

Doctoral supervision in virtual spaces: A review of research of web-based tools to develop collaborative supervision

Abstract

Supervision of doctoral students needs to be improved to increase completion rates, reduce attrition rates (estimated to be at 25% or more) and improve quality of research. The current literature review aimed to explore the contribution that technology can make to higher degree research supervision. The articles selected included empirical studies that sought to improve supervision through the use of technology. The literature search focused on technology, supervision and pedagogical supervision, and supervisor–supervisee relationships. Eighteen empirical articles, including Web 2.0 settings, were examined in relation to whether web-based tools could influence the training of doctoral students, be effective in supporting students, and reduce the breakdowns in supervisory relationships. With a few exceptions, these studies showed that Web 2.0 tools enabled greater dialogue and interaction between the student and supervisor rather than a passive viewing of content. They created virtual spaces that combined technology and pedagogy into a process where research projects could be developed in a more collegial and collaborative way. It appeared that combining technology with pedagogy translated into more innovative ways to undertake supervision, particularly participatory supervision. The need for digital pedagogies that facilitate multidimensional changes in higher degree supervision was identified for future research.

Keywords: Doctoral supervision; higher degree research supervision; community of learners/professionals; supervision pedagogy; Web2.0 technologies; doctoral education.

1. Introduction

The increasing use of virtual spaces through web-based technology in higher education has brought with it many changes in the ways in which academics teach, interact with students and colleagues, conduct research and supervise doctoral students. Doctoral supervision is an 'old profession' but new technologies may play a vital role in transforming traditional modes of supervision. Traditionally, the 'passing of the torch' of supervision wisdom has been conducted in an intuitive manner by professors who mentor students in an apprenticeship model to immerse them in their approach to research. Scholars often work as a team and, through their daily routine, share research habits that they learned from their own supervisors.

A major trend in higher education is the re-purposing of Web 2.0 systems, not only to access knowledge collaboratively but also to create and sustain communities of learners. In reviewing current articles, we questioned the impact of web-based tools on the training and support of doctoral students. The purpose of our literature review was to refine our understanding by asking the following questions: How are web-based tools used to enhance the virtual spaces of supervision? What supervision pedagogies were involved in past studies? How are supervisors and supervisees engaged with each other within these virtual spaces? And what criteria emerged that can help in identifying appropriate technologies and pedagogies that would enhance the supervision process in these virtual spaces? We examined articles on doctoral supervision to identify what contributions web-based tools can make to supervision and supervision pedagogy. We also identified the criteria for establishing a digital platform for supervision—a virtual space that enhances collaboration and dialogue.

This paper is located within a larger project, *Design of a participatory supervision support platform for improving higher degree supervision*, which investigates technology-based processes located in virtual spaces that can create a participatory supervision support platform (PSVSP) (Authors, 2012). It highlights key findings that contribute from a pedagogical perspective and

investigates which technologies with similar functionality to our conceptual PSVSP (Author & Herrington 2011) are available to support different processes of supervision. Our second aim, therefore, was through the literature review, to identify criteria for appropriate technologies that have the potential to enhance participatory doctoral research processes in virtual spaces.

2. Background

In recent years, doctoral supervision has moved from a model of individual relationships to a team approach that reduces periods of solitary research and provides a panel of supervisors who can support doctoral students with various forms of expertise (Green & Bowden, 2012). The result has been a shift from a one-to-one (classic master/apprentice) relationship in which the supervisor provides all the support, to a model in which a team of supervisors assist students using a more project-based research model. Others suggest that there has been an evolution from a product-oriented thesis to a process-oriented one and from a person-centred to a community-centred approach (Stubb et al., 2012). Another model is a systematic management matrix (Maxwell & Smyth, 2009) that places at its centre the research question which would guide students in developing the 'how' and 'why' elements of the research. Maxwell and Smyth propose that the matrix is compatible with most methods in which the research question takes a privileged place in the research process and hence can assist the supervisory relationship (p. 220).

