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ORIGINAL ARTICLE

Appsolutely smartphones: Usage and perception of apps for educational purposes

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Appsolutely smartphones: Usage and perception of apps for educational purposes

Abstract

Mobile education, in particular mobile learning, which uses applications on smartphones (i.e. apps), is growing in popularity at the higher education level. Driving factors are the anywhere, anytime learning experience, the dynamic and customisable nature of apps and their scalability. A total of 241 chemistry majors from the National University of Singapore were surveyed about ownership of smartphones, how they used them for academic purposes, frequency of use of educational and chemistry apps and most importantly, their perceptions of mobile devices and apps towards academic success. All respondents owned smartphones, using them 1 to 2 times a day for academic purposes mostly to search for information relevant to the lecture/discussion via search engine apps. On perceptions, there was a stark disparity between students' keen interest in mobile apps for technology-enhanced learning and lecturers' sparing use of mobile apps for technology-enhanced teaching. Those who showed greater interest in these non-traditional methods of learning were first- and second-year students who attained above average Cumulative Average Points (CAPs) for their year of study. The results of this study justify that there is value in creating apps specific to the institution's modules, where the novelty is in localising and tailoring them to enhance the experiential learning of the user base we have, our students.

INTRODUCTION

Mobile education can be viewed as education via a handheld, pocket-able device that is capable of wireless, unbroken internet connectivity via 3G/4G mobile networks and Wi-Fi signals (Traxler, 2005; El-Hussein et al., 2010; eCycle Best) enabling teaching and learning to occur anywhere, inside and outside of the classroom, and at any time (Brasher et al., 2005; Sharples et al., 2007; Oller, 2012). It expands the boundaries of higher education, allowing real-time skills and knowledge transfer through mobile connectivity, unlike the past (Sinclair, 2012). As mobile education typically occurs on a smartphone, a device which is broadly viewed as subjective and personal, there is a greater lean towards mobile learning, where the onus is on the user or student rather than on the teacher. At the same time, teachers may view what students do on their smartphones as individual and subjective as well as supplementary and outside the classroom, and thus, not perceive smartphone apps to be a suitable platform to teach on.

Smartphones, which include a wide range of functionalities and internet connectivity, on top of call and text, have become a ubiquitous part of most people's lives. According to the Nielsen report in 2012, Singapore's population has the highest smartphone ownership (72%) in the Asia Pacific region (Nielsen, 2012). On the National University of Singapore (NUS) campus, it is common to see students engrossed in their smartphone screens everywhere they go. The question of what is being read or otherwise accomplished on these smartphones, however, has not been fully explored. Many students are oblivious to the power of the instrument they hold in their hands; the power of educational apps and their contributions towards academic success if properly exploited (eCycle Best). The reasons for such technological behaviour is also worth exploring – is it due to the need for constant companionship, busyness or are these smartphones being utilised for other reasons? (Bomhold, 2013) Nevertheless, despite not fully understanding the what and the why, what is known is that these smaller and handier mobile devices, together with apps, have the potential to increase student engagement and facilitate learning (Sinclair, 2012).

Overall, the number of apps in the Apple App Store and Google Play Store have steadily increased over the past ten years. There were 1,157,278 and 1,192,013 apps in the two stores, respectively, as of April 2014 (148 Apps.biz and AppBrain). By category, education has the second highest app count after games, at 123,273 (11% of all apps), in the Apple App Store; and has the fourth highest app count, after entertainment, personalisation and lifestyle, at 82,385 (7% of all apps), in the Google Play Store (148Apps.biz and AppBrain).

The motivation for creating apps for educational purposes is driven by four main factors. First, apps on mobile devices allow an anywhere and anytime learning experience (Brasher et al., 2005; Sharples et al., 2007; Oller, 2012). Second, compared to textbooks and lecture notes which can be considered static, apps can be made dynamic as they incorporate animations, real-life videos, audio and interactivity (touch and response). Third, apps allow customised and subjective learning. For example, compared to looking for information on the Internet using a search engine, an app can consolidate information pertinent to the topic or module. Finally, the education value of an app is scalable to reach more students over time.

According to the New Media Consortium (NMC) Horizon Report in 2012, which put together insights from 47 advisory board members deriving from universities across 9 different countries, mobile devices, mobile apps and tablet computing as well as the use of collaborative environments and cloud computing will become common in education within the next year. An increasing number of educational institutions globally are integrating customised apps into the curriculum and course materials, in order to enhance the classroom learning experience, inside and outside the classroom. Mobile apps are the fastest growing segment of the mobile space in higher education, with impact on virtually almost every aspect of informal life, and increasingly, every discipline in the university (Johnson et al., 2012). Often cited are articles by the EDUCAUSE Center for Analysis and Research (ECAR), which compiles data on students' technology usage in the US. Since 2004, the annual EDUCAUSE report has charted undergraduate students' usage and perceptions of information technology as part of their college/university experience (Dahlstrom et al., 2013). The ECAR reports provide a paradigm for mobile device ownership and undergraduate academic use of smartphones over the past nine years.

Turning our focus on the academic discipline of chemistry, there is an increasing number of chemistry apps designed for prospective chemists at varying stages of their professional development: from secondary school students to graduates and beyond. In this regard, the use of smartphones by chemistry personnel and students has evolved recently (Williams et al., 2011). There are several articles that review and recommend chemistry apps such as, "Chemistry on the Go: Review of Chemistry Apps on Smartphones" (Libman et al., 2013) and "Smart Phones, a Powerful Tool in the Chemistry Classroom" (Williams et al., 2011). Websites have been set up and regularly updated by universities, such as Stanford University (The Mobile Chemist & Chemical Engineer), Monash University (Chemistry) and NUS (Appsolutely Chemistry), which recommend relevant chemistry apps specifically for their students.

