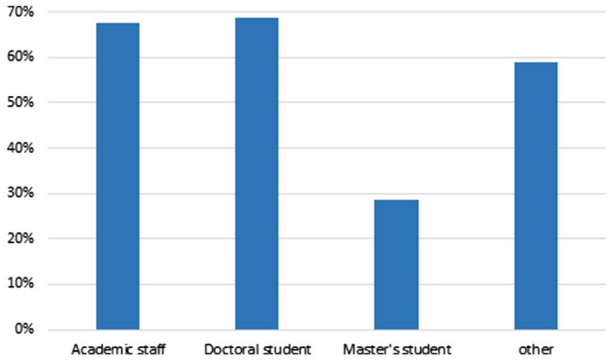

Fig. 4 Prior use of apps for academic purposes (multiple roles possible)

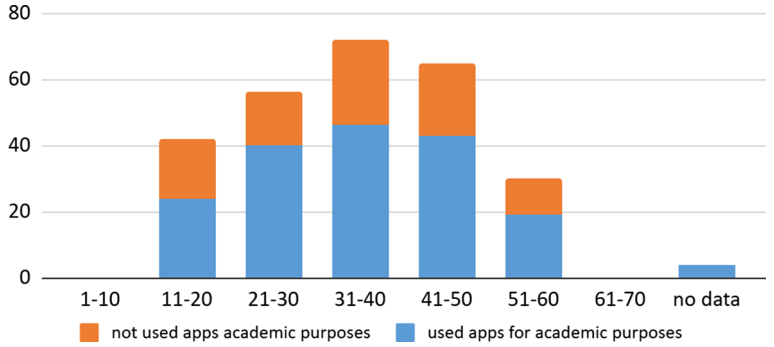

Fig. 5 Academic use of mobile apps by participant age range

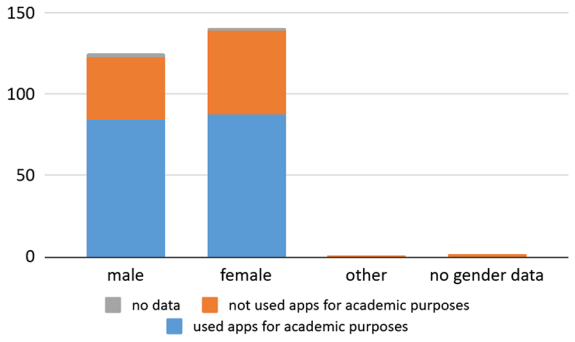

Fig. 6 Academic mobile app usage by participant gender

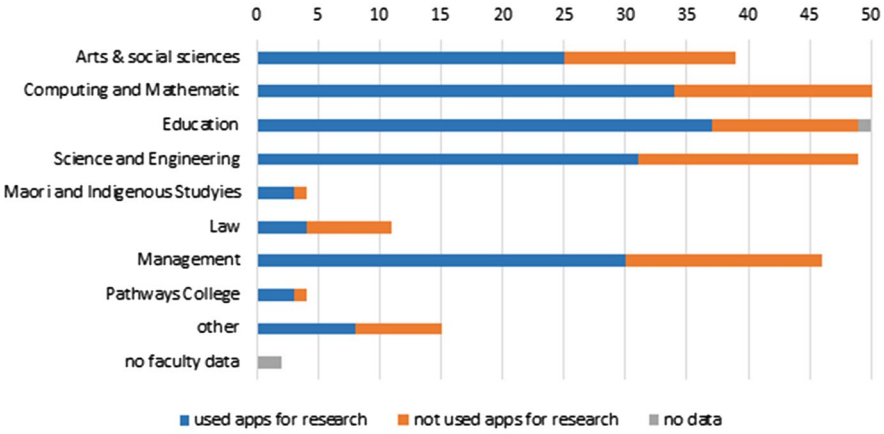

Fig. 7 Academic mobile app usage by participant school/faculty

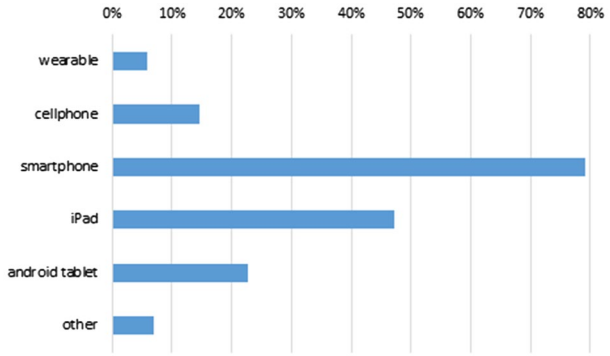

Fig. 8 Type of mobile device used (multiple selections possible)

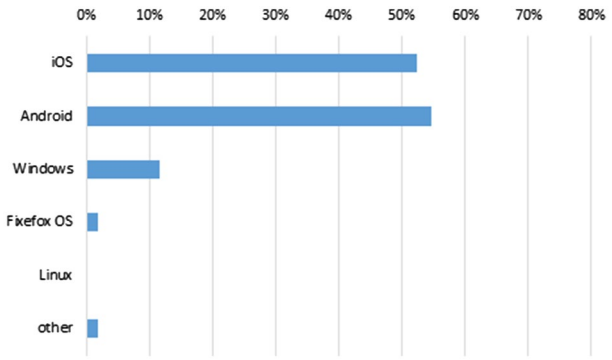

Fig. 9 Operating system used on mobile device (multiple selections possible)

3.3 Purpose of Mobile App Usage

In order to investigate the mobile app use-cases in the tertiary environment, we asked participants about the situations that they had used these. Participants could select either or both teaching/supervision, and/or research. Ninety-five (56%) of the 171 respondents to this question had used a mobile app for teaching/supervision purposes; 146 (85%) had used one for research purposes. Of these, 70 (41%) selected that they had used apps for both (see Fig. 10a, top).