According to Park (2005), online supervision can create virtual spaces that add a new dimension of complexity to supervision that is generated by the various configurations of supervision: theoretical versus work-based, practical doctorates; part-time versus full-time; dyad student-supervisor versus team supervision; and science versus social science and humanities disciplines. These elements interweave and affect the quality and outcomes of doctoral work. As a result of this complexity, Cumming (2010) suggests an 'ecosystem' approach rather than an input (physical and human resources)/output (theses and graduates) approach. This ecosystem would

reflect a 'complex web of interactions involving various structures, cultures, discourses, and networks' (p. 34) and many components that are interdependent and interrelated. This increases the number of stakeholders, embraces online technology, and produces an open and flexible co-production of knowledge, which may lead to a new type of pedagogical supervision. A pedagogical approach to supervision is based on developing a positive relationship with research students and encouraging critical thinking about the research question (Danby & Lee, 2012). In this pedagogical approach, the aim for students would be to enculturate into a research environment and be provided with enough support to emancipate them from the supervisory relationship and become researchers in their own right. Supervision pedagogy is a multifaceted concept that introduces students to learning and research through seminars and workshops and exposes them to scholarly research methods through mentoring, modelling, scaffolding and emancipation. The multifaceted approach to supervision pedagogy also includes critical exchanges of action and ideas that are relevant to each discipline.

Doctoral educators 'enable' learning through setting up opportunities for critical exchange and action relevant to disciplines and research fields. Decisions about pedagogical design in doctoral education involve reconciling competing demandsSuch considerations attend to the craft of designing pedagogical spaces that afford such possibilities. (Danby & Lee, p. 21)

Traditionally the doctorate was a degree that required a supervisor with specialised expertise to oversee the research process with careful attention to each step of the project. It is difficult to conceptualise this process in the virtual space of Web 2.0. To understand how the doctoral degree might work within a digital ecosystem, it is illuminating to review research on doctoral supervision within Web 2.0 environments that goes beyond wider structural changes and market opportunities. The use of wide-ranging pedagogy and digital technology is more prevalent in

undergraduate education (see, for example, Zhang, Olfman & Firpo, 2010) but is still emerging as an approach to supervision at the graduate level.

There are numerous ways to approach research supervision and new forms are emerging. Dron (2012) argues that it is hard to separate pedagogy from technology and asserts that ‘our pedagogies are in a very real and fundamental sense themselves technologies’ (p. 23). Therefore we combine pedagogy and technology in an attempt to enhance supervision and, more importantly, the social interaction between the academic and the doctoral student in virtual spaces. Technology also could be used to increase efficiencies and overcome some of the challenges, such as low completion rates, supervisors’ dissatisfaction with the quality of students’ theses, breakdowns in supervisory relationship and lack of support for supervisors or students. Transforming the character of research training could potentially raise research outcomes for universities, boost completion rates, reduce the time taken to complete degrees (Hammond, Ryland, Tennant, & Boud, 2010) and improve rankings in world league tables (Norton, 2012).

Increasingly students are enrolled externally or from a distance and are not in the same location as their supervisors. Remote supervision creates new challenges and at the same time new opportunities to overcome the tyranny of distance through the creation of virtual spaces using web-based tools. Thus, face-to-face research training is giving way to a demand for flexible, available-at-all-times, distance-learning that is mediated by software that takes advantage of common computer literacies and is accessible regardless of the choice of device.

With the progress of using technology in doctoral education a more holistic approach to doctoral education may be required, as Cumming (2010) asserts: “there is a need for ‘re-envisioning’ (Nyquist & Woodford, 2000), ‘reframing’ (McAlpine & Norton, 2006) and ‘rethinking’ (Walker et al., 2007) contemporary approaches to the doctorate” (p. 25). As supervisors, we are aware that the

supervision process of doctoral students is challenging and often undertaken in isolation from other supervisors and students; although there is a move towards a team approach across most disciplines (Danby & Lee, 2012). There remains, however, a need to theorise a robust framework for how to use web-based tools to reduce the isolation of the supervision process (Author & Herrington, 2011) while creating new incentives for interaction and adding efficiencies to already-demanding supervisors' workloads.