Reasons abound for keen educators to jump onto the bandwagon and develop apps, but to support the commitment of institional resources to such endeavours, there needs to be market research on student users' interest in and reception of such technology-enhanced education methods. In this article, we present the findings of an online survey involving of 241 NUS chemistry majors on their usage and perceptions of apps for educational purposes. As the NUS Department of Chemistry creates its own discipline-specific apps for students, this survey was undertaken to explore the pedagogic potential of mobile learning using chemistry apps. The aims of the survey were to assess students' ownership of smartphones, how they used them for academic purposes, frequency of use of educational and chemistry apps and most importantly, their perceptions of the impact of mobile devices and apps on academic success. The results of this study were then compared to other popular mobile technology-enhanced education studies.

METHODS

An online survey of all NUS chemistry major students was conducted via the NUS Integrated Virtual Learning Environment (IVLE) portal from 17 February to 5 March 2014 (via module code OTH 877 – Survey on Usage and Perception of Apps for Educational Purposes at http://www.chemistry.nus.edu.sg/_file/people/Hardcopy%20of%20Survey%20on%20IVLE.pdf). This survey was designed after conducting a review of similar surveys in the literature such as the ECAR study (Dahlstrom et al., 2013) and several others (Bomhold, 2013; Chen et al., 2012; Bowen et al., 2012; Chen et al., 2013; Walker et al., 2009). The survey questionnaire contained 36 mixed response questions that elicited information on various aspects under six sections (selected after reviewing the literature): devices; general, educational and chemistry apps; perception and demographics. Five types of questions, namely multiple choice, multiple response, Likert scale, fill-in-the-blank and essay, were used.

769 students from first to fourth year were invited to respond. Announcements were sent twice on 17 and 24 February and a follow-up message was sent on 5 March to recipients who had not completed the survey. A total of 241 students responded to the survey, providing a response rate of 31.3% (241/769). Of these, 35.5%, 29.5%, 21.7% and 13.4% were first-, second-, third- and fourth-year students, respectively. The percentage of male and female participants was 39.9% and 60.1%, respectively. These demographic data are representative of the chemistry student population at NUS.

For multiple choice questions (MCQ) and multiple response questions (MRQ), the percentages were calculated and graphed. For the Likert scale questions (LSQ), the least favourable option was coded 1, increasing by 1 up to the most favourable option coded 5 or 6, following which the mean was calculated. Four categories were used: frequency, importance, agreement and interest (see Table 1).

Table 1. Codes used for Likert scale questions (LSQ)

Code	1	2	3	4	5	6
Frequency	Do not use/Do not have	Very Rarely (once a month or less)	Rarely (2-3 times a month)	Occasionally (2-3 times a week)	Frequently (1-2 times a day)	Very Frequently (more than 2 times a day)
Importance	Do not use/Do not know	Not at all important	Not very important	Moderately important	Important	Very important
Agreement	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	
Interest	Do not know	Not at all interested	Not very interested	Moderately interested	Interested	Very interested

Open-ended responses (OER), such as fill-in-the-blank and essay questions, were grouped into key topics and evaluated.

RESULTS AND DISCUSSION

Profile of Students' Smartphone Usage

The distribution of mobile device ownership based on the total number of devices owned (318) is shown in Figure 1:

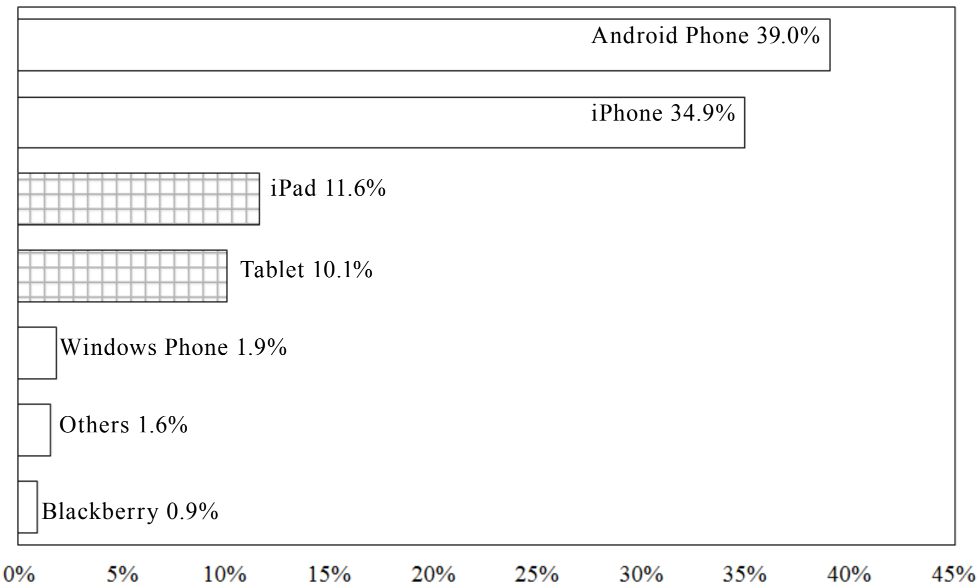

Figure 1. Ownership of mobile devices (smartphones and tablets (shown with grid)) (MRQ)

Each student owned an average of 1.3 devices. Out of the 318 devices owned, 78.3% were smartphones and 21.7% were tablets. Most students owned either an iPhone/ iPad device (products from Apple) or an Android mobile phone/tablet (from various manufacturers), with an even split between the two. All students in this study indicated that they owned mobile devices, unlike in the 2013 studies where only 77% of the students owned mobile devices (Bomhold, 2013; Dahlstrom et al., 2013). These findings show that students indeed have access to mobile devices, mainly smartphones, and hence their potential as an educational device is worth exploring.

Table 2 (following) shows that students spent an average of 4-6 hours a day on their mobile devices, about one third of their waking hours:

Table 2. Total hours spent on mobile devices per day (MCQ)

Time Spent	Percentage
Less than 1 hour	1.7% (4)
1 - 3 hours	31.1% (75)
4 - 6 hours	34.9% (84)
7 - 9 hours	13.3% (32)
10 - 12 hours	8.3% (20)
More than 12 hours	10.8% (26)

In a city like Singapore, the use of mobile devices is an integral part of urban culture and is understandably higher than figures cited for American college students in the latest College Explorer study (re:fuel, 2013). In the re:fuel study, American college students spent 3.6 hours on average a day on their smartphones, up from 3.3 hours last year, while spending less time with computers, TVs, handheld gaming devices and e-readers. This trend is to be expected as smartphones are more portable than computers, and yet give students the power of a computer, in the palm of their hand, anywhere and anytime (eCycle Best).

