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Reaching the unreached: de-mystifying the role of ICT in the process of doctoral research

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Information and Communication Technology (ICT) has become a necessary element of academic practice in higher education today. Under normal circumstances, PhD students from all disciplines have to use ICT in some form throughout the process of their research, including the preparation, fieldwork, analysis and writing phases of their studies. Nevertheless, there has been little research to date that explores PhD students' first-hand experiences of using various ICT to support their research practices. This paper brings together the findings and the key points from a review of significant parts of the existing literature associated with the role played by ICT in the processes PhD students use in doctoral research. The review is based on 27 papers appearing in international peer-reviewed journals published from 2005 to 2014. The study seeks to address the under-researched area in the current literature of how ICT plays a role in the processes of doctoral research. While there are many contributions taking the 'institutional' or 'teaching' perspectives, papers focusing on 'student' perspective, or the viewpoint of engaging ICT in daily study routine, are relatively fewer. As far as research methodology is concerned, this review found that many of the papers that were examined were mostly based on perception data such as surveys or interviews, while actual practice data were rarely present. With their ready access to technologies, PhD students are well positioned to take advantage of a range of technologies in order to carry out their research efficiently (in terms of means to an end) and effectively (in terms of reaching goals within a task). This review reveals that in the literature, this important area is under-represented.

Keywords: ICT; graduate; postgraduate; research; information consumption; literacy; role of ICT; graduate profile; actual practice; perception

1. Introduction

The use of Information and Communication Technology (ICT) has grown enormously in the last 10 years with computers and smart devices becoming indispensable to daily life. ICT is seen as vital for those wishing to engage in higher education (e.g. Aspden and Thorpe 2009), and this includes the activities of graduate students. A considerable portion of the current literature on computer use in academic contexts suggests that student's use of technology will result in students being efficient in their learning (Smith, Salaway, and Caruso 2009), for example, to

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facilitate online information searching. In addition, a number of studies claim that computer technology now plays a significant role in supporting undergraduate study (Aspden and Thorpe 2009; Dahlstrom *et al*. 2011; Guidry and BrckaLorenz 2010; Smith and Caruso 2010). It seems appropriate that ICT should also help PhD students to complete their research in doing background research for the thesis, in conducting the various research activities, in writing the thesis; in other words, in all phases of research and in the best possible ways (Jackson 2005; Onilude and Apampa 2010). While this is a claim that might be difficult to refute, the importance of ICT in a PhD student's research process may have been overlooked in the existing research literature. For example, a search of recent publications reveals that most empirical research on doctoral education has been focused on the notion of 'doctorateness' (e.g. Wellington 2012), the candidature discourses (e.g. Strengers 2014), the viva (e.g. Chen 2014), supervision (e.g. Mcalpine 2013) and the thesis examination (e.g. Clarke 2013).

In terms of PhD students' ICT use (e.g. Blignaut and Els 2010), documented studies have been focused on graduate students' computer literacy, communication (e.g. Lawlor and Donnelly 2010), entertainment use (e.g. McCarthy 2012) and the use of learning management systems (e.g. Sultan 2010). Of these studies, while focusing on the doctoral research process or the ICT use in general, there are few that research these two aspects at the same time. The lack of studies considering ICT use in doctoral research may suggest that institutions, that is, lecturers, supervisors and/or students, hold certain assumptions and expectations regarding PhD students' ICT use. PhD students' ICT use may have been taken for granted by academia or overlooked in general. The role of ICT in supporting PhD students' research processes is thus unclear, especially the degree to which ICT are being embedded into practice at different phases in the research process. Thus, a study examining PhD students' ICT use could be of benefit for different communities, including institutions, disciplines, lecturers, supervisors and students within the higher education context. This time-framed literature review, from 2005 to 2014, provides the foundational and theoretical underpinnings to a study that aims to explore the role that ICT plays in supporting PhD students' research.

This paper will begin by describing ICT and its role among the students in the current generation as well as the notion of doctoral research. A description of the method used to gather relevant literature is then outlined. Following this, findings and discussion from the reviewed literature on the basis of four themes are presented. Lastly, the conclusion identifies future direction in this research area.