3. Methodology

The databases ScienceDirect®, Editlib®, ERIC®, Academic Onfile®, ProQuest® and SAGE Journals® were used to search for articles that were included in this review. The initial search terms were limited to the names of 44 learning management software systems. While this produced numerous case studies related to undergraduate and adult professional learning, it yielded limited results within the context of doctoral supervision. The keywords were expanded to include pedagogical concepts such as 'face-to-face training', 'reflective practice' and 'distance education', and more general terms such as 'doctoral student training', 'doctoral process' and 'doctoral education'. This subsequent search identified several thousand articles.

The search was also restricted to articles published between 2006 and 2014, in order to align with technology change and uptake. Despite the benefits that could be associated with software created for managing learning in an online setting, an intervening factor in the long-term adoption of any single program is the pace of technology development that can make some projects obsolete within a few years. Our project was therefore focussed on the Web browser as a participation platform for which software applications are built.

More recent research involving software that was still widely in use and on case studies on supervising doctoral students using familiar applications was included for review. In particular,

articles examining a participatory supervision scenario within the demands of contemporary technological developments were considered more relevant than similar articles relating to technology that was revolutionary six years ago but superseded today.

The final set of articles consisted of 196 Peer Reviewed Papers, 64 Conference Proceedings, 8 Dissertations, and 16 Reports. These articles were imported into Sente 6[®], a scholarly referencing system, which was easy to acquire, organise, read and annotate. Suitable for note-taking and citing academic material, it allowed us to share the database across devices using cloud services (<http://www.thirdstreetsoftware.com/site/SenteForMac.html>). Using this software, the articles were collaboratively reviewed by academics from the School of Education at Murdoch University and the Digital Humanities Research Group, Western Sydney University. Subsequently, each article was tagged according to type and, after scrutiny, was graded according to key points in order to yield a final set of 18 papers that were considered most relevant to this project. The concepts used in our filter related to technology, supervision and pedagogical supervision, and supervisor–supervisee relationships.

From the 196 articles, 18 empirical studies that best fit the search criteria involving the use of Web 2.0 virtual setting during doctoral supervision were selected.

4. Review of Articles

In reviewing the studies of the process and outcomes of research on the supervision of doctoral students and the elements involved in their use of technology, our initial investigation suggested that the topic of doctoral supervision did not have a body of identifiable theory. In addition, there were significant knowledge gaps in understanding supervision and the factors that contributed to its failure or success. Although the concept of ‘enough’ is arbitrary, what became clear early on was that — with the exception of large-scale national studies such as the United

Kingdom's *Researchers of Tomorrow* (2009–2012) (Carpenter and colleagues' reports about Gen Y doctoral students) and the Grattan Institute's *Mapping Australian Higher Education* (Norton, 2012) — research on doctoral supervision was not very well developed. Appendix A provides details of the 18 articles reviewed in terms of their purpose, methods, field/country, type of technology and supervision pedagogy that was used. The following provides a critique of this information as well as a thematic analysis of the main issues in the articles.

4.1. *Purpose and countries of selected studies*

There were diverse research questions in the selected studies ranging from what currently works well for distance doctoral education students in Australia (Albion & Erwee, 2011; Andrew, 2012) to the experiences of Generation Y doctoral students (born between 1982 and 1994) in their supervision journey in the UK (Carpenter, 2012; Carpenter, Tanner, Smith & Goodman, 2011; Carpenter, Wetheridge, Smith, Goodman & Struijve, 2010). A number of Australian studies focused on doctoral pedagogy (Cumming, 2010; Danby & Lee, 2012), the use of virtual portfolios for supervision in Australian universities (Le, 2012; Manathunga & Lant, 2006), and what doctoral supervisors learned through supervising doctoral students and how this could be theorised (Halse, 2011). An Australian-New Zealand study (Hammond, Ryland, Tennant & Boud, 2010) identified existing training provisions for doctoral supervisors and examined their current and future needs.