A primary aim of this survey was to enhance our understanding of how students used their smartphones. In view of this, students were asked what types of apps they used and how frequently (see Figure 2):

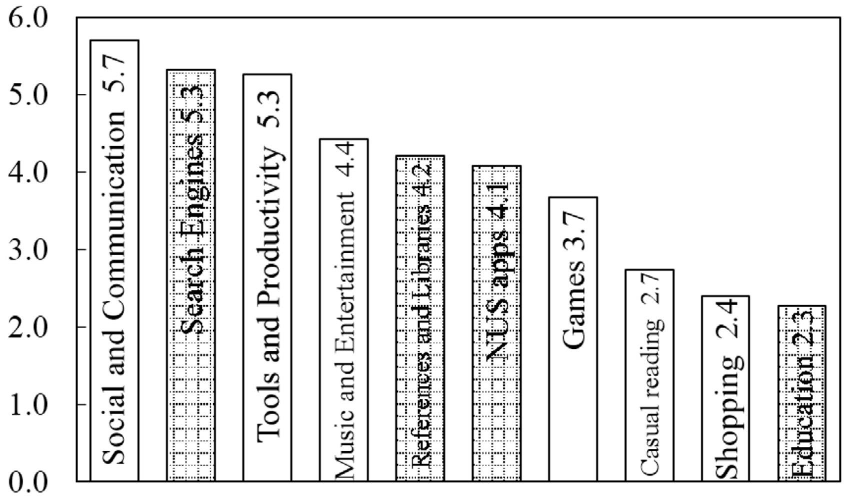

Figure 2. Frequency of use for app type on smartphones (LSQ; frequency, upon 6). Educational app types shown with grid.

Not surprisingly, the most frequently used app types were Social and Communication ones (“Whatsapp”, “Facebook”, “Twitter”, “Instagram”), with a mean of 5.7 upon 6, more than twice a day. Other categories of frequently used apps included Search Engines (“Safari”, “Google”, “Yahoo!”) and Tools and Productivity type apps (“Camera”, “Calculator”, “Dropbox”, “Email”, “Calendar”, “Evernote”). These top 3 most frequently used apps in our findings are identical to those of a 2013 survey at the University of Southern Mississippi (Bomhold, 2013).

A mean of 4.6 upon 6, which translates to 1-2 times a day, was recorded for students’ frequency of usage of mobile devices (smartphones and tablets) for academic purposes. The students said that they used their smartphones to search for information relevant to the lecture/discussion during classes and to photograph information (Figure 3):

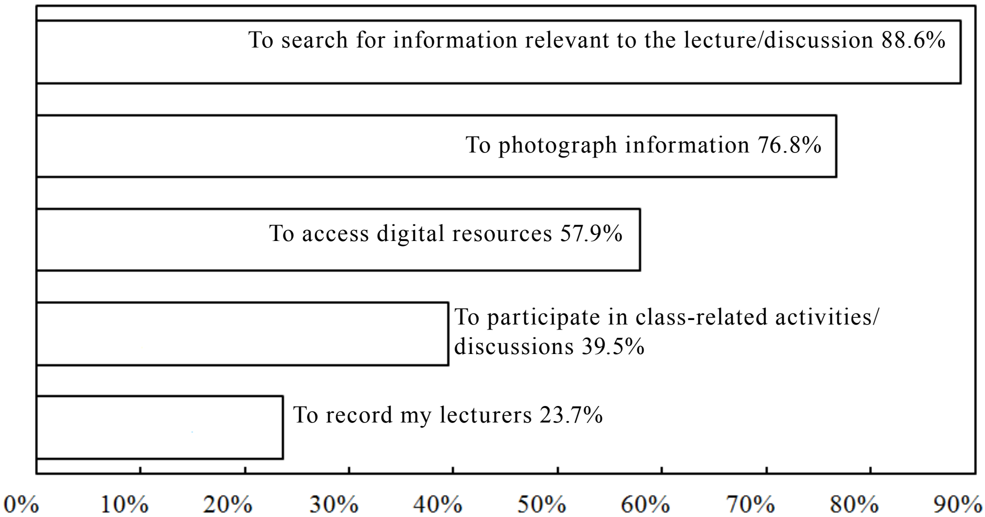

Figure 3. Ways students use their smartphone as an effective learning tool during classes (MRQ)

This is compatible with the findings in the ECAR study (Dahlstrom, 2013) and ties in with the high frequency of usage of Search Engines and Tools and Productivity type apps (Figure 2).

Educational and Chemistry Apps

The students were asked two survey questions: "How many educational apps do you have on your smartphone?" and "How many chemistry apps do you have on your smartphone?" These were perception questions as the students were free to define the apps they had as educational and/or chemistry apps. 71.4% claimed to have educational apps, with most owning 1-5, while only 39.3% claim to have chemistry apps, with a majority of them owning no chemistry apps at all (Table 3).

Table 3. Number of educational and chemistry apps on students' smartphones (MCQ)

	Educational App	Chemistry App
0	28.4% (64)	60.7% (136)
1 – 5	64.4% (145)	38.8% (87)
6 – 10	5.3% (12)	0.5% (1)
11 – 15	0.9% (2)	0.0% (0)
16 – 20	0.4% (1)	0.0% (0)
> 20	0.4% (1)	0.0% (0)

Most seemed to consider the following 4 app types as educational apps: Search Engines (“Safari”, “Google”, “Yahoo!”), References and Libraries (“Periodic Table”, “Dictionary.com”, “Wikipedia”), NUS apps (“NUS IVLE”, “NUS NextBus”, “Around NUS”, “NUS mSurvey”) and Education (“Coursera”, “Khan Academy”, “TED”), with Search Engines apps being the most frequently used (Figure 4):