2. Background/context

2.1. ICT and current generation of students

ICT refers to information technology in the context of telecommunications, computers, software and the data systems that support, store and transmit unified communication technologies for users to access and manipulate information (Murray 2011). For the purpose of this paper, ICT is categorised into hardware, software and networks as described below:

- *Hardware*: This includes various types of computers such as smart devices, desktops, laptops and tablets.

- *Software*: This is any set of machine-readable instruction that directs a computer's processor to perform specific operations, such as *Microsoft Office* and *Endnote*.
- *Networks*: These are systems of telecommunication that allow computers to exchange data, such as Wireless and Ethernet connections.

Students are well 'e-equipped' with increasing numbers of ICTs present in their daily lives. For example, a notebook and a pen may have formed the tools for study of prior generations but today's students come to class with 'e-equipment' such as smart phones, laptops and mp3 players (Economist Intelligence Unit 2008; ITS 2012). The existence of the above-mentioned hardware, software and networks offers students today the access to enormous information and knowledge beyond the classroom setting or the teachers' control. Such access enables students to capture, share, collaborate and publish in previously unavailable ways. It is undeniable that the Internet provides easy access to vast quantities of information (Williamson *et al.* 2007) and, as a result, it is claimed that students today '... think and process information fundamentally differently from their predecessors' (Prensky 2001, p. 1). This is evidenced by studies which describe how the present generation of students multi-task (even though the idea of multi-tasking has been critiqued in the existing literature) with digital technologies. Students take notes on a laptop, send text messages on a smart phone, while they may simultaneously have social networking software such as *Facebook* operating in the background on either their laptop or smart phone (Economist Intelligence Unit 2008, p. 11; Hembrooke and Gay 2003; Wood *et al.* 2011). According to Lieutenant Colonel Greg Conti, the director of West Point's Information Technology Operations Centre, 'it is impossible to sit someone in front of the World Wide Web and expect them [students] not to use it' in today's world because 'today's students are used to getting what they need instantly' (Economist Intelligence Unit 2008, p. 12).

It is believed, therefore, that, as time progresses and new technologies are introduced and embedded life, ICT will become even more interwoven into academic life than it already has. As a consequence, ICT will continue to have a significant impact on higher education (Economist Intelligence Unit 2008; TLTTeam 2011). The new challenge for higher education institutions is how to 'e-equip' students with the skills and knowledge required to use ICT effectively in the university as well as in preparing them for the workplace (Economist Intelligence Unit 2008; Güçlu 2010). This challenge can be especially significant for the postgraduate students.

2.2. What is doctoral research?

As noted earlier, PhD students' progress through a number of phases in the process of doing their doctoral research. Doctoral research is described as the process of developing the independent scholar, or a scholar who independently produces original research or new knowledge (Council of Graduate Schools 2005). According to Gardner (2008), overall, there are three stages in a PhD research journey: (1) admission, including applying to prospective programmes and institutions and meeting and talking with faculty members, staff and graduate students in these prospective programmes; (2) integration, including social integration with peers and faculty; the eventual choice of an advisor/supervisor/committee; and (3) candidacy, which is the

time during which the student focuses primarily on the research. Focusing on the candidacy stage as described by Gardner (2008), this review assumes four phases:

(1) preparation – when a PhD student creates a research project proposal, reads relevant literature and constructs a research framework;
(2) fieldwork – when the PhD student collects data as planned according to his or her research framework;
(3) analysis – when the PhD student engages with the collected data, in alignment with the designed research framework and the existing literature; and
(4) writing – when the PhD student writes the dissertation or thesis as a fulfilment of the degree requirements.

3. Starting point: methods

A literature search was conducted in 2014 using the search engine of the University of Otago Library site (http://www.otago.ac.nz/library/) and the databases, Google Scholar, ProQuest Central, Science Direct and EBSC host. Search terms were generated based on the criteria listed in Table 1.

Similar terms were used in the search engine and they were adapted according to the nomenclature of the individual databases. The search was conducted using the keywords and terms from Table 1 in both the abstract and main body of papers. In August 2013, Rich Site Summary/Real Simple Syndication (RSS) feeds of all the databases set up on Netvibes (http://www.netvibes.com/en) using the same search terms. Netvibes is a social media monitoring, analytics and alerts dashboard. This method facilitated the gathering and analysis of all the selected major journals in this research topic.

