Can mobile technology reduce the Digital Divide? A study in a South African tertiary education context

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Abstract

Undergraduate software engineering students are often required to participate in problem-based learning (PBL) and team-based project work. Assessment of information communication and technology (ICT) project deliverables contributes a major portion of the course mark. Collaboration and communication are supported to some extent by mobile hand-held devices, yet are limited by the digital divide created from not all students having access to smartphone devices and mobile Internet connectivity.

This study describes the findings of a mobile learning and digital divide (MLDD) survey undertaken by the primary researcher as part of an ICT4D 2.0 project. The survey investigated the nature and extent of the digital divide between software engineering students on two Western Cape campuses of the same tertiary education institution. A survey questionnaire synthesised for this purpose was administered to 35 fulltime software engineering students in March 2012. Survey findings indicate the nature and extent of the digital divide between students enrolled for the same course on the same campus and between students at the two different campuses.

Although survey findings indicate positive student attitudes to and perception of an m-learning solution to the digital divide, challenges associated with extending a face-to-face classroom experience to a blended mobile technology environment materialised. Study results indicate that whilst mobile technology does offer digital divide reduction opportunities, mobile technology implementation in itself could result in a paradoxical mobile technology digital divide.

Keywords

Digital divide, ICT4D 2.0, m-Learning, Mobile hand-held devices, Mobile technology, Problem-based learning (PBL), Software engineering

Introduction

For undergraduate students studying software engineering, teamwork in the form of collaborative projects and problem-based learning (PBL) in a social constructivist style are important components of the coursework. Projects are conducted jointly on laptop computers and individually from home-based personal computers (PCs), being supported partially by mobile hand-held devices. The primary researcher, who is an academic at a private, international university with campuses in South Africa, teaches courses in software engineering (SE) and knowledge management on two of these campuses, termed C1 and C2, which are situated in different parts of the city of Cape Town.

As teams of software engineering students worked on their collaborative projects, she encountered an anomaly in the differences between the approaches of students on the two different campuses. Certain students who had limited or no Internet access at home, and who could be viewed as being restricted by the digital divide, more readily conducted Internet research using mobile hand-held devices, some of which were highly sophisticated technologies.

To investigate the situation further, she undertook a mobile learning and digital divide (MLDD) survey as part of an ICT4D 2.0 project. The aim was to determine the nature and extent of the digital divide between information technology (IT) students on these two notably different campuses of the institution and to establish whether an m-learning application delivered by mobile hand-held devices could reduce this digital divide.

SE Tertiary Education and PBL

Although some face-to-face academic content was provided during twelve classroom-based SE lectures, examination of the theoretical part of the course contributed minimally to the final assessment. The major assessment portion comprised four project deliverables associated with one real-world software development project per team, in keeping with a PBL strategy. This approach aims to prepare the student for the real world of the business workplace and thus required a demonstration and evaluation of individual, technical programming as well as team work, leadership skills and time management strategies.

Internet Connectivity

The demographically-diverse classes on the two different campuses (C1 and C2) provided an opportunity to explore the digital divide between Internet-deprived students (C1) and Internet-wealthy students (C2). Whilst C1 classes comprised both South African and international students, the student body at C2 consisted only of South African students from backgrounds that were apparently more affluent. C1 students had limited on-campus Internet access and PC laboratory facilities, whilst C2 students had an Internet-enabled PC laboratory dedicated to their studies. A wireless network was also installed at C2.

The university has recognised the major influence of the digital era on education, acknowledging the positive impact of Web 2.0 social networking tools such as Facebook. In a pilot study, the potential is currently being investigated of electronic delivery of digital textbooks to all students via tablets.

In order to implement this project, several issues have been considered including the provision of mobile hand-held devices to students and the need for affordable, effective and safe Internet connectivity via an on-campus wireless network. Success of such a project would be dependent on positive attitudes on the part of students.

The next section considers the work of other researchers in relation to SE tertiary education and PBL, the digital divide and ICT4D 2.0, Internet connectivity and mobile technology contexts and, finally, mobile technology as a digital divide reduction factor. Various current trends contribute to overcoming the digital divide.

Related Literature

SE and PBL

Sommerville (2011) defines SE as a two-fold domain involving both the engineering discipline and software production activities with tools, techniques and methods aimed at the development of high quality products. SE students need to demonstrate both technical and communication skills, whilst collaborating on complex, real-world projects. The ideal SE student project requires software development abilities, and focuses on teamwork while motivating student creativity (Shata, 2011). It also requires the development of metacognitive skills and the acquisition of planning and negotiation skills as if real problems are being solved (Sheppard, 2011).

Real-world situations are simulated through a PBL strategy. PBL originated within the Faculty of Medicine, McMaster University, Canada circa 1960 when Howard Barrows and associates, a group of young physicians, championed the PBL learning model (Barrows, 1996). PBL is characterised by the challenge of open-ended problems to be solved in collaborative groups, supported by a teacher who is more a facilitator and guide than an instructor (Hmelo-Silver and Barrows, 2006). Findings of Qiu and Chen (2010) indicate that student collaboration on PBL projects produced a positive attitude to the relevance and interactivity for PBL project work.

Once in a real-world environment many of the SE graduates are likely to gain from first-hand undergraduate PBL experience and be simultaneously reminded of the challenges of the digital divide.

Digital Divide

The digital divide is a complex phenomenon. It is experienced by individuals, in teams, within and between diverse nations and across continents. It is a major global ICT issue. Mobile technology provides an opportunity to reduce the digital divide between developed and developing nations. ICT4D projects seek ways to reduce this divide.

The digital divide can be described as the gap that emerges between those who are able to efficiently and effectively access digital information via the Internet and those who remain disadvantaged, either with poor access or no access to the global information society.

Hilbert (2011) highlights the complexity of a digital divide definition which should incorporate *people* (in this case, students, teams, academic staff, campuses), their *characteristics* (age, culture, home languages), and *devices* (smartphones, laptops, netbooks, tablets), as well as *connectivity methods* (dial-up, ADSL, wireless, GSM, 3G) used.

National factors affect the prevalence of the digital divide. Typically, people from developed nations experience the impact of the digital divide to a lesser extent than citizens of developing nations. Digital technology constraints may include lagging infrastructure and power supply problems (Urien, 2011) as experienced by Nigerian citizens. In addition, urban and rural communities do not experience similar connectivity quality. For example, a particular form of digital divide is evident in Botswana where major regional disparities are reported (Oladokun and Aina, 2011).