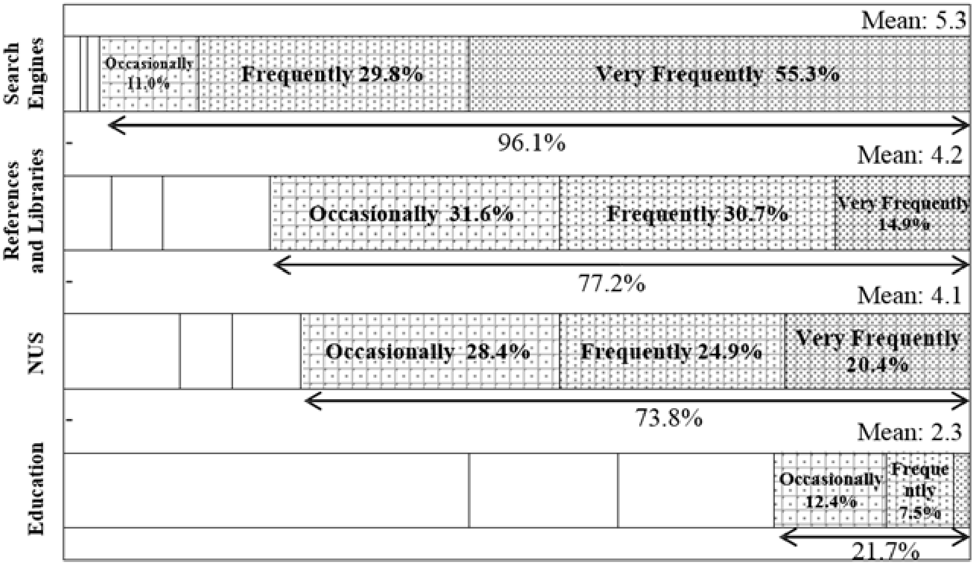

Figure 4. Frequency of use of educational apps (LSQ; frequency, upon 6)

The 39.3% of students who said that they owned chemistry apps (Table 3) were asked to indicate which of the 13 chemistry app types their apps belonged to. Most students reported that they own Periodic Table type apps (33.5%) (Figure 5), which is unsurprising since knowledge of the periodic table, together with the elements’ physical and chemical information, is essential for every chemistry student. There were 527 such apps available in the Apple App (275) or Google Play (252) Stores as of April 2014. Other commonly owned chemistry apps were of the Reference apps and Molecular Draw and View types:

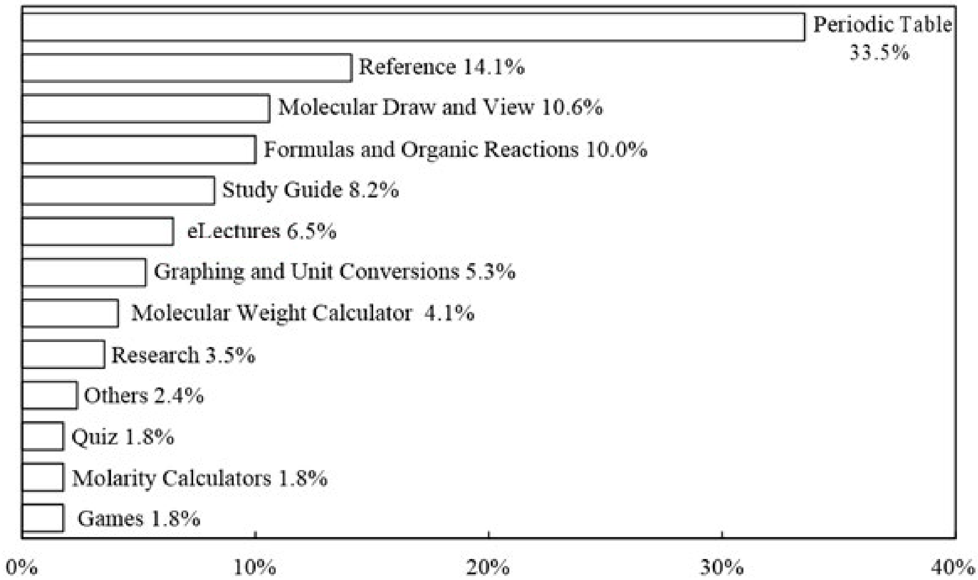

Figure 5. Types of chemistry apps owned by students (MRQ)

Students reported that they use chemistry apps to complete tutorial questions, laboratory reports or assignments for their classes. On average, students reported using them once a month or less, and only 11.3% reported using them ≥2-3 times a week, with a mean of 1.7 upon 6. This is perhaps due to the lack of apps available at the higher education level. Chemistry apps will likely have to be linked to students' chemistry modules and recommended and used by lecturers in class, in order to be frequently utilised by students.

Students were asked to name their top 3 most frequently used and preferred general, educational and chemistry apps (Table 4):

Table 4. List of the top 3 most frequently used and favourite general, educational and chemistry apps

	General App	Educational App	Chemistry App
Top 3 Most Frequently Used	- Whatsapp (20.9%)	- NUS IVLE (26.8%)	- Periodic Table (33.0%)
	- Facebook (13.7%)	- Dictionary.com (13.9%)	- SYM MO (25.7%)
	- Instagram (10.8%)	- Periodic Table (6.2%)	- TCT Lite (3.7%)
	- Google (7.2%)	- SYM MO (3.8%)	- Google (3.7%)
	- Twitter (4.5%)	- Wikipedia Mobile (2.4%)	- ACS Mobile (1.8%)
Favourite	- Whatsapp (34.4%)	- NUS IVLE (17.6%)	- Periodic Table (38.6%)

Out of the 669 general apps named, 50.8% were Social and Communication apps such as “Whatsapp”, “Facebook”, “Twitter” and “Instagram” and 14.5% were Search Engines apps, with “Google” being the most frequently used (Figure 2). 34.4% declared that “Whatsapp” was their favourite app as “it [wa]s free, convenient and allows connectivity with friends”.

Out of the 339 educational apps named, 28.0% were NUS apps with “NUS IVLE” encompassing 26.8%, and 25.4% were References and Libraries apps such as “Dictionary.com”, “Periodic Table” and “Wikipedia Mobile”. 17.6% have “NUS IVLE” as their favourite educational app because “it organises the resources well, location of the information is easy and it is convenient to use”.