In addition, further articles were identified from the reference list in the retrieved articles. The final collection of literature included original, peer-reviewed research articles with high relevance that met the aim and/or inclusion criteria for this planned investigation, written in English and published from year 2005 to 2014 in different parts of the world. The year 2005 was chosen, rather than an earlier date, because of the rapid changes in ICT development since then.

Among the articles listed, the aspects of investigations and the methods used were examined to determine whether they were appropriate to be applied as reference data for the current review. The aspects of investigation included the focus on students' computer literacy in communication, entertainment use, learning management systems use, library use and knowledge consumption process on Internet. The studies identified highlighted a range of aspects including skills in ICT use, the variety of ways different ICT have been used for academic practices and students' self-confidence in the use of ICT.

Table 1. Search terms based on question words as pointers.

Pointers	Search terms
Who	Graduates/postgraduates/PhD students
What	ICT/technologies
Where	University/higher education
Why	Thesis/dissertation/research
How	Use/utilise/adopt/integrate/engage
When	Year 2005 to 2014

As for the methods used, the search emphasised the collection of students' perceptions and/or behaviours related to ICT use. This process is detailed below.

3.1. The aim

This review aimed to summarise the relevant studies on the role of ICT among graduate students since year 2005. Specifically, it reviewed studies that have touched upon the ways graduate students engage ICT in their research practice.

3.2. The inclusion criteria

In this review, the literature relating to graduate students' engagement and integration of ICT is examined. More precisely, the viewpoints of different roles of ICT held by graduate students is taken. Thus, this includes literature dealing with the role of ICT for both research-related and non-research-related practices. Only those papers whose main focus was on the topic of this study were selected and therefore the articles that mentioned the topic only in their introductory remarks, or as collateral research themes, were excluded from the analysis. Within this sub-set, a smaller cluster of articles that specifically focused on this research topic were further identified and considered for the review. Further analysis resulted in the generation of themes, which consisted of 27 papers that were published from 2005 to 2014. These papers were examined in-depth. Table 2 presents the details of these 27 papers.

In summary, papers on this topic were published in various journals, presenting a wider research on computer use among graduate/postgraduate students in different countries (e.g. United Kingdom, Taiwan, India, Turkey and Greek). Also included are articles that addressed the role of computers in research practice in general.

3.3. The review process

The review process entailed a two-pronged approach. First, the papers were categorised on the basis of their content and the second categorisation was according to the research methods used.

The included papers were organised according to the perspective on content that they took: (1) an institutional focus ($n = 10$), which concentrated on ICT facilities in institutions; (2) a teaching focus ($n = 3$), which emphasised the ways ICT was integrated into teaching activities (through advisors/supervisors/committees); and (3) a student focus ($n = 14$), which reflected students' perspectives and behaviours in relation to ICT in learning. Despite the three different perspectives, the theme of the reported studies appeared to cluster around four key areas (see Table 1): (1) computer literacy; (2) ICT integration in a research practice; (3) research productivity alongside information consumption; and (4) student graduate profile in relation to ICT competency.

Papers were also examined on the basis of the research method(s) used. The review revealed that many of the examined articles were empirical studies ($\sim 89\%$), which used questionnaires, surveys, case studies or interviews as principle data-gathering techniques. There were very few contributions based on students' actual research practice with ICT. Such 'actual research practice' would include data gathered from, for example, observable behaviours while engaging with ICT. Only three papers (11%) out of the 27 articles included actual practice data. One paper used observation (Ismail 2011), one paper used an online testing system

Table 2. The selected 27 papers associated with their themes.