According to Brown, Campbell and Ling (2011), the exponential proliferation of mobile phones has facilitated Internet connectivity “on-the-move” among US teenagers, suggesting the emergence of a bridge across the digital divide. They indicate that young people in poorer communities seem more likely to spend their money on mobile technology. This introduces a paradox: poorer teenagers are prepared to, and do actually, pay more for connectivity than wealthier citizens.

A comparison of active mobile-broadband subscription trends for developed and developing countries throughout the world clearly illustrates a mobile phone digital divide (ITU World Telecommunications, 2012). Africa, with 3.79 subscriptions per 100 inhabitants, trails behind Europe and the Americas with 54.10 and 30.49 subscriptions per 100 inhabitants respectively. Although there is an increase in the uptake of mobile-broadband subscriptions in Africa, ITU statistics suggest that the gap is widening between developed and developing countries.

Researchers emphasize the role of education and the value, in an African context, of competence in digital skills and positive attitudes of both students and teachers, as well as the importance of improving university education as a means of bridging the digital divide (Otuonye, 2011; Yusuf and Balogen, 2011). In a bid to uplift ICT education, educational initiatives in Africa aim to narrow the divide both for impoverished student communities and for privileged student groups adversely affected by digital divide (Oneya and Gitau, 2011). One such initiative named BADILIKO, which means “change” in Swahili, is being sponsored by Microsoft and the British Council (Yussif, 2012). The project will finance digital infrastructure and technology training across the African continent.

Similar ICT4D 2.0 projects aim to find digital ways to reduce the divide in developing countries, by incorporating aspects of Web 2.0.

ICT4D 2.0

According to Heeks (2006), ICT4D is a four-part research strategy comprising:

- **I** Information - library and information sciences;
- **C** Communication - communication studies;
- **T** Technologies - information systems;
- **D** Development - a link to development studies.

By incorporating Web 2.0 principles of co-operation and co-creation into ICT4D, a transformed ICT4D 2.0 model materialises (Heeks, 2009). Telecommunications and wireless technology application development can provide connectivity solutions for developing countries where participation in social networking sites (e.g. Facebook) and interactive communication exploit digital technologies. A shift has occurred towards user-centric ICT4D projects.

Foster (2011) refers to a “para-poor” participatory development strategy, where ICT4D work occurs side-by-side with poor communities to develop content and products that reduce the digital divide. The user is no longer viewed as passive, but rather as an active, empowered participant (Banerji and Basu, 2006; Maail, 2011).

The exponential growth of the mobile phone industry, mobile connectivity and user involvement in a mobile technology context, seem central to producing a solution to the digital divide.

Internet Connectivity and Mobile Technology Contexts

South Africa is regarded as a developing nation with inadequate mobile technology penetration levels and a lack of quality cost-effective mobile connectivity for a diverse user profiles and contexts. Development projects for Africa such as the netsurfer Touch - a cost-effective tablet device in South Africa, M-Pesa (mobile finance) in Kenya and the West African Cable System (WACS) are attempting to make a difference. Digital learning management systems could alleviate the digital divide in an African educational context; however, researchers provide cautionary advice concerning limitations.

The benefits arising from the rapid spread of mobile technologies in developing countries where the digital divide is prevalent, by far transcend telephonic communication, since many mobile devices also provide Internet connectivity and contribute to reducing disparities in access to the electronic society (Duncombe, 2012).

Penetration levels for certain African countries are as follows: Nigeria (2.70%), Kenya (3.27%), Botswana (10.56%), Egypt (13.23%) and South Africa (9.42%), while the figure for Africa as a whole is 4.28%. A comparison of these levels with Europe (28.55%) and North America (44.04%) shows that Africa is far behind. The 9.42% for South Africa, where the present study is situated is one of the highest in Africa and, by implication, indicates awareness and use of Facebook among South African youth (*Facebook Statistics by Continent*, 2012).

South Africa is classified as one of the developing nations of Africa. South Africans experience Internet connectivity restrictions that include:

- Expensive and limited bandwidth;
- Poor quality connectivity and slow download speeds.

These factors differentiate users who are able to connect (albeit with difficulty) from users who are truly digitally disadvantaged. Various initiatives to alleviate the divide are now briefly addressed.

Ho, Smyth, Kam and Dearden (2009) discuss a mobile barrier comprising the prohibitive cost of affordable computing, together with the challenge of cross-cultural design to accommodate various environments and users.

Figure 1: netsurfer TOUCH

Figure 1 shows a cost-effective tablet solution for varied contexts and user characteristics. The device, called the netsurfer TOUCH (Future Mobile Technology, 2012) is assembled locally in South Africa. It offers mobile Android Internet connectivity and reaches out to the digital ‘havenots' within communities who might not be able to afford tablet (e.g. the Apple iPad) or laptop technology. This attempt to bridge the digital divide supports the view of Peña-López (2012) who suggests that ICT4D now represents a convergence of social sciences (affordable Internet connectivity for impoverished citizens) and digital technology (implementation of ICT4D methods and techniques).

Over a five year period Kenya's M-Pesa mobile money has reached more than 15 million "unbanked" citizens out of a total population of 40 Million Kenyans. Money transactions via mobile devices have become a highly effective mobile banking concept. M-Pesa is the product of a Vodafone-Safaricom ICT4D partnership. The project initially focused on urban workers who wanted to send money home to families in rural communities. The success of M-Pesa has been accredited to low transaction costs, people-contact rather than faceless bank interactions, and the support of an extensive distribution of networked agents. M-Pesa, which targets mobile subscribers without banking facilities, has grown exponentially (Mutuku, 2012) in parallel to mobile technology.

The West African Cable System (WACS) rollout was launched in May 2012. WACS will comprise submarine fibre optic cable, providing enhanced bandwidth for various West African countries including South Africa, Namibia, Togo, Nigeria and DRC linking Western Africa and European digital technology. WACS aims to improve data transfer speeds and capacity and to introduce competitive tariffs for Internet connectivity in Africa (Tredger, 2012). An opportunity to deliver an improved service to Africa will likely improve connectivity costs.

Whilst digital learning management systems may be regarded as a solution within Africa, researchers highlight limitations such as infrastructural issues and a lack of trained educators, equipped to promote, utilise and manage these systems (Unwin, Kleessen, Hollow, Williams, Oloo, Alwala, Mutimucuio, Eduardo and Muianga, 2010).