Four additional UK studies focused mainly on the pedagogy of supervision: what influenced supervisors' approaches to their work with doctoral students and its impact on their work with their students (Lee, 2008); doctoral students' uses of research software at various stages of their research (Stelma, 2011); pedagogical problems within supervision sessions and how supervisors might encourage creative thinking (Whitelock, Faulkner & Miell, 2008); and what constitutes group supervision and the opportunities through peer learning (Fenge, 2012).

A South African study (de Beer & Mason, 2009) focused on the problems that students experienced during their doctoral studies and whether a blended approach, with face-to-face and online web support, would reduce administrative workload and improve the supervision process to enhance student research. A French study (Malingre, Serres, Sainsot & Men, 2013) assessed how the portal *Form@doct*[®] was used as a resource rather than a network. An American study (Rockinson-Szapkiw, 2011) considered how the use of collaborative technologies supported distance doctoral students both socially and academically in comparison with traditional dissertation implementation.

4.2. *Methods used in selected studies*

Four studies (Albion & Erwee, 2011; Andrew, 2012; Rockinson-Szapkiw, 2011; Whitelock et al., 2008) involving distance education supervision identified the use of technology as a natural extension of supervision practice. However, it was argued that supervisors still needed to see their students face-to-face at critical points during the doctoral journey (Albion & Erwee, 2011). There was also one international doctoral education network (*Doctoralnet*[®]) that was established to support students and their supervisors (Danby & Lee, 2012) and one online tutorial for PhD students (*Form@doct*) in France (Malingre et al., 2013).

Most researchers employed qualitative methods based mainly on interviews (Andrew, 2012; Danby & Lee, 2012; de Beer & Mason, 2009; Hammond et al; 2010; Stelma, 2011; Whitelock et al., 2008) or open-ended questionnaires (Fenge, 2012) at different stages of supervision. De Beer and Mason, for example, analysed students' submissions and problems experienced and lecturers' feedback and then incorporated these into a model reflecting the study's findings. Halse (2011) employed a thematic analysis of two experienced supervisors. Reflection in action and reflection on action were used as viable methods to gain insights into the supervision process (Stelma, 2011). An

Australian empirical study used a mixed-method approach by involving a symposium in the first stage and then a survey followed by interviews with individuals and groups in the second stage (Hammond et al., 2010). Four other studies used mixed-method approaches: one examined the literature of supervision through the filter of interviews with 12 supervisors and two students (Lee, 2008); one used qualitative and quantitative methods through a combination of questionnaires with interviews with students and staff (Albion & Erwee, 2011); the third involved a national survey of 5,395 doctoral candidates followed by ten staff interviews in one university (Cumming, 2010); and the fourth used an online survey followed by face-to-face interviews to examine collaborative tools (Rockinson-Szapkiw, 2011).

Among the methods that stood out in this review was a particular statistical analysis, Google analytics (Malingre et al., 2013), which was used to identify how doctoral students appropriated a tool and its resources in *Form@doct*. An action research method was used (Manathunga & Lant, 2006) with data obtained from interviews with students and supervisors. Although this study was older than the others, it was included because it represents a concept similar to what we, as researchers, wanted to achieve.

There were two longitudinal studies. One followed 17,000 doctoral students over three years in the UK and focused on the information-seeking and research behaviour of Generation Y students from 2009–2011, and presented in a series of three papers (Carpenter, 2012; Carpenter, Tanner, Smith & Goodman, 2011; Carpenter, Wetheridge, Smith, Goodman & Struijve, 2010) with diverse foci. A second study of Australian universities examined existing practices and resources available for doctoral students and their supervisors (Hammond et al, 2010). Another quantitative study used an online questionnaire with a sample of 92 students (Rockinson-Szapkiw, 2011).