Authors (organised by year of publication)	Theme of the paper
Griffiths and Brophy (2005)	Web searching behaviours
Wallace and Clariana (2005)	Computer literacy skills
Aderibigbe and Aramide (2006)	Use of Internet
George *et al.* (2006)	Information-seeking behaviours
Divaris, Polychronopoulou, and Mattheos (2007)	Computer literacy and attitudes
Williamson *et al.* (2007)	Information seeking and use
Darus (2008)	Word processing
Gardner (2008)	Independence of doing research
Li (2008)	Computer literacy
Alkhanak and Mokhtar (2009)	Web services
Blignaut and Els (2010)	Computer and information literacy skills
Dange (2010)	Computer and Internet usage
Lawlor and Donnelly (2010)	Podcast use
Meerah (2010)	Research skills
Ongoz (2010)	Information searching
Onilude and Apampa (2010)	Use of ICTs
Winter *et al.* (2010)	e-Learning experiences
Gibbs, Steel, and Kuiper (2011)	Computing skills
Ismail and Kareem (2011)	Information needs
Magliaro (2012)	Information literacy needs
Varshney (2012)	Information use
Wu and Chen (2012)	Electronic resources
Nabeel, Shahrir, and Leng (2013)	Attitudes towards computer use
Odaci (2013)	Computer self-efficacy
Ahmad *et al.* (2013)	ICT competency
Lai and Hong (2013)	e-Learning characteristics
Bowman *et al.* (2014)	Laptop Ergonomic Education

(Wallace and Clariana 2005) and another one used qualitative data capture through written comments (Lawlor and Donnelly 2010).

3.4. Summary of the review

Contributions written from the institutional (viz. the role of university or library) and teaching (viz. the role of supervisors) perspectives were generally written in the mid-2000s. Papers focusing on student's perspectives (i.e. their e-literacy) were relatively more recent and their numbers have progressively increased. Additionally, in recent years, researchers have started to examine students' perceptions of the role of ICT and have included strategies to gather data on student behaviour and attitudes while using computers in research work. These two foci suggest the need for the collection of actual practice data alongside perception data. However, in this review no paper showing any specific relationship between the roles of ICT in the process of doctoral research and how PhD students engage ICT in their research practice, as evidenced through practice data, was found.

4. Findings and discussion: what is missing in the existing literature?

4.1. Content based

Most studies in the extant literature from 2005 to 2014 have focused on students' computer literacy (e.g. Blignaut and Els 2010), communication (e.g. Lawlor and

Donnelly 2010), entertainment use (e.g. McCarthy 2012), use of learning management systems (e.g. Sultan 2010), library use (e.g. Sutton and Jacoby 2008) and knowledge consumption (e.g. Griffiths and Brophy 2005). These studies have highlighted a range of aspects including skills in ICT use, the variety of ways different ICT have been used for academic practices and students' self-confidence in the use of ICT.

Where PhD student's use of ICT to support their research processes is concerned, the place of ICT with a focus on ways students use ICT in their research practices and research activities is often discussed in a limited way in the literature. For example, graduate students are described as 'binge' users of e-journals and as having a preference for electronic resources during their thesis writing process (Dange 2010; George *et al.* 2006; Liew, Foo, and Chennupati 2000; Rowlands *et al.* 2007; Tenopir 2003). It is also acknowledged that all PhD students will use ICT for their doctoral research. Depending on the academic discipline, some will use software applications such as *SPSS* and *NVivo* for data analysis, while some will use software designed specifically for work in their field of study. Most, if not all, will use widespread applications that facilitate searching references and typing and archiving documents. What is important is that the nature of PhD students' use of ICT for the integrated tasks involved in their study is unclear in the current literature. In other words, current studies do not offer a clear picture of *how* PhD students integrate computer technologies into their daily research practices; only reporting *what* students use computer technologies for.

In summary, a number of themes are under-represented or missing. The positive place of ICT in graduate education has been extolled in the literature, with the focus being on information searching through web browsers. Thus, the review undertaken here has identified four shortcomings, which are described below.

4.1.1. Computer literacy among PhD students

First, there are no up-to-date comprehensive studies of the level of computer literacy among graduate or postgraduate students, particularly among PhD students in their research practices.

There is a common belief that students entering graduate study, especially PhD study, have appropriate computing skills for study purposes and there is no longer a felt need for computer training programmes in tertiary education (Dange 2010). The concern is that focus on PhD students' ability to integrate ICT into their research practice is overshadowed or taken-for-granted as a consequence of their perceived or assumed readiness from undergraduate and/or Master's study experience. For example, there are studies showing that many postgraduates cannot cope with the demands of higher education, especially in terms of ICT use (e.g. Nair and Pillay 2004). These findings align with research indicating that poor preparation for the demands of higher education includes students' meager computer and information literacy skills, 'technophobia' and low computer literacy or competency (Castles 2004). The results in some studies suggested that postgraduate students were not competent at using office-type applications such as *Microsoft Excel*, *PowerPoint* and *Access* (Dange 2010). For example, there was one report that stated that students had 'high levels of ownership of application types' but these applications were not 'frequently used' (Shaw 2000).