Out of the 109 Chemistry apps named, 40.4% were Periodic Table apps which included “Periodic Table” and “The Chemical Touch (TCT) Lite” and 29.4% were Molecular Draw and View apps such as “SYM MO”. 38.6% have “Periodic Table” as their favourite chemistry app as “it is applicable to all chemistry modules, is convenient and provides molecular information such as mass, density and melting/boiling points of each element”. This ties in with the types of chemistry apps owned by students (Figure 5).

OER questions inquired about students’ usage of search engines, educational and chemistry apps to find out how they used their smartphones for academic purposes. Students were asked to recall past instances and complete the statement “I needed information…and the app used was…” Most students reported that they used search engine apps such as “Google” for information searching when they had difficulty understanding the lecture materials or when attempting tutorial questions. Search engine type apps were also used to find references such as Nuclear Magnetic Resonance (NMR) characterisation tables, Material Safety Data Sheets (MSDS) as well as online journal articles for laboratory reports.

“NUS IVLE” was the most common educational app used when students needed information on the modules taken in that semester. Information such as real-time announcements, lecture materials or even forums can be viewed on the go. Other educational type apps such as Dictionary, Translator or Thesaurus allowed students quick access to definitions and synonyms to help with grammar, spelling, pronunciation and translation.

Chemistry apps such as “Periodic Table” and “TCT Lite” are largely used when students needed information on atomic mass and electronic configurations of elements. When students needed information on molecular symmetry and visualisation of the various point groups, “SYM MO” was used. Other Chemistry apps such as “W Chemistry Handbook”, “Wolfram Alpha” and “Molarity” were used in laboratory-based modules to source for information on the chemicals used, the coherence of data obtained and to calculate the amount of reagents required for dilution, respectively. Despite smartphones’ small screens and keyboards, a number of students said they would use them to search for academic or ready reference type inquiries (Bomhold, 2013). This highlights the fact that students want information fast from sources that are “good enough” (Connaway et al., 2011).

Perceptions about the usefulness of Mobile Devices and Apps for Educational Purposes

In order to rationalise the development of educational apps, students’ reception of and interest in such technology-enhanced education methods were surveyed. Firstly, students were asked to identify their level of experience with smartphone usage based on a common set of descriptions (Bowen et al., 2012). The given descriptions were based on the timespan of ownership and characteristics that describe the level of smartphone usage.

Results show that students viewed themselves as skilled smartphone users, with 48.2% identifying themselves as intermediate smartphone users: “I have been using a smartphone for more than six months. I occasionally download apps when I have a need or when my friends recommend something new”; 47.3% identified themselves as advanced users: “I have been using a smartphone for two years and have installed and used a variety of different apps. I often install many of the same type of app to evaluate differences and make recommendations to my friends about the best apps”. These responses are consistent with a recent Purdue University study where 85% of students identified themselves as either intermediate or advanced users (Bowen et al., 2012). This is compatible with our study where 95.5% of our students responded in a similar manner.

Figure 6 shows responses to the questions “Why do you use apps on your smartphones?” and “Why do you use apps for academic purposes?”:

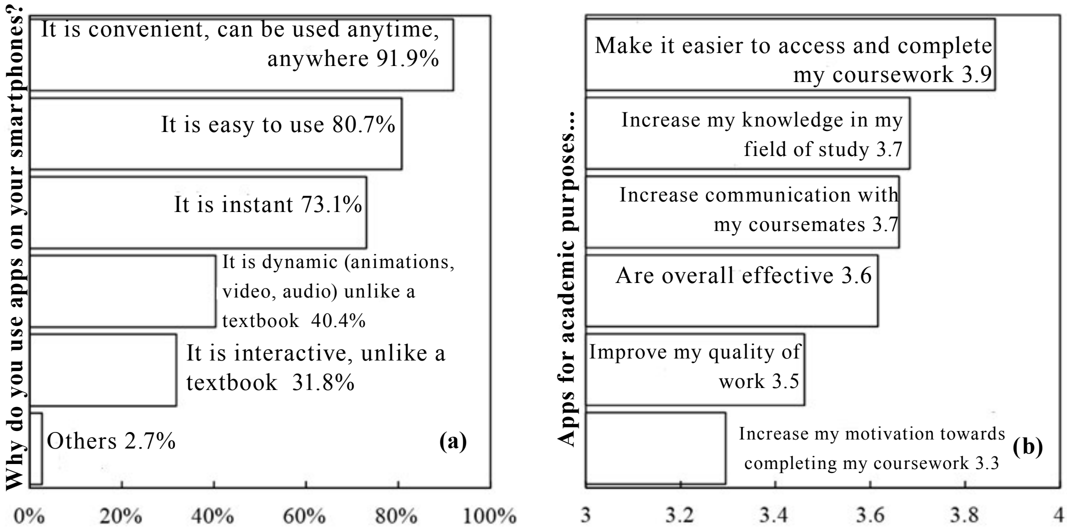

Figure 6. Reasons for (a) why students use apps on their smartphones (MRQ); (b) using apps for academic purposes (LSQ; agreement, upon 5)

91.9% of students indicated that they used apps on their smartphone as "it is convenient, can be used anytime, anywhere". This finding correlated with the high mean of 3.9 upon 5, where most students reported that "Apps for academic purposes make it easier to access and complete my coursework". "Easier to access coursework" was the most common reason to a similar question in the University of Central Florida survey (Chen, 2012).