Research Design and Methodology

Research Questions

The purpose of the mobile learning and digital divide (MLDD) survey was to determine the nature and extent of the digital divide among third-year undergraduate students enrolled for software engineering on two different Western Cape campuses. In addition, the study aimed to investigate whether an m-learning environment, as part of the course context, could contribute to reducing the digital divide. The research questions are:

1. What is the nature and extent of the digital divide between IT students on two campuses in the same city and of the same university?
2. Can an m-learning application delivered by mobile hand-held devices reduce the digital divide?

Research Design

This study forms part of a longitudinal design-based research project. A design-based research strategy is iterative and focuses on solving real problems, whilst looking towards future solutions. An important part of this research process is understanding the inherent digital divide between students.

The interpretive research design of the project involved the development of a custom-built m-learning environment, which evolved via an iterative design-development-evaluation approach. Following an initial design-and-research iteration, the need emerged for a specifically designed MLDD survey to explore mobile technology aspects associated with student profiles. The findings of this survey will inform and influence the next iteration. The survey involved mixed-method data collection and analysis, using a questionnaire comprising formal quantitative and qualitative questions, as well as informal qualitative post-questionnaire interviews.

Participants

Using a non-probabilistic sample of convenience (Oates, 2008), the researcher surveyed 35 students out of a total of 37 enrolled for the same final-year SE course at two different campuses, as part of a BSc in Computer Studies. Two students, who were absent on the day of the survey, could not participate. All the students were members of campus-specific teams of four to seven members randomly assigned to collaborative groups, which undertake team-based SE projects over a ten-month period. There were two cohorts of participants from the two campuses respectively:

- Cohort 1: Thirteen (13) participants from Campus 1
- Cohort 2: Twenty two (22) participants from Campus 2.

For ease of reference, Cohort 1 is termed C1, in line with the Campus 1 institution and Cohort 2 is termed C2.

Table 1 provides a breakdown of the sample.

Table1: Software engineering students at two campuses, C1 and C2, in the Western Cape

	C1		C2	
Students	#	%	#	%
Males	7	53.8%	22	91.7%
Females	6	46.2%	0	0%
Absentees	0	0%	2	8.3%
Total	13	100%	24	100%
Nationalities	South African, Namibian, Angolan, Ghanaian		South African	
Home Languages	English, Afrikaans, Xhosa, Tswana, Portuguese		English, Afrikaans, Xhosa	
Mode of Transport (%)	Bus (30.8), Own car (15.4), Taxi (7.7), Walking (23.1), Bicycle (7.7), Lift (7.7), Train (7.7)		Bus(0), Own car (72.7), Taxi (4.5), Walking (0), Bicycle(0), Lift(13.6), Train(9.2)	

This sample comprised 10.5% of the institution's national total of 324 students taking the same SE course in the same semester across twelve campuses of the institution. The findings in Table 1 provided the first proof that a digital divide exists between the two cohorts.

Although course content and structure is identical, students at the two campuses are demographically, culturally and financially heterogeneous. For example, in C1 only 15.4% of students used their own car for transport to campus, whereas in C2 there was a high percentage of 72.7% using their own car. Conversely, 23.1% of C1 students walked to campus and 7.7% rode a bike, while no C2 students walked or rode by bike. Similarly, almost 50% of C1 students used public transport, while less than 15% of C2 students did. Furthermore, C1 included a greater range of ethnic and regional groupings than C2.

Approach

The questionnaire survey was designed with the digital technology student in mind (Horrigan, 2010). In line with Olivier (2009), ethical consent was acquired, and confidentiality and anonymity were ensured. The questionnaire was administered in printed form, with qualitative and quantitative data in a single instrument. Respondents on both campuses completed it in approximately ten minutes, as part of a mandatory lesson on evaluating software applications.

Data Collection and Analysis

In order to evaluate the nature and extent of the digital divide on the two campuses, the MLDD questionnaire gathered data in six categories, together with attitudes to, and perception of, the potential of mobile technology to reduce the digital divide:

- General personal information;
- Mobile phone usage data;
- Personal mobile hand-held device feelings and attitudes;
- Mobile technology and the SE module;
- Internet access;
- User experience.

Findings and Discussion

The survey elicited quantitative and qualitative data, which is shown in both tabular and graphical formats. Firstly, quantitative data is presented, relating to brands, usage and location of use, Internet connectivity factors and student attitudes to a mobile technology strategy. Secondly, the qualitative data is presented.

Quantitative Findings

Mobile Phone Brands, Usage Location and Mobile Phone Activities

Students reported owning a variety of mobile phone brands, which they used in various locations. They also indicated the activities most often performed via these phones.

Figures 2 and 3 respectively provide information that compares the mobile phone brands used by C1 and C2 students and that shows where they use their m-phones. Figure 4 illustrates the activities performed by students on their mobile phones (m-phones).

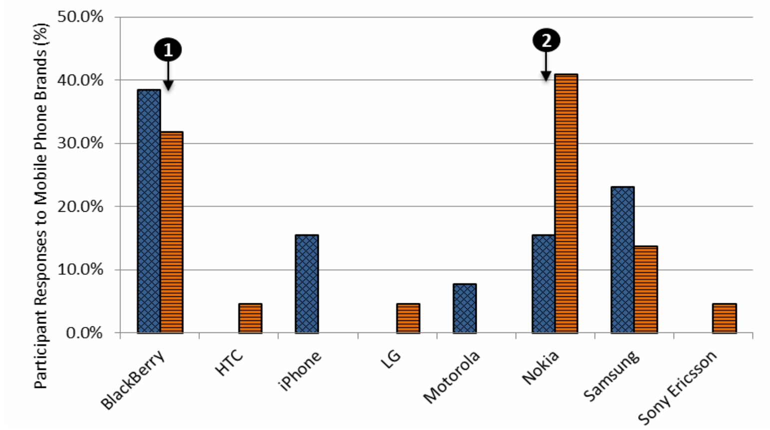


Figure 2: Mobile phone brands

Figure 2 illustrates the m-phone brand choices of C1 and C2 students. Key differences are noted for BlackBerry and Nokia.

❶ C1 students (38.5%) have a stronger BlackBerry culture than C2 students (31.8%), reflecting the greater appeal to C1 of the almost-free Internet connectivity offered by BlackBerry. Three C1 students used iPad tablets regularly, in addition to their smartphones. However, no use of tablets was reported by C2 students.