Do these findings and results indicate the limitations in graduate students' ability to make the best use of ICT in their research practice? It appears that the degrees to

which graduate students could be regarded as competent computer users in terms of using basic academic software in order to complete their dissertations are still unclear. The difference between being part of the 'digital generation' or digital migration (Dobbins 2005; Kennedy *et al.* 2009; Prensky 2001) and being competent computer users could be deeper than much research to date assumes. ICT is expected to be at the heart of all aspects of a student's life, especially at graduate level. PhD students are viewed as developing researchers, and therefore knowledge of the computer literacy of PhD students and its association with ICT integration into research processes is essential, if the best support and opportunity are to be provided to ensure their success as scholars.

4.1.2. The role of ICT in the process of doing research

A second shortcoming highlighted by this review is that limited attention has been paid in the literature to how ICT integration happens in the process of research, especially at doctoral level.

Shaw's (2000) study involving over 300 graduate students in a northeastern US university examined students' academic computing attitudes, uses, needs and preferences. Student perceptions were reflected in comments such as: 'Using a computer makes me more organised in my graduate work'; 'Using a computer makes me more motivated to do my graduate work'; 'Sharpening my computer skills in graduate school is essential in my professional work'; and (the negatively worded) 'I prefer to do my academic work without much use of computers' (Shaw 2000). The students in the study claimed that the computer skills they used in their graduate and/or professional work included: 'writing' (91%) and 'research' (83%); nearly that proportion (79%) identified 'doing regular course assignments'; and roughly two thirds indicated 'corresponding with professors' (68%) as well as 'corresponding with classmates' (61%) (Shaw 2000). In short, the purposes identified by the students focused on typical activities that are part of the research preparation phase (searching information about the topic) and the write-up phase (writing and doing regular course assignments), as well as for communication tasks (corresponding with teachers and classmates).

Students in these studies did not seem to recognise the use of computers in the fieldwork phase of their research (e.g. survey tools, recording and note taking applications) or in the analysis phase (i.e. the use of data analysis software). In summary, one conclusion that could be drawn is that graduate or postgraduate students could be considered as active computer users, especially during their write-up phase, but could be considered less active users of ICT in the process of doing research. Given the growing access to Internet-based digital devices, it seems that ICT integration throughout the entire doctoral research process has not been extensively investigated. The majority of the reviewed studies discussing graduate or postgraduate students' ICT integration appeared to focus on the certain aspects of research practice only, that is, using e-resources and writing.

4.1.3. Productivity during the process of doing a research

A third shortcoming revealed in this review is that those studies on graduate students' productivity, or how they make use of, or consume, information online, are rare.

This could be seen as particularly concerning, considering PhD students are expected to be producers of 'new' knowledge.

Most reviewed studies on graduate students' ICT integration seem to focus on their literacy (Blignaut and Els 2010), communication (Lawlor and Donnelly 2010), recreation (McCarthy 2012) and their utilisation of learning management systems (Sultan 2010). As for the role of ICT in graduate students' research practices, the existing studies are limited to their library use (Sutton and Jacoby 2008) or knowledge consumption (Griffiths and Brophy 2005). This might suggest that the role of ICT in the process of doing research is limited to web browsing or data collection. It is also interesting to note that this view might match students' view of ICT too. One study (Economist Intelligence Unit 2008) reported that about 75% of participants who were asked about ICT use in their study said 'the greatest potential benefit of technology is something far more straightforward—namely, the expanded access to educational and reference resources that it provides' (p. 6).

According to a substantial portion of literature, graduate students are 'binge' or excessive, users of e-journals and prefer to use electronic resources (Aderibigbe and Aramide 2006; Dange 2010; George *et al*. 2006; Liew, Foo, and Chennupati 2000; Rowlands *et al*. 2007; Tenopir 2003) during their dissertation writing journey. Students seem to be treating computers as simple devices for accessing web-based information (Dahlstrom *et al*. 2011), rather than as offering them production capabilities as well. There seems to be a need to expand research literature to inquire into the ways in which graduate students use, experience and integrate ICT in their research practice, beyond web/journal/information searching.