In summary, all except two research projects used qualitative or mixed-method approaches; a UK longitudinal study and an Australian study used quantitative methods with larger samples and over longer periods of time.

4.3. *Technologies used in selected studies*

The Appendix shows that various technologies were used in these studies: Skype®, Elluminate®, Wimba®, Second Life®, telephone, and MSN messenger in distance education (Albion & Erwee, 2011; Andrew, 2012); Wikis®, Microblogging®, Social Bookmarking and email (Carpenter, 2012; Carpenter, Tanner, Smith & Goodman, 2011; Carpenter, Wetheridge, Smith, Goodman & Struijve, 2010); ePortfolio (PebblePad®) and an in-house virtual portfolio as a dialog tool (Le, 2012; Manathunga & Lant, 2006); and Microsoft Office Share-Point for collaborative writing (Rockinson-Szapkiw, 2011) and WebCT® (de Beer & Mason, 2009; Stelma, 2011) in more traditional supervision. Two research studies (Danby & Lee, 2012; Malingre et al., 2013) stood out because they created completely new virtual spaces: *Doctoralnet* and *Form@doct*.

4.4. *Supervision pedagogy and the supervisory relationship*

Throughout the literature, there emerged a new type of pedagogy that involved sustained higher degree communities of learners and extended the notion of supervision to a participatory one, embracing the concepts of connectedness, more intense supervision, ecosystem, team, community centre, emancipatory relationship with supervisor, specialised pedagogical intervention, peer learning, and group supervision.

Through combining supervision pedagogy within virtual spaces, these research projects reflected a shift to a process of creating communities of scholars. The social aspects of scholarly

communities and introducing new doctoral students to senior scholars or research communities have their merits in 'normal' doctoral studies. This is even more so in distance doctoral education with the increased need to create connectedness between the distance doctoral student and the research community. However, when examining the research behaviour of Generation Y doctoral students (Carpenter, 2012; Carpenter, Tanner, Smith & Goodman, 2011; Carpenter, Wetheridge, Smith, Goodman & Struijve, 2010) who used Web 2.0 technologies, most confirmed that their supervisor was not very interested nor competent in new web-based tools and continued to supervise in a traditional way. This longitudinal study also examined to what extent supervisors influenced their students to use the latest technologies or to change their research behaviour to integrate the use of virtual spaces. This set of papers suggested that there was no strong synergy between students and supervisors in spite of the opportunities available to use social learning technologies and to capitalise on students' competency in this area. Apparently supervisor's knowledge and competency in using technology for the advancement of the process was lagging behind that of their students (Carpenter, 2012).

One study (Cumming, 2010) advocated a supervision pedagogy that entailed a holistic approach with an integrative, nested model of the doctoral enterprise that resulted in a change in attitude about how to conduct supervision and how to implement it in a more collaborative way to co-produce new knowledge. The article argued for more 'open and flexible' approaches 'enabling candidates to exercise greater autonomy with regard to when, where and how they learn' (p. 36). In another study (Danby & Lee, 2012), there was greater emphasis on pedagogy with the hope that it would improve design and action, enabling the supervision process to integrate these two in a better way. De Beer and Mason (2009) utilised a storyboard technique to capitalise on supervision as a process and scheduled events and activities to enhance the process and encourage students to complete dissertations on time.

Other significant pedagogies involved group learning (Fenge, 2012) that combined the notion of a community of scholars/researchers/learners developing an individual's knowledge and practice through peer learning, or participatory and proactive-led discussion, with discourse and performativity as the essence of supervision pedagogy (Halse, 2011). Similarly, literature reviewing and interviews identified five major approaches to supervision in which enculturation and emancipation encouraged students to become members of their disciplinary community. Other pedagogies involved collaborative processes through using either ePortfolio as a resource and communication tool (Le, 2012; Manathunga & Lant, 2006) or the development of immediacy relationships through a collaborative Website virtual workspace to facilitate discourse between doctoral students, their peers and their communities (Rockinson-Szapkiw, 2011). Overall, the strongest pedagogical supervision approach demonstrated throughout this literature was the dialogue between the students and supervisors and the emphasis on being part of a community to achieve collaboration.