More female participants are using apps than male participants (see Fig. 10b, bottom). For teaching, there was not significantly more male respondents using apps than female respondents ($p=0.96$). For research, more female participants were found to be usings apps than male participants, though this was still not significant ($p=0.69$). We further note that female respondents tended to use apps for research or for teaching only (63.2% of 87 female compared to 54.7% of 84 male). Conversely more male respondents used apps across both categories (marked in gray). However, the difference between male and female use of apps for both purposes was not significant ($p=0.59$). The majority of the participants who had used apps for teaching or supervision were academic staff (86 of 95). A

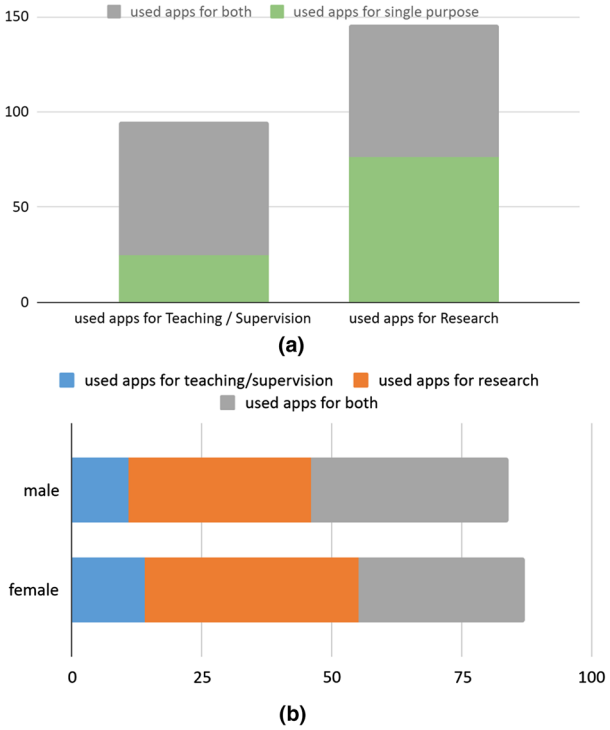

Fig. 10 Mobile app usage: (**a**) by purpose (top), (**b**) by gender (bottom)

small number of participants who had used mobile apps for teaching identified as doctoral students (15 of 95), none as Master's students, 7 as Other (multiple selections possible). 88 Academics, 55 Doctoral students, 2 Master's students and 18 Others reported using mobile apps for research purposes.

We observe that higher percentages of academic staff used a mobile app for teaching and supervision purposes compared to research purposes (see Fig. 11). Conversely, doctoral students were more likely to use apps for research purposes than for teaching/supervision purposes. Quite predictably, Master's students and other participants were more likely to use mobile apps for research.

Only 6 participants reported being asked by their lecturer or supervisor to use mobile apps for academic purposes (50 reported having not been asked, 214 provided no answer). They named the following app purposes: document sharing, storage, referencing, communication; bookshelf app for recommended lecture text; conference presentation app; google drive and dropbox for backups of theses, and app examples to explore for research on interactive tour guides.

3.4 Apps for Teaching/Supervision

Ninety-five participants reported using mobile apps for academic purposes for teaching or supervision related activities. Unsurprisingly, the majority of these participants reported themselves as teaching staff. At this university, it is not atypical for staff to work across roles in a university, and for some higher degrees students to be contributing to teaching initiatives at various levels and therefore some doctoral students and participants in the 'Other' category had also used apps for teaching purposes. These 95 participants were asked to select from a shortlist of possible academic-related apps (see Fig. 12) the mobile apps that they used for teaching or supervision purposes. Also shown in Fig. 15, the participants were asked if these apps were used by themselves or by students under their supervision. There was a substantial number of Other options named, including Google Drive (8), Google Docs (5), Facebook (4), Google Sheet (3), Kahoot (3), and Kindle (3) and a further 11 programmes named twice, and 65 programmes named once showing that a diverse range of apps were used (not shown in Fig. 12).

Mobile apps for teaching purposes were reported as being used by 95 participants, the specific purposes for using apps for teaching are elaborated on in Fig. 13. The aspects teaching staff most engaged in were sharing or storing documents, as well as

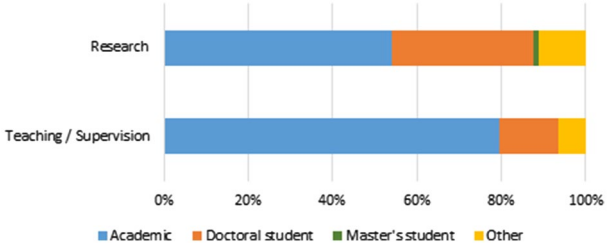

Fig. 11 User roles for mobile app users

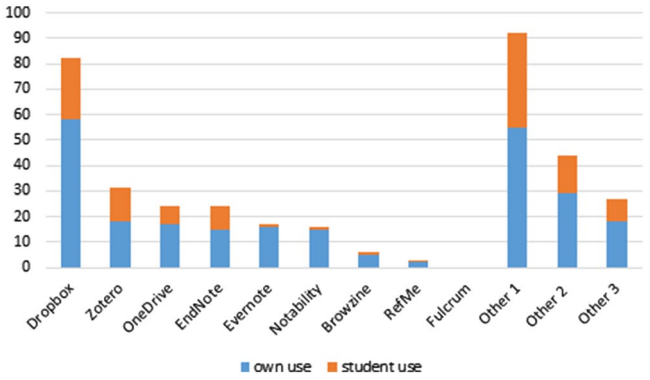

Fig. 12 Apps used for teaching/supervision (multiple selections possible)

communication with colleagues. Other tasks mentioned were communication with students, in-class surveys, or keeping up with recent blogs.

There were 95 participants that had used a mobile app for teaching/supervision, of which 71 had requested their students to do the same. These participants were asked to state the purpose for making this request; results are summarised in Fig. 14. The responses in the 'Other' category included quizzes, vocabulary practise, feedback, class activities, creative practice. Figure 14 shows that the primary reason for asking students to use mobile apps was for the purposes of communicating with others, sharing documents, followed by accessing course information.