Students were also asked to rate the importance of smartphones, tablets and educational apps to their academic success and their responses are collated in Figure 7 below:

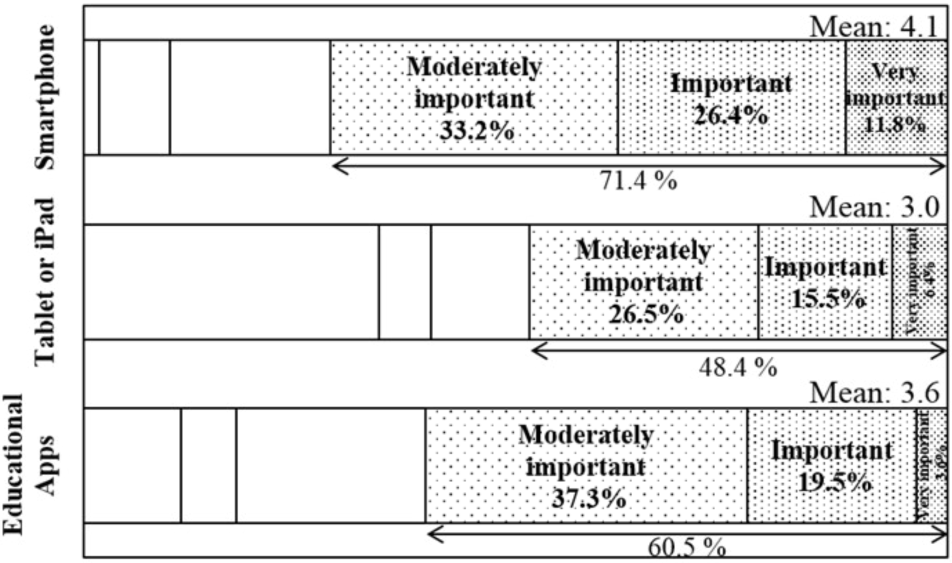

Figure 7. Importance of mobile devices and educational apps towards academic success (LSQ; importance, upon 6)

Figure 7 shows that 71.4% of the students considered smartphones to be important for their academic success, as can be expected of intermediate or advanced smartphone users who use smartphones ≥2-3 times a week for academic purposes (~69.7%)[1]. This is unsurprising, considering that smartphones are basically ubiquitous, as out of all the devices owned, 78.3% are smartphones whereas 21.7% are tablets (Figure 1). In contrast, a smaller percentage of tablet owners (48.4%), perceived tablets to be important to their academic success, which is perhaps expected, considering that only 21.7% of all the devices owned are tablets (Figure 1), and only 19.3% of students use tablets ≥2-3 times a week for academic purposes.

[1] The estimated values for usage of device ≥2-3 times a week for academic purposes is calculated from the percentage of students that use their mobile devices ≥2-3 times a week for academic purposes (89.0%) multiplied by percentage ownership of that device i.e. smartphones or tablets.

Figure 7 also shows that 60.5% of students view educational apps as important to their academic endeavours, which is unsurprising as 71.4% of students have educational apps on their smartphones (Table 3), and on average 67.2% use educational apps ≥2-3 times a week (Figure 4).

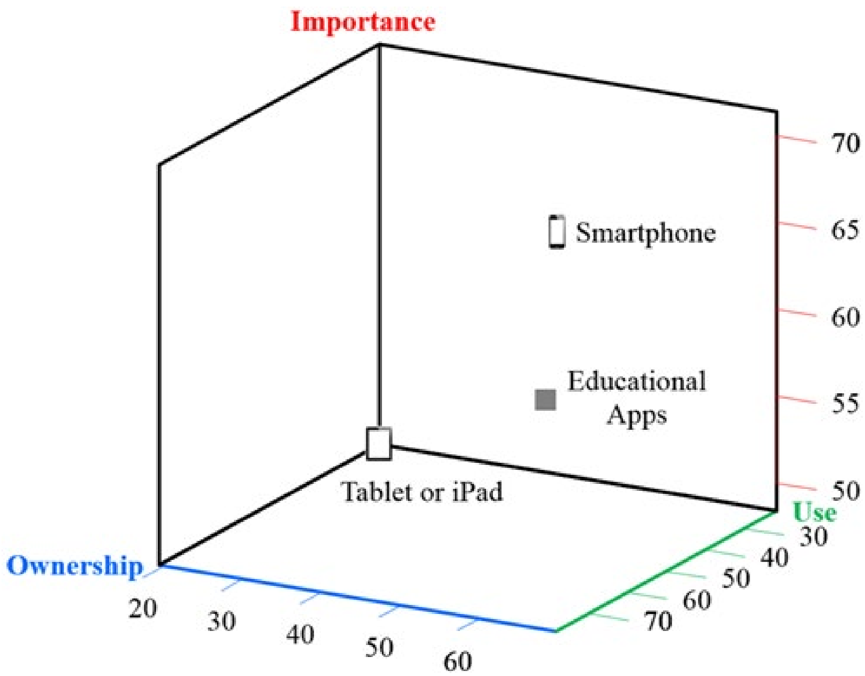

Figure 8. Correlation of ownership, use and importance for mobile devices and educational apps

The responses with regards to ownership, use and importance were correlated, in Figure 8, to determine if our students are logical consumers. Such a finding is consistent with the ECAR 2013 study (Dahlstrom et al., 2013), reporting a significant increase in use and importance of smartphones for academics, from 2012 to 2013, which is the steepest change over a year compared to the same period over the past 10 years.

The survey also attempted to determine whether it is worth devoting institutional resources to development of educational apps. Are students interested in downloading and trying out educational apps? Figure 9 shows that 82.8% and 91.0% students express positive attitudes towards their institution, namely NUS and the Department of Chemistry, respectively, creating and using apps to facilitate their learning:

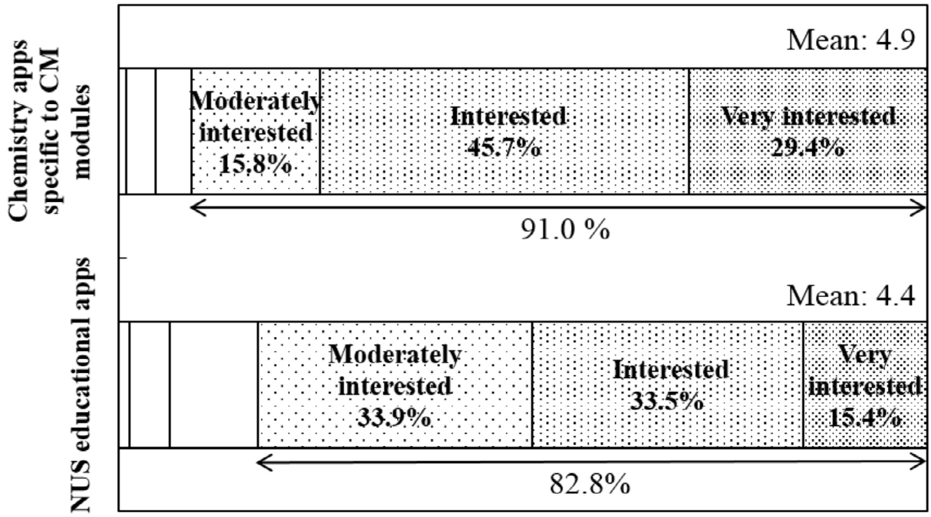

Figure 9. Interest in chemistry apps created specific to chemistry modules and in NUS educational apps (LSQ; interest, upon 6)