5. Discussion

Designing a platform to improve supervision to achieve higher completion rates would need to run in conjunction with understanding the nature of this key relationship and the factors which work for and against doctoral supervision. Without this understanding, any future software implementation runs the risk of repeating the high intakes but low success rates of existing doctoral education.

This review of selected studies demonstrated a new trend in higher degree supervision in which the supervision relationship had become more reciprocal and less hierarchical (e.g., Andrew, 2012; Fenge, 2012), involving a shift from the master apprentice model to one in which the supervisor facilitates and negotiates rather than directs or instructs. The relationship between students and their supervisors has considerable impact on a doctoral journey (Dron, 2012; Halse, 2011). Recognising this, we tried to identify whether virtual spaces were used in these studies to enhance the student-supervisor relationship and whether new types of pedagogies were created utilising

Web 2.0 technologies. We identified that there was a fundamental shift towards participatory pedagogy for supervision and in the way in which students and supervisors approached the supervision process.

A major impetus for using Web 2.0 technologies was to initiate doctoral students into scholarly communities. Fenge (2012) discovered that group supervision supported peer learning and enabled the supervisor to complement the learning process by enriching the different perspectives offered by individuals in the group. Through group supervision, relationships developed into more participatory ones and allowed greater 'cross pollination of ideas' (p. 409). Halse (2011) argued for a change from an intense personal relationship to more of a professional one as a 'necessary survival strategy' (p. 565).

Through the use of ePortfolios as virtual spaces, Le (2012) and Manathunga and Lant (2006) found that the participatory forums that were created became highly interactive. Thus, these studies demonstrated that the collaborative-based technology in which students and supervisors were interacting delivered a sense of connectedness that promoted social and academic achievement. A new approach to this participatory notion was the web-based international network, *Doctoralnet*, that Danby and Lee (2012) developed to unite doctoral students from nine countries. Stelma (2011) also used a network for the exploration of resources and an online discussion forum as a virtual space to provide ideas and prompts to encourage ongoing reflection.

Not all the studies revealed that supervision was moving towards a more participatory process. De Beer and Mason (2009) claimed that relationships did not change as a result of using technology: the supervisor still maintained the role of advisor and mentor and provided support and quality control, but with the advantage of digital forms of communication. Cumming (2010) also found that the supervision relationship was not changing enough and suggested that there was

mounting pressure to implement a more open and flexible type of supervision. Finally, Carpenter's (2012) study revealed that the majority of the research students worked alone and shared ideas and created research outputs more with their peers than with others in the scholarly community or their supervisors.

6. Conclusions

This literature review confirms the need for a web-based platform, such as PSVSP, for improving doctoral supervision. We have identified necessary and desirable principles for developing such an application. Two sets of criteria emerged: technological and pedagogical perspectives. Our aim of future research is to merge these into a digital pedagogy conception, as one is not sufficient for success without the other. We must capitalise on web-based tools that can accommodate a complex interaction in virtual spaces through a Web browser, ePortfolio or Cloud Computing (Velte, Velte & Elsenpeter, 2010). However, the technology should empower rather than control or direct the process of learning. A robust framework must be easily accessible, user friendly, transparent and attractive to students and supervisors.

The structure of the virtual spaces should enable the creation of a community of learners/practitioners who interact and provide support to each other. An example of a successful application is *Doctoralnet* that includes a virtual space with Web 2.0 affordances, such as online discussion, a collaborative writing space and face-to-face meetings that provide a strong digital pedagogy framework.