❷ On the contrary, more C2 students (40.9%) used Nokia devices than C1 students (15.4%). C2 students indicated they did not need free Internet, and preferred to use a phone brand that is popular among their peers.

Students used their mobile phones in various places. Figure 3 reflects these locations.

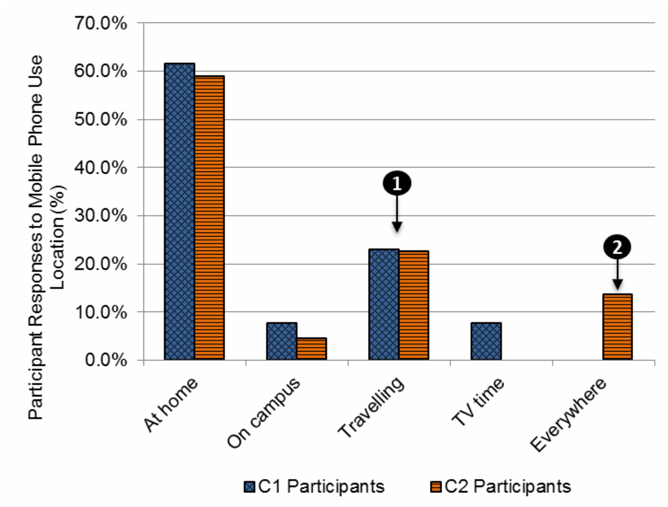


Figure 3: Location of mobile phone usage

❶ C1 students (23.1%) and C2 students (22.7%) used their phones to similar extents whilst travelling to and from campus, although C1 students travelled greater

distances and for longer periods. The similarity between the two sets of results reflects the characteristic nature of university students, who tend to use their phones on an ongoing basis.
❷ However, 13.6% of C2 students claim they use their phones everywhere, compared with no C1 students. This is likely due to the issue of security. In a follow-up discussion after questionnaire completion, C1 students verbally mentioned the risks of using technology on public transport. The mobile device is a precious commodity and, if stolen, is not easily replaceable.

Figure 4 shows a range of activities performed by students on their mobile devices. Activities include calls, SMS's (text messages), Internet browsing, banking, photo sharing, listening to music, music downloads, music sharing, video downloads, watching videos, podcast downloads, podcast watching, Facebook, Twitter, MXit, mobile education, study notes, research and games. Four activities from Figure 4 have been selected for further discussion, namely: Banking, Facebook, MXit and a combination of Mobile Education, Study Notes and Research.

❶ *Banking*: Mobile handheld devices are used more regularly and readily by C1 students (69.2%) for banking than C2 students (22.7%). This pattern strongly differentiates the more cosmopolitan culture of C1 students from the culture of the purely South African C2 students, who are more likely to have uncapped ADSL at home or who use their own transport to get banking done.

❷ *Facebook*: C1 students (92.3%) show a greater propensity for Facebook use via m-phone and are more receptive to social networking sites via mobile devices than C2 students (63.6%). This difference suggests the likelihood that C1 students would more easily adapt to a Web 2.0 context, regarding mobile technology as an important way of staying in touch.

❸ *MXit*: Greater use is made of the free messenger application MXit by C2 students (59.1%) than by C1 (30.8%). This is in line with the findings that fewer C2 students use BlackBerry smartphones. As stated previously, BlackBerries have certain associated free communication facilities. In order to communicate at no cost, C1 students therefore need to make use of MXit.

❹ *Mobile Education, Study Notes and Research*: Mobile education, study notes on mobile devices, and research via mobile Internet are more common among C1 students (38.5%, 69.2%, 76.9 % respectively) than C2 (13.6%, 31.8% and 18.2% respectively). This supports the notion that m-learning would be more relevant for, and acceptable to, C1 students.

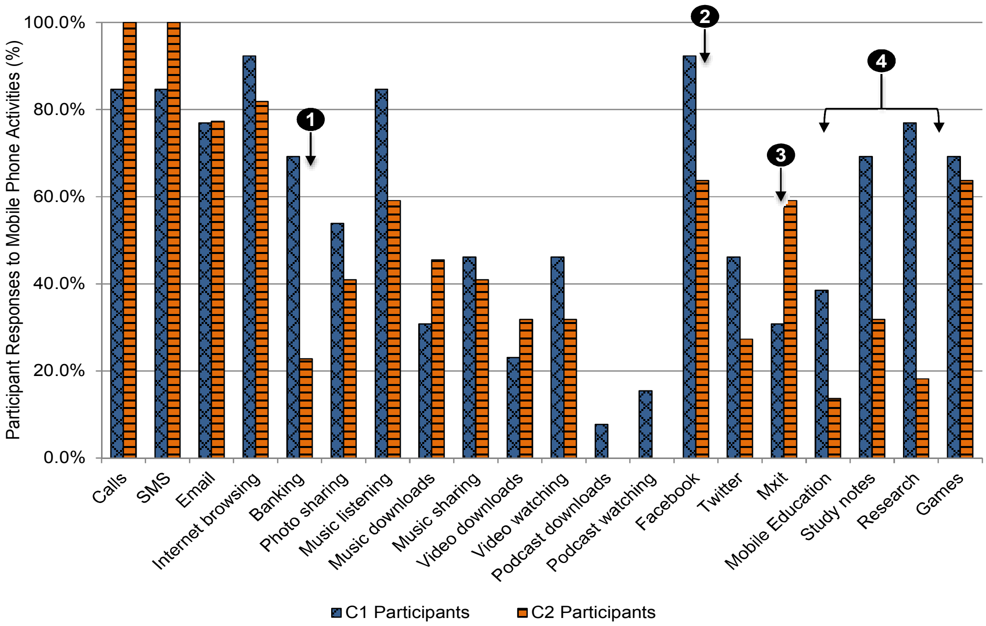


Figure 4: Mobile phone activities

In summary, C1 students are Web 2.0 savvy and, due to the digital divide they experience on a daily basis, have developed mobile coping mechanisms based on the use of their phones. On the other hand, C2 students prefer to send SMS's and make calls with their phones because, for Internet connectivity, they have other options.

C1 students would probably find it fairly easy to adapt to an official m-learning strategy, while C2 students would likely need to be persuaded to take ownership of the concept. C1 students, with their limited financial resources, have learned to do Internet research on their mobile phones. In contrast, the phone brands and activities chosen by C2 students show that they regard m-phones primarily as a means of communication.