NUS has developed apps to extend teaching and learning beyond the classroom, using apps such as “NUS IVLE” and “NUSCast”. These apps allow access to lecture materials and webcasts. Like many other universities, NUS has also developed directory apps such as “Around NUS” and “NUS NextBus” which allow students to navigate through campus (Johnson et al., 2012). The apps created by NUS are usually targeted at the whole student population and not specific to a faculty, department or discipline.

Thus far, the Department of Chemistry has developed apps such as “SYM MO” and “SM2 Chem”. The apps are specific to the chemistry modules being taught. For instance, “SYM MO” includes 3D molecular structures onto which symmetry elements can be superimposed. These 3D molecular structures can be moved and manipulated. From the point group, the symmetries of atomic orbitals are determined and subsequently, the molecular orbital (MO) diagram is constructed, together with the molecular orbitals. Eight simple molecules taught specifically in CM1111 – Inorganic Chemistry 1 are included in the app. “SM2 Chem” is created specifically for students reading SM2 Chemistry. 1160 Chemistry terms extracted from the SM2 Chemistry lecture notes, in both Chinese and English, along with hanyu pinyin, phonetics, definitions, structures and audio pronunciations, are presented chapter-by-chapter or searchable in a user friendly design. There is a chapter-by-chapter Quiz mode for self-assessment and learning. Additionally, the app also consists of a Periodic Table mode with elemental data relevant to topics in their syllabus including atomic weight, melting point and boiling point, electronegativity, ionisation energy, atomic radius and images. These apps are tailor made for the modules taught by the Department of Chemistry.

Students were then asked if they agreed with this statement "I would like my lecturers to use apps to facilitate my learning". Only 46.6% of students agreed or strongly agreed with it, higher than the 36% in the University of Central Florida survey (Chen, 2012); but this figure is incongruent with their high interest level in Figure 9. A very likely explanation is that this teaching and learning mode is unfamiliar and its benefits are difficult to predict or foresee. This explanation is supported by the 95.5% of students who answered "No" to whether their lecturers recommend and/or demonstrated and/or taught using apps during lectures. For the 4.5% minority who answered "Yes", apps introduced by the lecturers are "SYM MO" (66.7%), "Polymath" (16.7%) and "Wolfram Alpha" (16.7%); among which, 45.0% downloaded and used the apps on their mobile device. Obviously, there is a stark disparity between students' keen interest in mobile apps for technology-enhanced learning (Figure 9) and lecturers' sparing use of mobile apps for technology-enhanced teaching. The major issues the lecturers had with using apps during class related to concerns that apps are for individual, subjective, supplementary, and outside classroom learning; or that switching from the traditional method of teaching using PowerPoint slides on a desktop to using apps on a mobile platform is disruptive (Oller, 2012).

As shown in Figure 10, 77.8% of the students ranked Formulas and Organic Reactions as the most popular app type to facilitate chemistry learning:

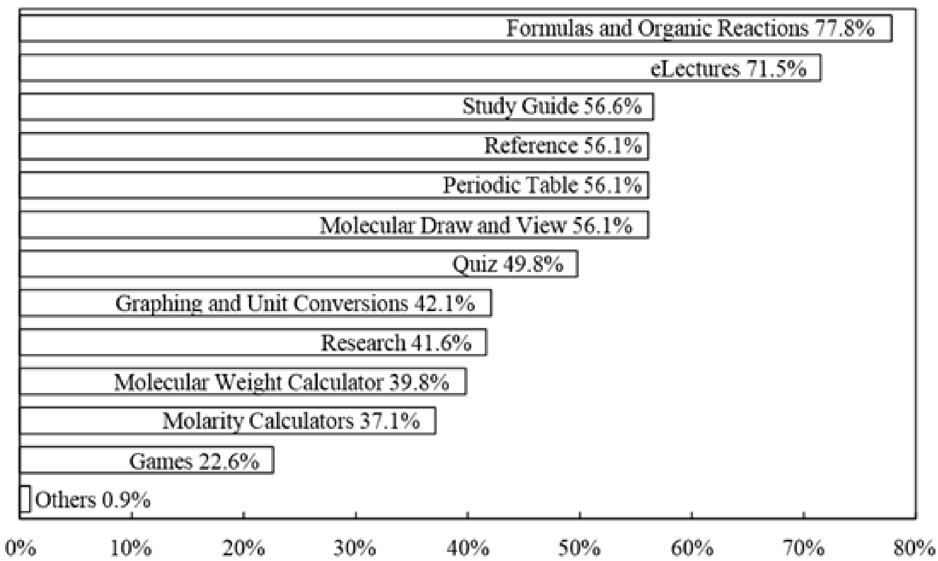

Figure 10. App types that students would find useful for facilitating learning in Chemistry modules (MRQ)

A quick search on Apple App Store found relatively few Organic Reaction type apps; only 7 were available and among these were “ReactionFlash” and “Organic Named Reactions”. Correspondingly, Figure 5 shows that Formulas and Organic Reactions; eLectures and Study Guides are not the top 3 app types currently owned by the students. Hence, this signifies that there is a lack of supply of such apps and thus a resulting high demand for these type of apps. (Figure 10)

Knowing the ways in which students become aware of and subsequently download mobile apps is important for app marketers. Figure 11(a) shows that the primary mode was app recommendations from friends (78.5%); and second was through searching on Apple App or Google Play Stores (51.1%):