A major issue when creating a community for doctoral students is to sustain this community for the duration of the doctoral journey and to provide a context for ongoing dialogue with reflection and co-creation of knowledge. One approach is to involve significant people from the

profession to add quality and provide exposure for doctoral students' future employment. Recently researchers (Albion & Erwee, 2011; Fenge, 2012; Halse, 2011; Le, 2012; Rockinson-Szapkiw, 2011) found that group supervision, cohort-based pedagogy, peer learning, and a connectedness approach to supervision helped to create a sustainable community. The structure of such a community of scholars and practitioners should be flexible to accommodate different models of supervision and both international and local students.

We propose that a digital pedagogy model that brings about these multidimensional changes using Web-based applications could help to create the next generation of supervision pedagogy and promote the development of appropriate virtual spaces keyed to doctoral student needs. Ideally it would develop a more participatory relationship to shift supervision from an intense personal relationship to a more professional relationship. A technological tool to assist in implementing this vision is only a first step in providing the foundation for a sustainable bridge between technology and supervision pedagogy. Critically, further empirical studies are needed. Such research, in focussing on the multidimensionality of contemporary supervision, is likely to contribute to the recognition of doctoral supervision as a field of scholarly work.

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Appendix A

Description of Review Articles

Publication	Purpose	Methods	Field/ Country	Technology	Supervision pedagogy
1. Albion, & Erwee (2011)	Identify what works well for students and academics in distance doctoral studies.	Online questionnaires (students) and interviews (staff).	Education/ Business Australia	Skype, Elluminate, Adobe Connect, Wimba, Second Life.	Technologies for doctoral supervision. Initiation to scholarly community. Maximise networking: introductions to senior/international peers and/or researcher communities.
2. Andrew (2012)	Investigate skills and understandings for mediating supervisor–supervisee dyads within remote distance education.	Case studies of three PhD students.	Writing Australia	Email, Skype, Telephone, Elluminate, MSN Messenger.	Absent presence becomes virtual presence. Practice-Led Research (PLR). Negotiation rather than direction; interpretation rather than transmission; reciprocal academic power rather than hierarchical. The supervisor mediates, facilitates and mentors instead of master-apprentice model.
3. Carpenter (2012)	Study over three years of information-seeking and research behaviour of doctoral students in ‘Generation Y’ (born 1982 - 1994), educated with limited access to technology.	17,000+ doctoral students, three annual surveys; longitudinal student cohort study.	Interdisciplinary United Kingdom	Social media: Wikis, VOIP, Micro-blogging, Social Bookmarking.	Doctoral students’ take-up of technology, web-based applications, and information services. Supervisors not very interested or competent in latest web technology collaboration applications. Most work alone.
4. Carpenter, Tanner, Smith, & Goodman (2011)	Examine attitudes and behaviours of Generation Y doctoral students.	Longitudinal study. National survey allowed comparisons. 2239 surveys Generation Y students and 2568 older students.	Interdisciplinary United Kingdom	Social media: Wikis, VOIP, micro-blogging and social bookmarking.	Key elements in relationship between Generation Y candidates and supervisors: good fit in terms of expertise and knowledge of research area and ‘getting on’ together. Supervisors generally not interested in up-to-date technology, which influences students’ research approach.