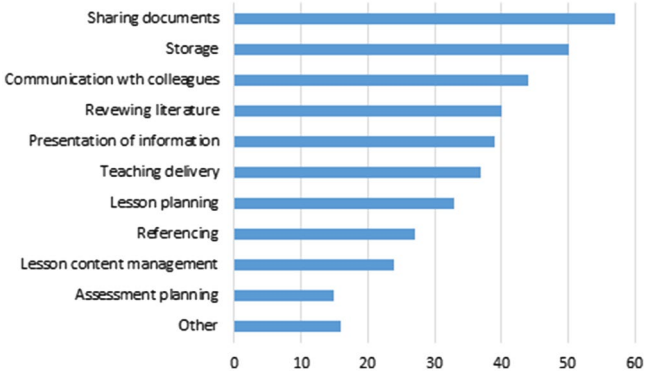

Fig. 13 Use of mobile apps in teaching practice (multiple selections possible)

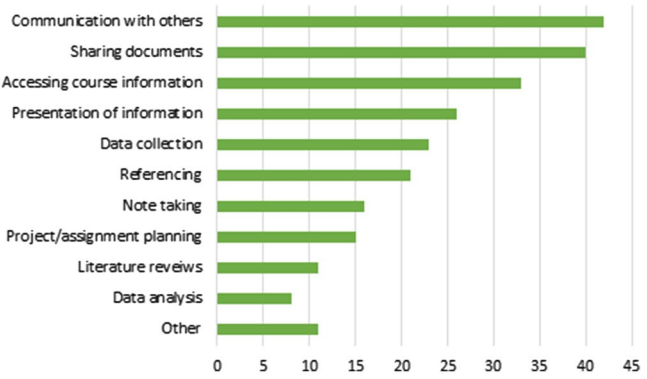

Fig. 14 Mobile apps recommended to students (multiple selections possible)

3.5 Apps for Research

Of the 172 participants who had used mobile apps for academic purposes, 146 did so for research purposes (85%), one participant provided no answer. This group of 146 participants were asked what academic-related mobile apps they had used for research purposes from a list of possibilities provided. The results, summarised in Fig. 15, show the file-hosting app Dropbox was extremely popular and used by 62% of researchers (N = 91). There was a substantial number of participants (65) who provided 'other' options, with many participants naming up to 6 or 7 apps, including Google apps (N = 22, among which were Drive: 12, Docs: 3, Keep: 3, Slides: 2, Gmail: 3), Mendeley (N = 5), Skype (4), voice recording (3), Twitter (3). Participants also mention apps that had been written by themselves or their students.

Participants were also asked what research purposes they used mobile apps for (see Fig. 16). Storage and sharing of documents, as well as searching and note-taking were the main reasons for researchers using mobile apps. Only 22 'Other' answers were collected, mostly naming different uses such as reading (6), recording of various data, such as interviews (2) and notes on whiteboards (1), and app development (2).

3.6 Impact of Apps on Academic Experience

All participants who had indicated that they used mobile apps for academic purposes were asked to respond to questions on their use of mobile apps for their teaching/supervision or research, their knowledge of apps, and their use of mobile apps. The response required from participants was on a 5-point Likert scale from strongly agree (1) to strongly disagree

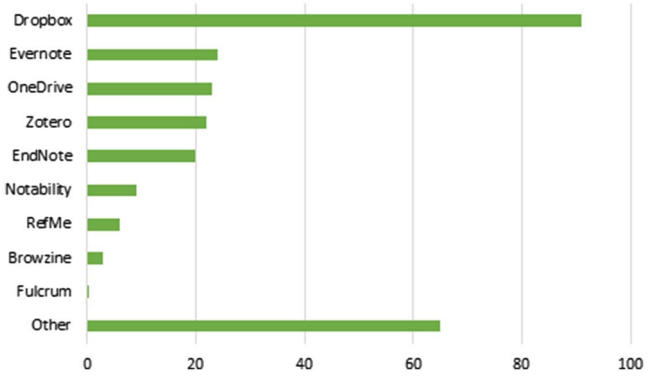

Fig. 15 Mobile apps used for research (multiple selections possible)

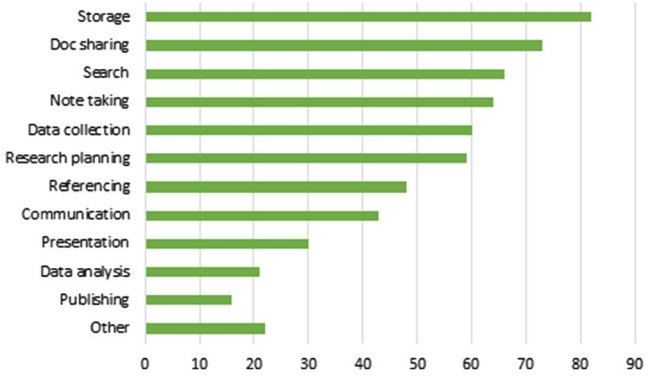

Fig. 16 Purpose of mobile app use for research (multiple selections possible)

(5), see Fig. 17. The factors that participants reported to most strongly agree with was "my research or teaching benefited from the use of mobile apps" (mean = 1.72) and they "had no problems finding a suitable app for my research or teaching" (mean = 2.40). The attitude statement that participants most strongly disagreed with was "I experienced difficulties in using mobile apps" (mean = 3.60). Other responses regarding the attitude towards app use were; "the outcome of my research or teaching was impacted by the use of mobile apps" (mean = 2.49), "my research or teaching practice was conducted differently as a result of using mobile apps" (mean = 2.53), and "I know where to go to get help with mobile apps" (mean = 2.62).

Only 20% of participants experienced difficulties when using mobile apps in an academic setting. 45 to 60% of participants knew where to seek help and where to find suitable apps (vs 15–25% who did not; 7% no answer). A similar observation holds for the perceived impact of using apps for research and teaching both in terms of change of practice and outcomes.