Internet Connectivity Factors

In the cases where students use PC's in the university laboratories, several factors contribute to an inability to perform optimally. When performing SE research activities on campus, they encounter issues such as connection problems; buffering whilst watching videos; blocked video, audio, podcast and software downloads; problematic availability of PC's in the lab; and limited access to a campus wireless network. Figure 5 illustrates participants' perceptions of digital divide restrictions that resulted, not from the divide as such, but from policies regarding on-campus usage of Internet and limitations on the research activities undertaken by SE students. The percentages show the percentage of students in each cohort who perceived that issue as a problem.

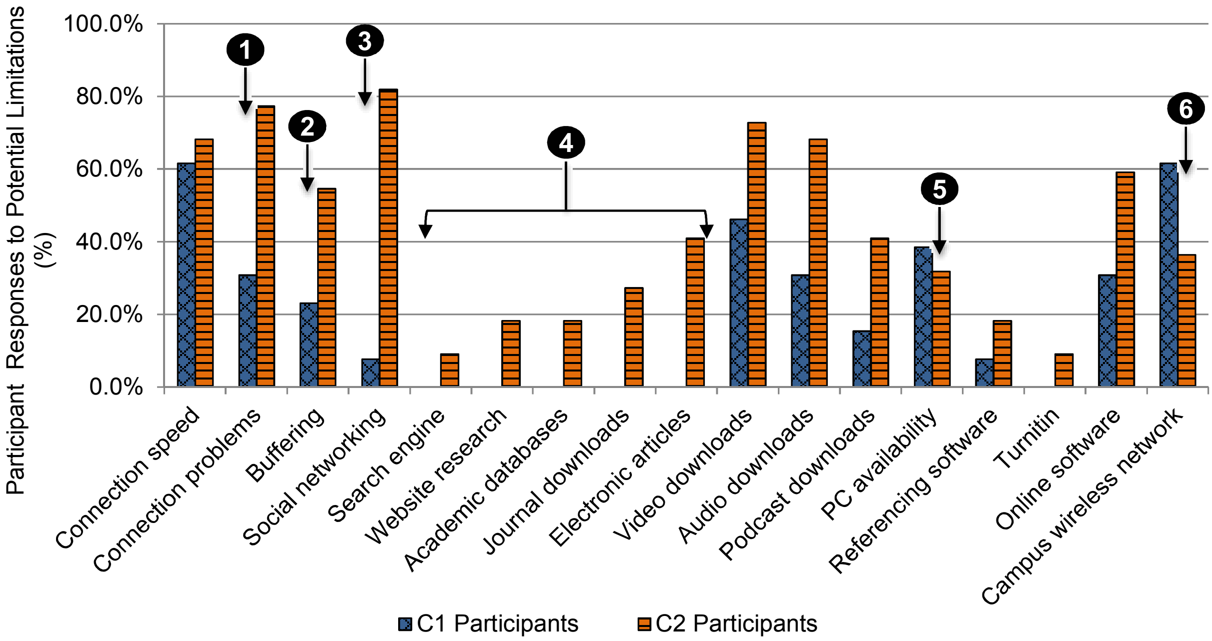


Figure 5: Student perception of on-campus digital limitations that could hamper SE research

Six limitation categories have been selected for further discussion.

❶ *Connection problems*: The campus network is intermittently disrupted. C2 students complain about this to a greater extent (77.3%) than C1 students (30.8%). This is easily explained. C1 students seldom use the on-campus facilities, whilst C2 students have a dedicated PC lab for third year students.

❷ *Buffering*: This problem has a similar explanation. The lecturer downloads all lecture material onto a USB and transfers it to a PC in the lab from which students copy it to their own USB drives, so that they are not disadvantaged by buffering problems. Although C2 had the better network, those students complained more (54.5%) than C1 (23.1%).

❸ *Social networking*: Some C1 students innovatively organised their own internal social networking system, by setting up a group. C2 students (82.8%) complained that the campus does not provide this option, versus only (7.7%) of C1 students who experienced this as an on-campus limitation.

❹ *Search engine, Website research, Academic databases, Journal downloads and Electronic articles*: These issues relate to using the Internet for research to acquire deeper insight into course content, due to the lack of university libraries. C1 participants did not report limitations, whereas a number of C2 participants did: search engines (9.1%); website research (18.2%); academic databases (8.2%); journal downloads (27.3%) and electronic articles(40.9%). This is certainly the opposite of what might have been expected, as C1 facilities do not match those at C2. However, the researcher knows that C1 students spontaneously use their mobile devices to Google for information, because they are accustomed to poor Internet access on campus and had no expectations in this regard. From the researcher's observation, C2 students seldom use Google for academic information.

❺ *PC availability*: C1 students (38.5%) found PC availability more of a limitation than C2 students (31.8%). This is understandable due to the availability on C2 of a dedicated, fully-equipped PC laboratory with both wired and wireless Internet connectivity. Contrarily, C1 students have limited access to PCs, relying instead on personal mobile devices for their software engineering studies.

❻ *Campus wireless network*: C1 students (61.5%) complained about not having a wireless network option. However, some C2 students have been able to access the campus wireless network, resulting in fewer complaints (36.4%).

Mobile Internet Access

Table 2 compares the connectivity packages used by C1 and C2 and students' estimates of monthly expenditure on mobile telephony. Table 3 summarises Internet access for C1 and C2 participants who have 3G and GSM access via their mobile phones. Similar levels were reported from C1 and C2 by those students who had 3G and GSM connectivity.

Table 2: Type of mobile phone connectivity and associated monthly expenditure

	C1			C2			Overall		
Connectivity Package	#	%	Average Monthly Spend (ZAR)	#	%	Average Monthly Spend (ZAR)	#	%	Average Monthly Spend (ZAR)
Prep-paid	10	76.9	246.50	12	54.5	106.17	22	62.9	169.95
Contract	3	23.1	200.00	10	45.5	299.00	13	37.1	276.15
Totals	13	100.0	235.77	22	100.0	210.13	35	100.0	209.40

Table3: Mobile phone Internet access via 3G and GSM

	C1		C2		Overall	
Internet Access	#	%	#	%	#	%
3G	9	69.2	12	54.5	21	60.0
GSM	10	76.9	12	54.5	22	62.9

Table 2 shows that more C1 students invest in pre-paid connectivity (76.9%) than in contract connectivity (23.1%). By contrast, C2 students report greater levels of contract connectivity (45.4%). The average monthly expenditures for C1 and C2 for pre-paid connectivity (ZAR 246.50 and ZAR 106.17, respectively) reflect the greater use made by C1 students of their mobile phones for Internet access.