4.1.4. Graduate profile in relation to ICT integration in research practice

Fourth and finally, there is little empirical evidence about the profiles of graduate students, specifically PhD students, in relation to their engagement with ICT in their daily life as researchers.

According to one-third of the employers who responded to a questionnaire in a study about ICT training for new graduates, 'some on-the-job training will be necessary to acclimatise new employees' and this is explained as 'this generation is not content with passive involvement' (Economist Intelligence Unit 2008, p. 11). It appears that a student, especially a graduate or postgraduate student, is not aware of the intended graduate outcomes of their institutions. One study argues that graduate students 'are benefiting from the pedagogical advantages of information technology and preparing for the professional world of work', with 'appropriately anticipating that skills in the use and management of information technology will be essential for advancement along their chosen career paths' (Shaw 2000, p. 34). Some of the current literature on computer integration in academia stated that postgraduate students now require more computing skills, such as the basic concept of computer knowledge (e.g. computer applications) in order to advance their research practice (Case, MacKinnon, and Dyer 2004; Wallace and Clariana 2005). These skills have been identified and they include: some basic ICT skills, such as file management, word processing, spreadsheet manipulation and graphical presentation (Blignaut and Els 2010); familiarity with basic components, terms and conditions, such as basic choice and use of hardware and software; overcoming of 'technophobia'; use of computer peripherals; basic formatting and editing functions; data entry; error management; use of operating

systems; backing up; and basic network interaction (Blignaut and Els 2010; Meerah 2010; Wallace and Clariana 2005).

Studies on how the students apply these computer skills in their doctoral research are misty and how these skills support research practice is limited. Further, it is also unclear how ICT plays a role in assisting graduate or postgraduate research students to develop their graduate profiles or how students' ICT integration is shown in their research practice to support their graduate profiles. The beliefs and the findings in the existing studies thus far may have signalled a further investigation into students' ICT engagement. This is especially important when ICT integration in the process of doing doctoral research is unavoidable, and ICT proficiency is significantly related to a student's graduate profile in today's world.

4.2. Data-gathering methods used in this research domain

Most studies on student's use of ICT in higher education rely on perception data, often gathered via surveys, interviews and questionnaires. Perception data refer to students reporting on what they believe they do or what they have done through post-event recollection. In an above-mentioned example, graduate students self-reported as 'binge' users of e-journals or as having a preference for using electronic resources during their graduate study (Aderibigbe and Aramide 2006). However, the results in some studies suggested that graduate students are not competent to the same extent in using generic spreadsheet, presentation, word processing and database applications (e.g. Dange 2010). As mentioned earlier, another report suggested that students had high levels of ownership of application types that they did not frequently use (Shaw 2000). One of the reasons these studies raise different scenarios of graduate students' use of ICT could be that they rely on perception data, often gathered via surveys and questionnaires. Thus, none of these studies can lay a claim to knowing what students actually do in practice. This situation prompted Conole *et al.* (2008) to state that, 'more in-depth research is needed to understand the nuances of how students are using technologies to support their learning' (p. 512). In short, from the point of view of the research methods, the under-representation of certain research methodologies, such as actual practice data, suggests opportunities for future research.

As suggested by Dange (2010), there should be more ongoing studies to monitor the situation as technological and educational environments continue to change. The 'first necessary step of this process is an accurate and realistic assessment of the actual computer skills of the student' (Divaris, Polychronopoulou, and Mattheos 2007). The studies should be based on students' observable behaviours in relation to their engagement with ICT. One reason is that such findings, while relevant to explorations of postgraduate students' perceptions of ICT use, also offer a convincing picture of student practice as experienced in their day-to-day practice. In Sim and Butson's (2013) study on the use of personal computers by third-year undergraduate students, it was argued that 'the difference between the students' beliefs about their personal computer use and their computer use highlights that self-report data reliant on post-event recollections should not be relied on to represent actual practice' (p. 338). Furthermore, there is no, or little, practical significant correlation between performance and students' expectations of additional technological support (Blignaut and Els 2010; Sim and Butson 2013; Wallace and Clariana 2005). In other words, data gathered through self-rating data collection techniques are not a reliable measure to assess ICT use by graduate students. This assertion aligns with the

findings of van Vliet, Kletke, and Chakraborty (1994) that the self-ratings are not accurate indicators of computer skills, as students often rate their skills lower or higher than their practical skills reflect (Blignaut and Els 2010; Butson and Sim 2013; Sim and Butson 2013, 2014). It is worth considering that actual practice data-gathering methods be employed in order to reveal students' daily technological academic practices, rather than through the more traditional approaches of questionnaires, surveys and interviews only.