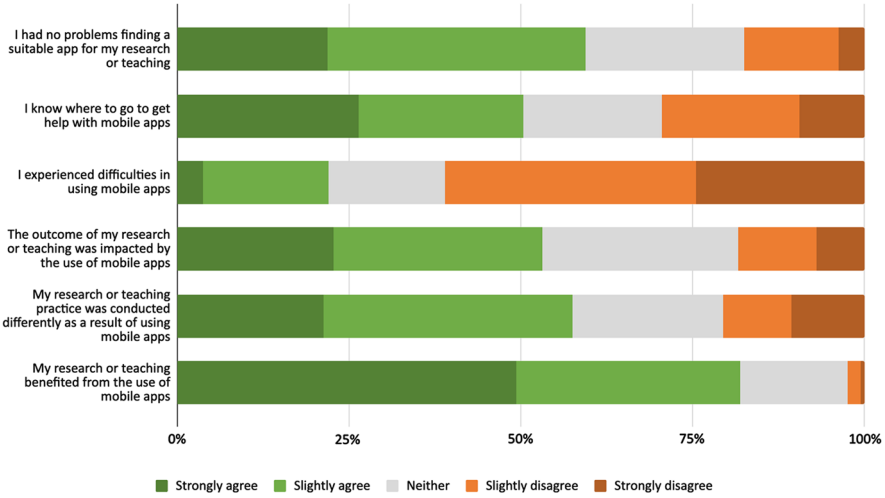

Fig. 17 Attitude to mobile app use: data out of 100% = 172 participants

However, nearly 90% of mobile app users responded that they felt they had benefited from, or felt neutral about, the inclusion of mobile apps in their academic activity (2% slightly disagreed, 8% no answer).

3.7 Experience of Users

The survey provided an opportunity for participants to provide any further comments they wished on mobile app usage in an academic setting. 60 participants provided comments, 18 from participants who had not used apps for academic purposes, and 42 from participants who had experience with such apps. Participants will be referred to by identifiers P1 to P269. Many of the concerns voiced were brought up by non-users and users alike. We, therefore, do not discuss their comments separately but indicate which category a participant falls into next to the identifier (P_U for users and P_N for non-users).

In comments provided by non-users, **distrust in app/technical reliability** were expressed, such as by participant P_N124: "Technology moves so fast that planned obsolescence is commonplace. New apps have a track record of failure in their first years: this does not look good to students if suddenly the app for their course falls over". Similarly, P_N146 comments "I wish people would switch their bloody mobile phones off, and get a life really.", and P_N231 "I do not have a mobile".

Participants also discussed mobile app **usefulness from a pedagogical viewpoint**, stating that "[…] we have gone into more and more web-based teaching, and moodle etc. However, I have seen that … students who will end up as designers in some companies do not gain much from these approaches. In my judgement and experience … use of white board and limited amount of notes uploaded will work well, with [a] lot of laboratory type hands-on elements. I strongly believe that if we [lose] the 'human touch" in [the] classroom setting, it will gradually and negatively affect the quality of the graduates we produce" (P_N128).

Several users commented that they are planning to do more or feel still at the beginning of their journey and **wish for more support**: P_U233: "I've been reluctant because of time,

planning and other flexibility related restrictions it places", P_U254: "Most of the learning on this is on my own. more exposure is needed through seminar etc." P_U87: "Would be great to get some training on this)". Some expressed reservations about institutional support, for example, P_U108: "Help with mobile apps seems to be largely found in internet searches of forum posts and vendor provided documentation".

Participants expressed that **guidance** on choosing apps was needed as "It would also be great if there was some sort of online resource on the uni website that lists and briefly explains some of the apps that might be useful when conducting research" (P_U39), and the concern that "There is simply not the capacity in ITS to support mobile app usage" (P_N124). Similarly, non-users wished for more support: P_N108: "Help with mobile apps seems to be largely found in internet searches of forum posts and vendor provided documentation",

Some participants considered app use **inconvenient**, claiming "In many instances and situations a well thought out website enhanced for use on mobile will be more useful and less cumbersome than an app. I despise having to download and constantly update several apps, plus they come with intrusive permissions" (P71). Or participants felt that apps were "only useful where use of a real computer is impossible". The context within which apps could be integrated into the learning environment caused some uncertainty, with several comments highlighting this reservation, "It is sometimes challenging to find the most appropriate app to meet a specific teaching purpose" and "The challenge will be to develop apps or modify existing apps to suit the purpose of the user and the context of the user".

Finally, some participants expressed a **dislike or unfamiliarity with/for phones and technology** in general: "I wish people would switch their bloody mobile phones off, and get a life really [..]" (P_N146) and a distrust in apps as they expressed concern that "they need to be reliable enough that researchers can be confident that they will not suffer data losses if they use just apps" (P_U105). Similarly, worries about the hardware were expressed: "Our devices need updating. Phones are personally owned and my ipad is too old for some of the apps I want to use." (P_U155).

Some comments seemed to be expressions of **undisclosed fears** that were channelled into the reasons given. For example, P_U104 raised the issue that "One can only move as fast as students are able. One can only do so much introducing of new technology—you can get to a point where you have built a learning task for example on a particular resource and then find that half the class cannot even access it".

A theme that was detected in the responses received reinforced the **mobile nature of both tertiary education** and academic publishing today. This can be specifically seen in the discussion of mobile and on-the-go teaching, learning, and research. Participants listed the importance of being able to collect data, take notes, as well as communicate with peers, participants, and users in a variety of situations. One participant noted, "I've largely found it useful for mobility rather than anything else." Another participant, whose complaint we noted earlier regarding screen size making viewing information less pleasurable for them compared to a computer, did note "at least information is available and accessible when on the move". A further PhD student stated that "mobile apps are great. If you are in tedious work meetings you can work on easy bits of your thesis and people just think you are diligently taking notes".

Similar numbers of participants believed their work-life was or was not impacted by mobile apps as participants who believed their teaching or research practices were different today because of their mobile app use. Investigation of the impact of technologies including mobile devices and applications on traditional pedagogies and research practices and processes warrants further empirical investigation.