In summary, in order to beat the digital divide, C1 students take the digital lead by investing time, money and energy on mobile Internet access, readily engaging in social networking, spending more of their money to stay connected. Contrarily, C2 students suggest that connectivity via mobile phone is associated with telecommunication, rather than with access to Internet-based information. They expect the campus to provide the access that they require. The connectivity limitations reported by students support these observations.

Student Attitudes to a Mobile Technology Strategy

The survey included two sections in which students' attitudes to mobile phones (Table 4 and Figure 6) and m-learning (Table 5 and Figure 7) were investigated. These sections were included to explore the perspective of student users, whilst supporting a central tenet of the design-based research strategy, whereby real problems are solved and solutions are developed for the future (de Villiers, 2005).

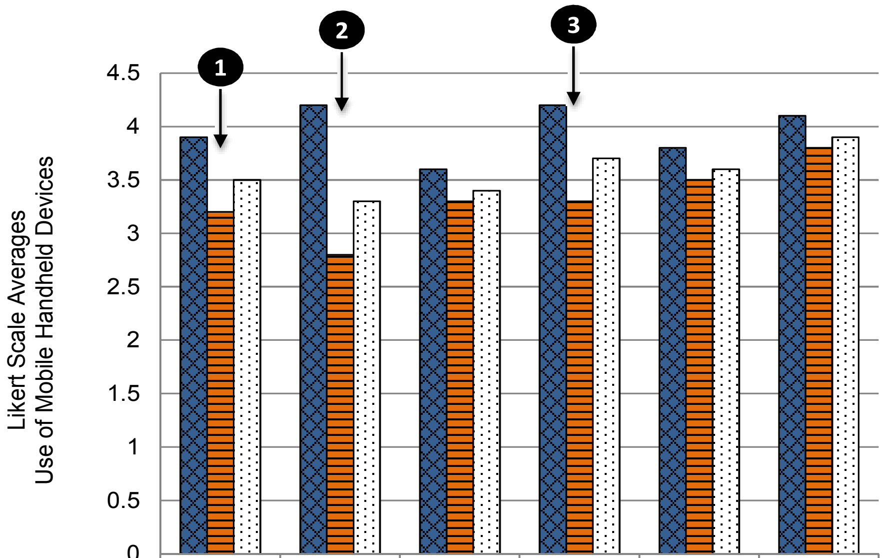
Ten questions, each based on a five-point Likert scale where 1= Strongly Disagree, 2= Disagree, 3 = Unsure, 4 = Agree and 5 = Strongly Agree, were presented to participants. Six questions targeted students' attitudes to the use of mobile phones, whilst four questions related to attitudes on the use of an m-learning environment.

Table 4 and Figure 6 present findings on attitudes to using mobile phones. Table 5 and Figure 7 depict attitudes to the use of an m-learning environment. In order to establish whether or not differences between observed Likert scale averages were significant, two-tail two-sample t-test analysis assuming unequal variances, was conducted for each question and for both sections.

Table 4: Likert scale averages of student attitudes to the use of mobile phones

	Use of Mobile Phones	**C1**	**C2**	**t-Values**
Q1	Do you believe that the use of your mobile phone could support your studies?	3.9	3.2	**0.034***
Q2	Could mobile phone technologies provide support for course group activities?	4.2	2.8	**0.001***
Q3	Would you feel safe submitting quizzes and coursework by mobile phone?	3.6	3.3	0.381
Q4	Are you comfortable with lecturers contacting you by mobile phone?	4.2	3.3	**0.004***
Q5	Would you feel secure receiving SE exam results by mobile phone?	3.8	3.5	0.612
Q6	Would it be beneficial having study resources on your mobile phone?	4.1	3.8	0.548
	Averages: Use of Mobile Phones	4.0	3.3	**0.013***

* $p < 0.05$ – Mean differences between C1 and C2 are significant; these values are discussed further.



	1	2	3	4	5	6
C1 Participants	3.9	4.2	3.6	4.2	3.8	4.1
C2 Participants	3.2	2.8	3.3	3.3	3.5	3.8
Overall	3.5	3.3	3.4	3.7	3.6	3.9

Figure 6: Student attitudes to the use of mobile phones in the context of studying SE

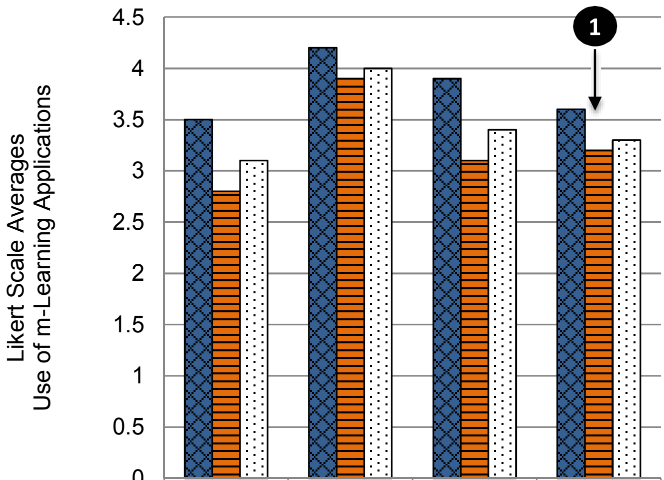
Average responses to Questions 1, 2 and 4 by C1 and C2 have been highlighted in Table 4 (red t-values) and Figure 6 (black arrow placement). The average Likert ratings are higher for C1 participants than for C2. In comparison with C2 students, C1 students strongly agree that: ❶ the use of the mobile phone could contribute to support for studies (3.9) and ❷ group activities (4.2) indicating ❸ comfort about lecturers making mobile phone contact (4.2).

The t-values of 0.034, 0.001 and 0.004 for these three questions respectively, indicate significant differences in attitude between C1 and C2, contributing to a significant overall t-value of 0.013 for the section.