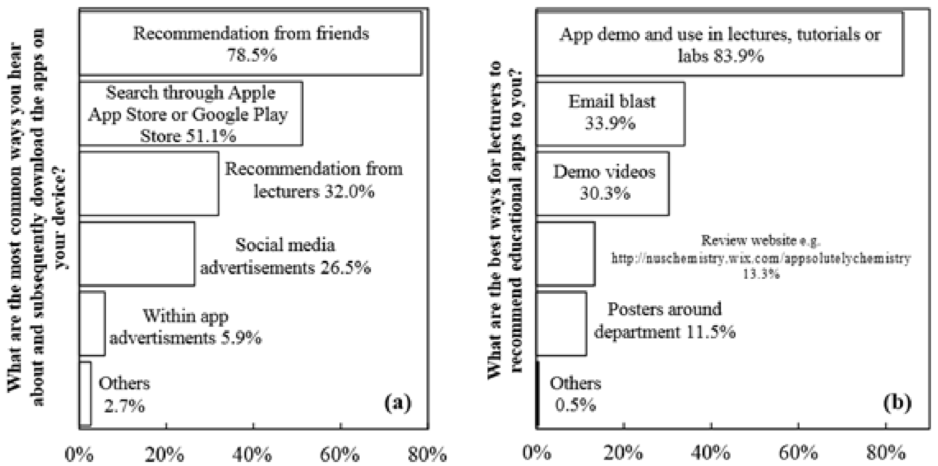

Figure 11. Methods by which (a) students hear about and download apps (MRQ); (b) lecturers should recommend educational apps to students (MRQ)

Considering that the Department of Chemistry is looking into creating apps specific to students’ learning of chemistry modules, determining the best ways for lecturers to recommend educational apps is pertinent. App demo and use in lectures, tutorials or labs have the highest percentage of 83.9% compared to other ways (Figure 11(b)). For the marketing of the “SM2 Chem” app, out of all the ways in Figure 11(b) that were carried out, app demo and use in lectures was the widest reaching as class attendance was compulsory. These sets of data (Figure 11), reaffirms that students are social beings relying heavily on relationships, be it friendships or lecturer-student associations, to dictate the apps they have on their smartphones.

From the analysis of the OER question regarding the ONE thing that can be done with apps to better facilitate or support their academic success, there were various types of responses ranging from basic requirement of an app to specific uses for chemistry modules. Commonly mentioned basic requirements included user friendliness, interactivity, fast loading of information and offline usage. Other common suggestions were more distinctive for academic purposes, for example, relevance to chemistry modules taught such as organic reactions and laboratory skills, a forum to encourage discussions between lecturers and students and ability to view recorded eLectures.

Cumulative Average Points (CAPs) and Demographics

The findings from this study show a close relationship between Cumulative Average Points (CAPs) and students' interest in non-traditional methods of learning such as using apps. For the question "The Department of Chemistry is currently creating Chemistry apps which are specific to Chemistry modules. How interested are you to download and try these apps?" and the statement "I would like my lecturers to use apps to facilitate my learning.", the majority of first and second year students that answered "very interested" and "strongly agree", respectively, attained above average CAPs for their year of study.

Overall, most of the students who answered "very interested" and "strongly agree" were first-year students, followed by a significant decrease towards later years. Hence, in our view, new approaches to technology-enhanced education are best introduced in the earlier years at the institution.

REFLECTIONS AND CONCLUSIONS

Survey Conclusions

This section concludes by summarising the key findings of the survey. Firstly, the main characteristics of the majority of the survey respondents is that most are female, first year chemistry majors, who typically own 1.3 mobile devices, most likely one with an Android operating system. They typically spend 4-6 hours a day on them, and a majority perceive themselves as intermediate smartphone users having used one for more than six months. Most of the survey respondents use apps on their smartphones as it is convenient, can be used anytime, anywhere and most frequently use Social and Communication type apps, with one of the top 3 most frequently used apps being general apps such as "Whatsapp", "Facebook", "Instagram".

A majority do also use their mobile devices 1-2 times a day for academic purposes, mostly via Search Engine type apps to search for information relevant to the lecture/discussion. On their smartphones, most have 1-5 educational apps and 0 chemistry apps. For those who do have chemistry apps on their smartphone, it would be used once a month or less to complete their coursework and it would most probably be of the Periodic Table app type. Besides general apps, the other two of the top 3 most frequently used apps in the different categories are: educational – "NUS IVLE", "Dictionary.com", "Periodic Table" and chemistry – "Periodic Table", "SYM MO", "TCT Lite".

It is clear that a majority of respondents consider both their smartphones and educational apps moderately important to academic success, predominantly because apps make it easier to access and complete coursework. The bulk of students are moderately interested in NUS creating and using apps for educational purposes. They are also interested in downloading and trying chemistry apps created by the Department of Chemistry, which are specific to chemistry modules, with preference for those of the Formulas and Organic Reactions app type.

However, lecturers typically do not recommend, demostrate or teach using apps during lectures. The most common way respondents hear about and subsequently download apps onto their devices is from friends' recommendations. According to the respondents, the best way for lecturers to recommend educational apps is by app demonstration and use in lectures, tutorials or labs. In selecting apps, lecturers should also bear in mind that the most valued characteristics of apps to better facilitate or support students' academic success are user friendliness, interactivity and relevance to chemistry modules.

Reflections

Although there is an abundant supply of apps available in the app stores, there is value in creating apps specific to the institution's modules or programmes. The novelty is in localising and tailoring them to the user base we have, our students. For instance, "SM2 Chem", an English-Chinese dictionary app, was created specifically for students reading the SM2 Chemistry module. After being recommended and its use demonstrated in class at the start of the semester, the mid-semester survey revealed that 97.1% of the SM2 Chemistry students have the app on their smartphones, 87.9% used the app ≥2-3 times a week and a significant majority of the students said that the app improves their understanding of the lecture material (68.7%) and is effective overall (85.9%). Such findings prove that module-specifc apps indeed have much potential to contribute to the academic success of students.

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