Significant discussion related to use of apps for **teaching** rather than research. With some being enthusiastic: "We are moving into the new generation Apps is the tool to connect with the students. / Let's not hesitate. We need to be engaging successfully to create a sense of new age." (P_U81), while others are quite reserved about technology use, including " web based teaching, and moodle" (P_N128). P_U78 described challenges: "It is sometimes challenging to find the most appropriate app to meet a specific teaching purpose". P_N203 teaches online papers and comments "it would be great to have a way for students to access discussion groups and to have virtual communication through a mobile app".

Several participants explicitly wished for apps that allowed access to library resources such as eBook readers (P_U33, P_U7), library search (P_U42, P_U120), and a personal library (P_U202). Some participants were very enthusiastic about the potential of apps in the academic environment, such as "We are moving into the new generation of Apps is the tool to connect with the students. Let's not hesitate. We need to be engaging successfully to create a sense of new age" (P_U81) and "Apps greatly increases my ability to store quotes and research links" (P_U67). Conversely, some participants used the open feedback option to comment on the shortcomings of their personal phones (P_N169: "I find the real estate of my mobile device is too small [..] my tablet is too slow"), on perceived shortcomings of innovation management (P_N182: "endless workshops") or even expressed fears about the motivation of the survey (P_N166: "The outcome of studies like this can be deeply political"); conveying a sense of fear about potentially being forced to use apps for research and teaching.

3.8 Experience of Non-Users

In Sect. 4.2 we report that 35% of the participants had not used mobile apps for academic purposes (N = 93). More than half of these non-users (N = 50/93) indicated that they did not intend using mobile apps for academic purposes in the future. Forty-four percent (41/93) of these non-users reported that they do plan to use apps in the future. We asked non-responders what their reasons for non-use of mobile apps in academic contexts were. Forty-seven people responded to this question. Nearly half of the 47 participants reported they lacked knowledge about how they might use mobile apps for their purposes. Further to this approximately one-third of the participants confessed their disinterest in apps, while approximately a third considered them to be irrelevant for their teaching or research needs. Eight participants reported a lack of apps for their purposes and 7 participants discussed the perceived lack of support from the university. Other opinions suggested that computers and large screen devices serve their needs better than mobile devices for academic purposes. One academic responder twice noted planned obsolescence as a factor hindering their use of mobile apps in the academic context. Some participants also named specific fields for which they believed mobile apps or small screen devices would not be suitable.

We noted earlier that 44% of non-users had indicated they might use mobile apps in the future. We asked these non-users to select what factors might influence their future use (multiple selections were possible). 40 participants responded to this question (1 provided no data) resulting in 145 selections (see Fig. 18). Non-users were most interested in mobile apps that supported them to share or communicate with others (selected 23 times), see Fig. 19. The option 'Other' included participant sign-up, reading, engaging with students in and out of lectures (3), and the possibility of so far unforeseen usages (3).

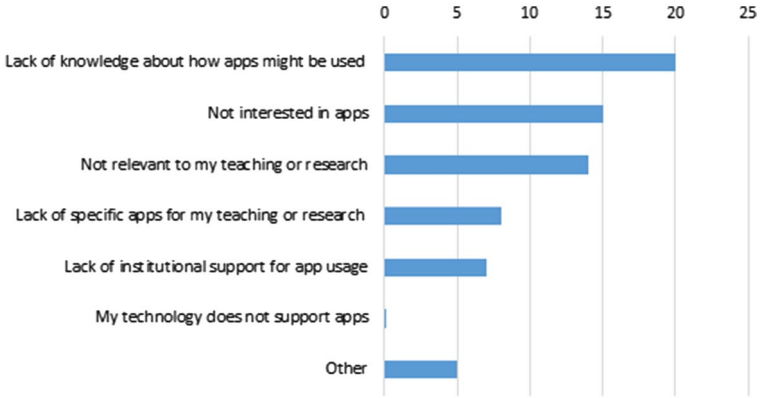

Fig. 18 Reasons for intended non-use of mobile apps (multiple selections possible)

The 41 participants who reported not using mobile apps were asked how helpful the six factors shown in Fig. 20 might be in facilitating the uptake of mobile app usage for academic purposes. This question was posed as a 5-point Likert scale from very helpful (1) to very unhelpful (5), for which 38 of 41 people responded. Responses show that "more appropriate apps" (mean = 1.54) and "easier to use apps" (mean = 1.55) were the factors most likely to facilitate uptake with app non-users. This was followed by; "more practical support" (mean = 1.58), "more institutional support (mean = 1.66), "more information about apps" (mean = 1.66) and better access to appropriate devices (mean = 1.81).

Of the six factors posed, the two that were defined as very helpful and helpful were factors relating to "easier to use apps" and "more appropriate apps".