Green *et al.* (2006, p. 1) suggested that students' participation might be secured by allowing them to play a 'researcher-like' role in the study and experience the invested outcome of the study. Conole *et al.* (2008) also agreed that research should focus more on the student voice, their ongoing use, experience and perception of technologies to elicit and explore their e-learning strategies in different contexts. Although students might be more familiar with research methods such as survey and focus groups (Dahlstrom 2011), there might be unexpected outcomes by engaging research participants as peers and colleagues when collecting the data. Applying such methods recognises the participants' power and uniqueness as sources of evidence, as well as engaging them in the inquiry. It enables the introduction of first-person observational perspectives to the collection and analysis of the data.

4.3. Summary of findings and discussion

Generally, what has emerged in the reviewed literature is the lack of in-depth studies on ICT use by PhD students with regard to their practices. The research into PhD students' computer literacy is also limited. Similarly, the existing empirical research has yet to consider PhD students' productivity with ICT integration in their research practice, especially in relation to graduate capabilities. Even though the literature indicates a rising interest in different perspectives on the role that ICT plays in higher education, such growing interests from the research community have not yet expressed the awareness of students' practices in this area. The increased inclusion of students' perspectives in this research area in recent years seems to be mainly focused on information-searching activities or measurement of computer literacy. Evidence of students' actual practice alongside their perceptions is still limited.

5. Conclusion: identified directions for future research

This paper sought to identify what is lacking in the literature about the role that ICT plays in PhD students' lives. In this paper, 27 research contributions published after year 2005 were examined. The papers were analysed using a two-pronged approach: the paper contents addressed and research methods adopted. The contribution of this review is twofold. First, this review provides a structured review and guide to earlier research on the role of ICT in the process of doctoral research. Second, this review identifies research issues for future investigation, mainly in the area of broadening the research methods being employed. In summary, research reporting on students' ICT use has increased in recent years but the focus is mainly limited to computer literacy measurement or information-searching activities. Such growing interests from the research community have come with increased, though still limited awareness of students' ICT practices in this area. A focus on the importance of this for the development of students' graduate profile in relation to ICT is also still limited.

The difference found between perception and practice data in the studies thus far signals the need for a substantial shift in the way to understand and gather data in this emerging field.

In terms of PhD students' ICT use (e.g. Blignaut and Els 2010), as mentioned earlier, documented studies have been focused on graduate students' computer literacy, communication (e.g. Lawlor and Donnelly 2010), entertainment use (e.g. McCarthy 2012) and the use of learning management systems (e.g. Sultan 2010). These studies, while focusing on the doctoral research process or the ICT use in general, there are few that research these two aspects at the same time. The lack of studies considering ICT use in doctoral research may suggest that institutions, that is, lecturers, supervisors and/or students, hold certain assumptions and expectations regarding PhD students' ICT use. PhD students' ICT use may have been taken-for-granted by academia or overlooked in general. The role of ICT in supporting PhD students' research processes is thus unclear, especially the degree to which ICT are being embedded into practice at different phases in their research process. Given the arguments concerning the role of ICT in a process of doing research, what is the argument about the impact of ICT on playing a role in a doctoral research? The 'simplified' assumptions about the ongoing relationship between ICT and graduate or postgraduate students should be avoided (Larsson 2002), and more emphasis should be placed on how technological support should be designed in order to assist PhD students in their doctoral research in the best possible ways (Jackson 2005; Onilude and Apampa 2010). Future studies should start looking at the way that graduate students interact with ICT and the way that ICT supports their day-to-day practices, and then let this understanding inform the development of appropriate technological support that is firmly based on close investigations of how doctoral research is performed on a daily basis. Again, the matter of interest is to study, understand and describe what PhD students actually do, not to prescribe what they should do or what they think they are doing.

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