Table 5: Likert scale averages for student attitudes to the use of an m-learning environment

	Use of an m-Learning Environment	C1	C2	t-Values
Q7	Would m-learning motivate you to achieve improved results?	3.5	2.8	0.079
Q8	Are you willing to install a 3rd party m-learning application on your mobile phone?	4.2	3.9	0.348
Q9	Are you prepared to purchase a new mobile device for m-learning?	3.9	3.1	0.081
Q10	Could you improve overall course outcomes with an m-learning application?	3.6	3.2	**0.031***
	Averages: Use of an m-Learning Environment	3.8	3.2	**0.033***

* p < 0.05 – Mean differences between C1 and C2 are significant; these values are discussed further.



	7	8	9	10
C1 Participants	3.5	4.2	3.9	3.6
C2 Participants	2.8	3.9	3.1	3.2
Overall	3.1	4	3.4	3.3

Figure 7: Student attitudes to mobile phones and m-learning in the context of studying SE

Average responses to Question 10 by C1 and C2 have been highlighted in Table 5 (red t-values) and Figure 7 (black arrow placement). The average Likert ratings are higher for C1 participants than for C2. Both C1 and C2 agree to some extent that: ❶ an m-learning application could improve course outcomes. A t-value of 0.031

indicates that a significant difference between C1 and C2 student feedback exists for question ten.

In summary, C1 students indicate overall positive attitudes to educational benefits that could be achieved via a mobile technology strategy, namely: support for studies (Q1); collaborative group activities (Q2); lecturer communication via mobile phone (Q4); and improved outcomes (Q10). Although C2 students demonstrate a measure of positive attitude, t-values indicate that the difference in responses is likely to be significant and not due to chance.

Qualitative Findings

The survey elicited qualitative data as well. Qualitative textual information was gathered from participants in responses to three open-ended questions in the survey. Participants were explicitly asked about positive ways in which mobile technology can support learning and about negative aspects or limitations associated with using mobile phones for learning. Their unprompted responses were thematically analysed to determine themes and patterns that emerged.

Table 6 presents feedback from C1 and C2 participants regarding *positive* ways in which mobile phones might scaffold their studies. Table 7 summarises various *negative factors*, as students expressed opinions regarding limitations entailed in studying via a mobile phone.

Comments and quotations in Tables 6 and 7 are attributed to the participants as follows: [P1.X] refers to a comment by Participant X in Cohort 1, while [P2.Y] refers to a comment by Participant Y in Cohort 2.

Positive ways in which mobile phones could support studies

Table 6 summarises positive feedback from C1 and C2 regarding how phones could be used to support studies. Comments were grouped into a six themes: course announcements, academic tasks, support functions, research-related aspects, working on-the-go, and communication.

[P1.1] is a truly digitally disadvantaged student, who had no Internet access, neither on a computer nor via a smartphone. Unlike campus peers who had overcome the divide by using their mobile phones to support their studies, he had no connectivity and was embarrassed as indicated by his comments in Table 7.

[P2.15], on the other hand, was totally and solely connected via m-phone, using it to type assignments; upload documents; and download PDF's, images and research articles. He displayed many of the attributes of a stereotypical member of the C1 cohort but, due to living closer to C2 than to C1, he was enrolled there and could be viewed as being on the 'wrong' campus. Similar to [P1.1], though conversely, he has different characteristics and abilities from his/her peers and has difficulties settling into the designated C2 team.

Limitations when using mobile phones to learn

Table 7 summarises C1 and C2 feedback regarding the limitations of using m-phones in learning. Comments are grouped into three categories: mobile handheld devices; connectivity issues; and attitudes. A student from C1, [P1.1], expressed strong feelings about not having the same quality of connectivity as others in his/her cohort.

This emphasised the divide between his/her technical potential and the requirements of being part of a PBL team project. The attitude of [P1.10] whose phone represented the latest technology was one of joy about his/her phone. In contrast, attitudes of [P2.4], [P2.5] and [P2.16] towards their mobile phones, indicated negativity.

Table 6: Student feedback - ways in which mobile phones can support studies

C1	C2
• ***Course announcements*** Students can be sent reminder SMS's for deliverables [P1.1]*; Could be notified about readings [P1.1]*; announcements/updates [P1.7]; Specific module info [P1.7]; Forum to answer or ask questions about course subject matter [P1.7].	• ***Course announcements*** Receive notifications, important information [P2.6]; Get tips on course and study work [P2.8].
• ***Academic tasks*** Write study notes [P1.2]; Uploading from YouTube [P1.2]; Load study notes onto phone [P1.2].	• ***Academic tasks*** Download study information [P2.1]; I use my phone as a laptop; phone is my personal device; I use it to do research and upload work [P2.15]**.
• ***Support functions*** Record lectures [P1.3]; Search for info [P1.3]; Make notes [P1.6]; Can open documents e.g. spread sheets; can make PowerPoint shows and PDFs [P1.3]; Typing is less tiring than writing [P1.3]; My phone supports me in my studies because I use the dictionary; open emails, download documents [P1.11].	• ***Support functions*** Record chapters to listen to while doing chores [P2.1]; Can get (previous) exam papers on my phone which will help me to study [P2.17]; Access documents: PDFs, Office docs [P2.21].
• ***Research-related*** When I don't understand something or a word in my studies, I can research it on my mobile, as it is faster than researching it on a computer [P1.10]; Researching online [P1.2]; File sharing with other students (my team) [P1.8]; Research done easier [P1.8].	• ***Research-related*** Access Internet at any time via Blackberry [P2.10]; Do a lot of mobile research on the Internet access Internet at any time via Blackberry [P2.10]; Do a lot of mobile research on the Internet [P2.14].
• ***Working on-the-go*** Ideal for reading on the go [P1.4]; Use on train, buses [P1.3]; Browse Web for info while travelling [P1.6].	• ***Working on-the-go*** Read on the go [P2.1]; BBM other students [P2.10].
• ***Communication*** Communicating with teachers [P1.5]; receiving class notes from teachers [P1.5].	• ***Communication*** An excellent teaching medium between teacher and student [P2.13]; Exchange SMS's with friends using my phone to ask them about study questions [P2.19].

[P1.X] and [P2.Y] refer to feedback from student X from C1, and student Y from C2, respectively.

* [P1.1]: this C1 student is disadvantaged in several ways. He has an old phone which is only capable of sending and receiving SMSs. He travels long distances to campus and has no computer facilities at home. When group work was being done, his team complained bitterly about his lack of delivery on electronic promises and ostracised him. His computer literacy skills are rudimentary compared with other members of his team.