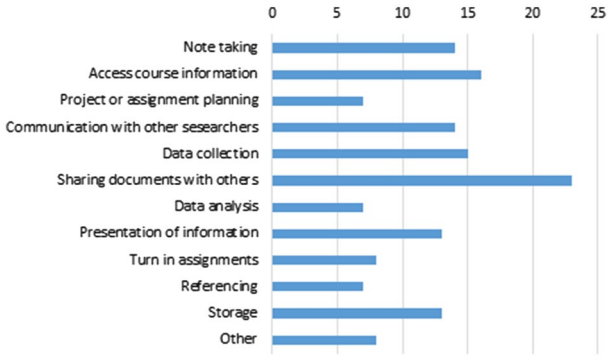

Fig. 19 Non-users intended future use of mobile apps

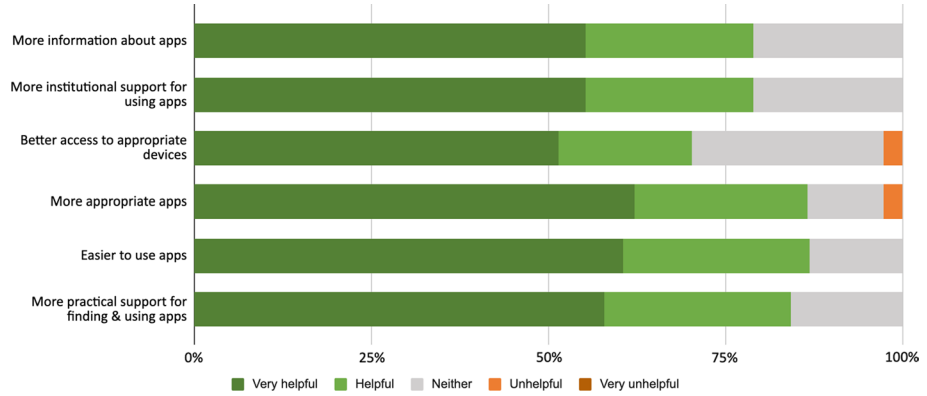

Fig. 20 Factors facilitating uptake of mobile apps

4 Discussion

We here discuss our findings in light of our research questions, their implications and opportunities. Our research was motivated by three questions, which we will answer here based on our study results. We will compare and contrast our findings with the related work, giving specific relation to two related surveys of academic use of mobile technology use (Lai & Smith, 2018; Shraim & Crompton, 2015).

4.1 Answering RQ1: Are Academics Using Mobile Apps?

Our study had 269 participants from a potential pool of 1400 staff and HRD students (19.2% response rate, including 28% academics and 10%). The two related surveys had similar response rates of 24% among teaching staff (Lai & Smith, 2018) and 29% (Shraim & Crompton, 2015), with similar distributions across gender (i.e. a slight to significant majority of male respondents).

172 of our 269 participants (64%) had used mobile apps for academic purposes such as teaching or research. The percentages among academic staff and doctoral students were comparable at 67% and 69%, respectively, but much lower for Master's students. 95 of 172 (56%) had used a mobile app for teaching/supervision purposes; 146 (85%) had used one for research purposes; and 70 (41%) had used apps for both. By contrast, Lai and Smith (2018) found that the majority (75–90% for comparable categories) of their respondents had not used any mobile technology for teaching. Shraim and Crompton (2015) did not report previous app use for academic purposes.

We found that 62% of the 141 female participants and 67% of the 125 male participants had used apps for academic purposes. By contrast, Lai and Smith (2018) found that more female teachers used mobile technologies for teaching than male teachers. They hypothesised that the reason may have been that the female teachers were younger than the male teachers in their response cohort. They also found that junior teachers are more willing to learn to use new technologies than senior teachers. We similarly found the strongest engagement with mobile technology among the 21–30 year-olds (71%), followed by the 31–40 year-olds (64%). Shraim and Crompton (2015) noted that three-quarters of their

respondents were aged between 25 and 45, going so far as to suggest that older faculty chose not to respond, perhaps being less inclined to use mobile technology as part of their teaching. Some of our participants were of a generation where the technology may be seen as a hindrance or unfamiliar tool. For example, participant P_N191 stated "I think strategic training is really necessary for people like myself who is not a digital native—what are the benefits? How to develop greater usage in daily work and life?" However, very few participants who had used apps did report technical difficulties (see our discussion in Sect. 4.3). We conclude that the study participants who did use apps for teaching and research were proficient, while the extent to which non-users experienced difficulties is hard to gauge.

Our findings support the related literature that academics are using mobile technology and mobile apps for teaching and research. These findings imply there is a need to more deeply understand the reasons for app use/non-use by academics across tertiary institutions. From there, an exploration can be started of how appropriate support can be provided.

4.2 Answering RQ2: Which Apps are Used by Academics for Teaching and Research?

Apps for Supervision/Teaching Participants reported app use for tasks that involve sharing or storing documents, as well as for communication with colleagues and students, and some use for in-class surveys, or keeping up with recent blogs. Similarly, it was reported that teachers required students to use apps primarily for communication and information storage or delivery purposes. This is in line with many studies that suggest that mobile devices in higher education may provide new opportunities for information gathering and use, content access, communication, collaboration and reflection (Beddall-Hill et al., 2011; Bowen & Pistilli, 2012). The tool that academics most reported as being used by themselves and by students was Dropbox, a file sharing and storing app that facilitates collaboration and information dissemination. Neither of the two related surveys (Lai & Smith, 2018; Shraim & Crompton, 2015) focussed on the use of mobile apps or specific software, but rather on technology use.

However, many participants reported a lack of time, resources, and control as reasons why they have not successfully implemented mobile apps into their teaching for use by or with students. Participant P_U233 noted "I've been looking at Kahoot at the like for teaching. I've been reluctant because of time, planning and other flexibility related restrictions it places", while P_U154 reported "at the moment, I am just using the iPad to save paper. It hasn't really impacted how I teach. I am aware that there is far more I could do with it, but I do not have a lot of control over what/how I teach." Lack of time, resources and knowledge are well-known issues for academic use of technology that were observed in other studies as well (Ajjan & Hartshorne, 2008; Lai & Smith, 2018; Shraim & Crompton, 2015)).

Another interesting aspect was the perception that teachers need to restrict students' screen time (P_N187): "with my overseas students (English language learners) … I try to promote personal f2f interaction in my lessons and try to get the young students away from their screens!" While this was not a prevalent theme, it deserves consideration in future research.

Apps for Research Sixty-four percent (172 of 269) of participants had used apps for research or teaching. A number of apps were listed for participants to select from. The participant was able to select multiple apps that they had used for their research. The research team had hypothesised a number of bibliographic, file sharing, and document creation tools for participants to select from. While file hosting and sharing was reported as being used

significantly by participants, it was interesting to note that social media (Twitter), communication (Skype), as well as file creation and storage solutions (Drive, Google apps, voice recording) were also listed by numerous participants. If we consider the nature of research and international connectedness that is expected in universities today, it is unsurprising that a number of these apps that allow for asynchronous collaboration and long-distance telecommunication are listed as central to the modern research framework. This is summed up by one participant (P_U206) who commented "the survey seems to focus on information management. Apps also allow easy access to communication and collaboration channels."

Higher numbers of academics and students reported using apps in the early phases of the research process for tasks such as note-taking (64 participants), search (66), research planning (59), communication (43), data collection (60), and document sharing (73), compared to later phases of the research process such as data analysis (21), presentation (30), and publishing (16).

App use for research was not considered in the related surveys (Lai & Smith, 2018; Shraim & Crompton, 2015). To the best of our knowledge, no comparable data has been collected so far. The implications of these findings is that work to support and develop appropriate mobile applications that service academics during all phases of the teaching and research process are required.

4.3 Answering RQ3: What is the Experience of Academic App Use?

We here discuss first the experience of respondents who had used apps, and then those of respondents who did not use apps but had identified obstacles.

Impact on Academic Experience The majority of our participants did not encounter any issues with finding and identifying relevant apps. Our participants also did not encounter major technical difficulties when using apps. For example, only three explicit comments called for technical support and only 20% of participants mentioned technical difficulties. Most observed that using apps influenced the way they did their teaching and research. The vast majority of mobile app users (90%) in our study felt that they had benefited from, or were neutral about, the inclusion of mobile apps in their academic activity. Both Lai and Smith (2018) and Shraim and Compton (2015) also explored teachers' attitudes towards mobile technology use in the classroom but did not ask if teachers experienced the technology as having been helpful. Like most other publications on technology use for teaching (Hahn, 2014; Canuel & Chrichton, 2015; MacNeill, 2015), they asked instead about the teachers' beliefs in the opportunity of enhanced learning, which may not align with the actual experience of using mobile apps. As a potential drawback, they named students becoming less critical, or increasing their workload (Lai & Smith, 2018). Given the low percentage of mobile technology use (<25%), this feedback is largely not based on the academics' experience. While they reported that their departments supported the use of mobile technology, it remains unclear if this describes a positive attitude or practical help (Lai & Smith, 2018).

Lack of support A common theme was a lack of support by the institution for mobile device and mobile app use for teaching, learning, and research purposes. Participants noted a need to be supported in identifying apps of relevance and suitability to their teaching and research. One academic participant discussed a "notable lack of support for adequate apps, a case in point being that the Uni does not provide apps suitable for reading online books" (P_N124). The results of both studies suggest that non-users may be more willing to use mobile apps if institutional support and guidance were provided. This desire for institutional support came from both academics and students, with higher degree student P_U33 reporting "it would be very beneficial to have an online list, or equivalent, of useful apps for students, varying from note-taking, referencing, data collection right through to ones specific to different fields of study. Many of the apps I now use would have been extremely useful had I known about them when I began this degree." This reporting by academics of a need for institutional and wider support in selecting and using apps to support their pedagogy, classroom practice, and research is in line with Horizon Report Preview (EDUCAUSE, 2019) that calls for sustained support and professional development in order to take advantage of the new teaching practice opportunities afforded by the inclusion of digital devices within the education environment. A similar sentiment has been mirrored in other studies (Ajjan & Hartshorne, 2008; Chen et al., 2015; Lai & Smith, 2018; Shraim & Crompton, 2015).

Non-use 35% of our participants reported *not* having used mobile apps for academic purposes. Furthermore, approximately half these reported they had no intention to use apps in the future. Disinterest in mobile apps for teaching, or a view of mobile apps as being irrelevant to the participant, were common reasons for these responses. Some also noted a preference for desktop solutions for these tasks. This is summed up by P_N174 who noted "I don't like/prefer to use apps for academic purposes. I feel more comfortable on desktop/laptop when having to access content relating to academic needs", while another participant stated "computers have more options than mobiles" and the perennial concern "screen size makes viewing information not as pleasurable as computer".

Of the non-users, slightly under half suggested they might use or were willing to use mobile apps in the future for academic purposes. Non-users of apps were primarily interested in the potential ability to communicate or share with others. It is interesting to note that the communication affordances are of high interest because in both surveys the view that there is no use for apps besides for communication was a common criticism for mobile apps. Perceived potential benefits of mobile apps by non-users were features such as participant sign-up, reading and engaging with students in and out of lectures. Another feature that participants noted as a potential positive for mobile apps was the perceived convenience of managing, capturing, collecting, and storing information.

Many participants saw a need for future development, advancement, and indeed further research such as that we offer here. Almost all non-users identified "easier to use

[apps]" and "more appropriate [apps]" as important or helpful. One participant summed this up "the challenge will be to develop apps or modify existing apps to suit the purpose of the user and the context of the user", while another stated "I think [mobile apps] have some good potential for engaging students in classrooms and out of classrooms. I also don't think they are the be all, end all of engagement (i.e., necessary but not sufficient for good engagement)." There appears, in addition, to have been a perception that because software or apps are open source that they do not require coordinated technical support or training from the University. Through conducting this survey we found that there is a need to provide support and information to users for both subscription software as well as open-source alternatives.

The survey has highlighted that current users have typical usage patterns and generally feel confident with the use of mobile apps for a range of purposes. There was also a group of non-users and low-users that did not feel confident. We feel the implications of our findings are the need to support academics to locate and use mobile apps during teaching and research and the desire from academics for this support as well as for new mobile apps to meet their needs.

4.4 Limitations

This study was based at a single university in New Zealand; however, its results and recommendations for engagement and need for ongoing support are potentially widely applicable for a western tertiary education environment due to similarities in academic environments. One may expect differences in the specifics of apps used, such as the prevalence of Google tools in this sample, vs the use of OneDrive for similar tasks in universities with Microsoft contacts.

A participation rate is in keeping with typical response rates for similar online studies (Fosnacht et al., 2017; Nulty, 2008; Van Mol, 2017). As the participants were self-selected, it is unclear to what extent our sample accurately reflects the university situation. As our participants were self-selected, they did not necessarily constitute a representative sample of the whole university but rather reflected the feedback of people who felt strongly enough to engage in the process. While both users and non-users of mobile apps were explicitly targeted, the resulting sample consisted of predominantly mobile app users (66%). We hypothesise that non-users may have been less inclined to respond to a survey about app usage.