** [P2.15]: this C2 student is a genuine mobile student, suffering from digital divide pressures. His words explain: *"I have to share a computer with my family, so I use my phone as a laptop to do assignments and to do research and my work on it. I type and upload my assignments with my phone."* His mobile-technology literacy skills are advanced, due to his determination to overcome the challenges.

Table 7: Student feedback - limitations when using mobile phones to learn

C1	C2
• ***Mobile handheld devices*** Spam, compatibility of software for mobile devices [P1.1]*; RIM (BlackBerry) has a limit on its browser cache and downloads, phone is a bit slow [P1.3]; Phones too small for proper research, phones must also be faster [P1.4]; What about students who do not have smartphones? [P1.5]; What about those who cannot pay for the Internet? [P1.5]; The small size of the screen [P1.8], [P1.13]; Reading documents from the phone is quite hard, limited screen resolution [P1.9]; Space is limited, meaning I might need to get a device that could store more [P1.12].	• ***Mobile handheld devices*** Some phones are too old to use then cannot connect to Internet, can just make calls and SMS [P2.4]***, [P2.5]****; Most phones do not support all applications - incompatibility e.g. PDFs [P2.10], [P2.16]*****, [P2.21], [P2.22]; Slow response rate [P2.10], [P.21]; Limited battery power; security risks [P2.8], [P2.11], [P2.15]; Screen resolution; small keyboard can be tiring. [P2.10], [P2.13]; Small screen size [P2.14], [P2.18], [P2.20].
• ***Connectivity issues*** Cost of data. Would have to use wireless at home (WiFi) [P1.7]; Absence of an Internet connection; not all files can be opened [P1.11].	• ***Connectivity issues*** Mobile connectivity issues [P2.6]; Connectivity costs and lack of airtime could restrict use for learning purposes [P2.8]; Data is expensive; doing work via a computer is cheaper than mobile phones; no airtime [P2.9], [P2.15], [P2.17]; expensive to download large files [P2.18]; Coverage not always trustworthy, available; difficulty viewing large documents on small screen [P2.2].
• ***Attitudes*** Distractions on your phone such as MXIT, Facebook, BBM, Games, Music which could pull students away from studies [P1.6], [P1.10]**.	• ***Attitudes*** Distraction from social networking, SMS's, random phone calls [P2.1], [P2.12].

[P1.X] and [P2.Y] refer to feedback from student X from C1, and student Y from C2, respectively.
* [P1.1]: "You are almost inexistent if you're not on BBM or WhatsApp, if you don't have a smartphone, you appear broke and uncool."
** [P1.10]: *"I love my phone; I can't stay more than half-an-hour without it."*
*** [P2.4]: expresses a general C2 attitude, *"I don't have feelings for my phone!"*
**** [P2.5.]: in disgust, "*You can kill somebody with it, it is a brick!"*
***** [P2.16]: emotive and negative about his phone, *"I find my BlackBerry claustrophobic and terribly incompatible, which is why I am looking for an upgrade to an android-based mobile device"*.

Conclusion

An MLDD survey was conducted among SE students in a tertiary education context, with the aim of answering the following research questions:

1. What is the nature and extent of the digital divide between IT students on two campuses in the same city and of the same university?
2. Can an m-learning application delivered by mobile hand-held devices reduce the digital divide?

To answer the first question, various digital divide factors which emerged from the findings of this study are summarised. A digital divide of a complex nature and extent was identified. This divide was based on the differences between students; shortcomings of campus infrastructure; device-specific aspects such as the device type and data cost; Internet connectivity issues; and attitudes to mobile technology.

On each campus, an intra-campus divide occurred. On C1, a student who was ostracised for not being able to use a phone for mobile research, expressed disgruntlement with the ‘smartphone brigade’. On C2, a mobile-savvy student who had no option other than to type assessment reports on a mobile phone, equally experienced conflict with team mates when deadlines for deliverable were missed.

It was expected that a digital divide would materialise on C1 due to the cosmopolitan nature of the C1 students, as well as the sub-standard Internet connectivity and PC facilities offered on the campus. However, feedback from C1 students indicated that they had independently developed mobile Internet research methods which compensated for shortcomings of the campus infrastructure and the connectivity gaps they encountered due to lack of Internet access at home. This interesting paradox is emphasised by feedback from C2 students, who, whilst benefitting from having their own transport, higher household incomes, and powerful on-campus and at-home connectivity, complained about Internet connectivity issues. Several of the C2 students did not regard their mobile phones as potential learning tools, but rather as tools for communicating by calls and SMS’s.

Students owned a variety of mobile phone brands with diverse capabilities and used their phones in various locations, carrying out a range of activities other than telecommunications. C1 students revealed a generally positive attitude to their mobile phones, whilst several C2 students seemed negative about the functionality of their phones. Statistical analysis of C1 and C2 attitudes to using mobile phones and an m-learning environment, revealed significant differences between the C1 and C2 participants, thus providing quantitative measures of the divide.

To answer the second question, feedback from C1 indicated that students had become accustomed to mobile technology through necessity, unintentionally reducing their own digital divides. An m-learning environment, as part of the educational context, could further reduce the digital divide.

However, the study reveals several anomalies. Student devices are so diverse that there would be major complexities in implementing an official m-learning environment. Students across the board would need to be equipped with similar mobile hand-held devices. Further issues are that there is no wireless network to support connectivity at C1 and the network at C2 is inadequate. These infrastructural issues need to be addressed. Finally, attitudes of all the students on both campuses would need to be aligned positively to a mobile technology strategy.

This research was limited in two respects. The survey targeted only two out of twelve national campuses in the institution. Each of the other ten is likely to reveal its own digital divide and idiosyncrasies. Although the small sample provides interesting feedback, the results cannot be generalised. Future research incorporating the entire population of twelve national campuses would be valuable. Moreover, the study excluded the input of academics and administrative leaders, as well as the content designers, policymakers and motivators who would be required to energise the implementation of a mobile technology learning strategy.

Despite the small size of the sample, insight has been provided about the nature and extent of the digital divide in a tertiary education context in South Africa. The findings indicate that an m-learning application has the potential to reduce this divide. Further ICT4D 2.0 research is suggested, involving aspects suggested in the previously-mentioned definition of ICT4D by Heeks (2006).

Finally, this research highlights the phenomenon of how context – both the context of personal socio-economic situation and the ethos of the academic institution – impacts on students. This, in turn, results in differences in the types of technologies used, in this case mobile phone devices, and the ways in which learners interact with them.

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