The study ran at the same time in two consecutive years. One notable difference was the proportion of academic vs student participants within the studies. However, there did not appear to be overall a significant variation between the results obtained in the first year vs the results from the second year, which were therefore presented here together. We noted that some participants commented also on the use of web applications. In order to keep the study results comparable, we did not change any questions. However, in future studies we would wish to include both mobile apps and web apps (i.e., software as a service), thus addressing the use of any software services away from the office or lab environment.

5 Conclusion

While students and academics use digital devices in the higher education environment, the uptake of mobile apps for tertiary teaching and research has only begun to be studied. Research on technology use in teaching and learning rarely focuses on the experience of app use by academics. The impact and experience of the institution's expectations regarding apps by academics is not well studied. Our research attempts to understand how apps are being used in tertiary teaching and research, including what are the perceived benefits and barriers. Our study used an online survey, aiming to answer three research questions. Our study here is unique in that it has investigated students and academics' attitudes to mobile apps in both the tertiary classroom and the research environment.

The contributions of our research presented here are the following: We conducted the first study into the experience of mobile app use for teaching and research by academics. Findings from our research are as follows: (1) Mobile apps were used by academics and students for both teaching and research, primarily in the form of document & data storage and exchange, and communication. Furthermore, the stated primary motivators for future mobile app use for both teaching and research were again the ability to communicate, collaborate and share with others. (2) Very little app use was recorded for in-class activities (teaching) or in-field activities (research). (3) Our study results and related work show that at present academics and students use mobile apps due to intrinsic personal motivations rather than institutional support or provision. There remain, consequently, opportunities for better support of mobile app use. (4) Both students and academics reported that institutional support and flexibility would likely provide motivation and lead to increased app use for both research and teaching.

Many of the apps named in our study were mobile versions of web apps (such as Dropbox, Evernote, Google Drive). Some participants may even have interpreted mobile app use to mean both mobile apps and web apps (e.g., for bibliographic software Zotero and Endnote). This interplay of mobile apps and web apps (or mobile access to web apps) has not been explored for the academic context so far and should be studied in a follow-up survey. Extending this survey with consideration of software as a service (SaaS) used on mobile devices may shine a light on some of these wider-reaching applications which also facilitate teaching and research.

Our study is the first of its kind, exploring the practical experience of academics using mobile apps for teaching and research. Data such as ours can inform academic management to better support students and staff with mobile app selection and use in the academic context.

Appendix

Q1 - Q4 Demographic information

Q5 Have you used any mobile apps for academic purposes? *Yes/No*

[If 'No' to Q5]	**[If 'Yes' to Q5]**
Q6 Are you intending to use, or might you use, mobile apps for academic purposes in the future? *Yes/No* **Q22** [If 'Yes' to Q6] For what purposes do you think you might use a mobile app for academic purposes? *(You can select multiple options)* **Q23** [If 'Yes' to Q6] On a scale for Very helpful to Very unhelpful, how helpful do you think the following things might be to increase your use of mobile apps for academic purposes? *(Likert Scale 1–5)* • *More appropriate apps* • *Easier to use apps* • *More information about apps* • *More institutional support for using apps* • *More practical support for finding and using apps* • *Better access to appropriate devices* **Q9** [If 'No' to Q5 & If 'No' to Q6] What is stopping you from using mobile apps for academic purposes?	**Q8** What type of device did you use when using the mobile app? **Q10** What was your operating system when using the mobile app? *(You can select multiple options)* **Q12** For what purpose did you use mobile apps? *Teaching or Supervision/Research* **Q11** [If 'Teaching or Supervision' to Q12] What mobile apps did you use for TEACHING/SUPERVISION purposes and were they for your own use or did you ask students to use the app? *(You can select multiple options) Own use/Asked students to use it* **Q13** [If 'Teaching or Supervision' to Q12] For what specific aspects of YOUR TEACHING PRACTICE did you use the mobile apps? *(You can select multiple options)* **Q27** [If 'Teaching or Supervision' to Q12] As part of your TEACHING /SUPERVISION did you ask YOUR STUDENTS to use mobile apps for any of the following? *(You can select multiple options)* **Q19** [If 'Research' to Q12] What mobile apps have you used for RESEARCH purposes? *(You can select multiple options)* **Q18** [If 'Research' to Q12] What were the purposes of your use of mobile apps for RESEARCH purposes? *(You can select multiple options)* **Q29** [If 'Research' to Q12] Have you been involved in the development of any mobile apps that might be used for academic purposes? If so, please briefly explain the app and its purpose: **Q14** [If 'Doctoral Student'] Have you been asked to use a mobile app for academic purposes by a lecturer or supervisor at the University of Waikato? *Yes/No* **Q25** [If 'Masters thesis Student'] Have you been asked to use a mobile app for academic purposes by a lecturer or supervisor at the University of Waikato? *Yes/No* **Q16** [If 'Yes' to Q14 & If 'Doctoral Student'] Please briefly explain what the mobile app was, and the purpose of the app that the lecturer/supervisor asked you to use **Q24** [If 'Yes' to Q14 & If 'Doctoral Student'] Please briefly explain what the mobile app was, and the purpose of the app that the lecturer/supervisor asked you to use **Q20** On a scale from Strongly agree to Strongly disagree please rate the following statements: *(Likert Scale 1–5)* • *My research or teaching benefited from the use of mobile apps* • *My research or teaching practice was conducted differently as a result of using mobile apps* • *The outcome of my research or teaching was impacted by the use of mobile apps* • *I had no problems finding a suitable app for my research or teaching* • *I experienced difficulties in using mobile apps* • *I know where to go to get help with mobile apps*

Q21 If you have any other comments on mobile app usage in an academic setting please use this space

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Availability of Data and Material Data not available for privacy reasons.

Code Availability Not applicable.

Declarations

Conflict of interest Not applicable.

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