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5. Carpenter, Wetheridge, Smith, Goodman, & Struijvé (2010)	Track over three years research behaviour of 60 Generation Y doctoral students.	Qualitative longitudinal study; national survey 2000+ Generation Y and 3000+ older students.	Interdisciplinary United Kingdom	Social media: Wikis, VOIP, micro-blogging, social bookmarking.	Role of supervisors' relative to Generation Y students' research behaviour.
6. Cumming (2010)	Examine conceptions of contemporary doctoral education.	Mixed methods.	Varied Australia	'Open and flexible' approaches.	Holistic conception, represented as integrative model of doctoral enterprise comprising three components: participants, academy, community.
7. Danby, & Lee (2012)	Use two cases to describe how learning opportunities were designed and to theorise engagement in doctoral pedagogy.	Case study of international doctoral education network (Doctoralnet), which unites students and experienced researchers internationally. Design model: twin concepts of design and action, drawing on ethno-methodological understandings of pedagogy as social action.	Interdisciplinary Australia, international	Chain of email exchanges as shaping identity between students and supervisors. Doctoralnet: Networked doctoral education for geographical isolation. Linking doctoral research to larger collaborative research. Online network, Web 2.00: discussion, chat, video-conferencing, blogs, linked homepages, collaborative writing spaces.	Two inter-related conceptual framings: pedagogy as design; pedagogy as practice-in-action. The term pedagogy draws attention to how learning and teaching are often embedded in activities and relationships not always explicitly educational. <i>Doctoralnet</i> , an international network of doctoral students and researchers engaging online and face-to-face, and transcript analysis group for which group of researchers, supervisors and students meet regularly to discuss transcripts, audio-recordings or video-recordings.
8. de Beer, & Mason (2009)	Examine whether a blended approach to research- supervision reduces administrative workload and improves the supervision process and quality and success of students' research.	Qualitative case study involving students' submissions, problems and lecturers' feedback.	Department of Management South Africa	WebCT (Blackboard)	Storyboard provides common point of reference and theoretical framework that accounts for supervision process with schedule planning all activities required by student. Role change based on activity required: advisory, quality-control, supporting and mentoring roles.

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9. Fenge (2012)	Explore group supervision processes and evaluate student and staff experience across three cohorts of professional doctorate programme.	Practice-led research: Questionnaire to evaluate student and group supervisors' experience of group supervision, including qualitative open-ended questions. Across three cohorts to first, second and third years.	Interdisciplinary United Kingdom	The programme specification for professional doctorate clearly identifies that cohort-based group supervision is central to programme. Face-to-face or email interactions.	Group Learning Pedagogy, cohort-based, reflexive with discursive processes on identity as researching professionals, creativity and discussion. Group supervision an 'add-on' within certain doctoral programmes. Peer learning and influence of learning environment on developing individual knowledge and practice. Not all students responded well to group supervision sessions.
10. Halse (2011)	Address gaps in doctoral education literature regarding what supervisors learn through supervision, and how impacts on supervisors might be theorised.	Thematic analysis of two complementary interview studies of cross-disciplinary sample of doctoral supervisors.	Education Australia	Not applicable.	Discourse of performativity; research as a business. Social and political contexts of supervision leading to self-protective strategies. Disciplined supervisory relationship as survival strategy, redefining doctoral supervision from intense personal relationship to form of professional work.
11. Hammond, Ryland, Tennant, & Boud (2010)	Identify training provisions, current and future needs, and recommendations for effective supervisor training.	Stage one: symposium of key academics in supervision pedagogy. Outcomes informed second stage when information was sought from individuals and groups, via survey and interviews, about existing practices, available resources, and perceived future needs.	Interdisciplinary Australia & New Zealand	Online discussion	Make Pedagogy of Supervision framework available as part of Student Research Centre standard suite of resources. There is need for increasingly sophisticated and constructive conversations about supervision pedagogy.

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12. Le (2012)	Examine concept, structure and functions of e-Portfolio in graduate research and its significance in enhancing quality of (research students and their learning environment).	Exploratory discussion, commencing with the concept of e-Portfolio with modern digital technology and innovative educational perspectives (critical thinking, social interaction, task-based and independent learning).	Department of Rural Health Australia	E-Portfolio; (PebblePad) enhanced three aspects for research students: academic development, research profile and social networking. Empowers students to take control of learning and research. Cloud computing examined for development of e-Portfolio.	Collaborative process working in e-Portfolio. Helping students become architects of learning process. Supervisors should develop e-portfolios as supervision resource. E-Portfolio contributes to enhancement of educational practices by moving focus from supervisor-centred to student-centred learning and research and from technological control to technological empowerment.
13. Lee (2008)	Explore what influences supervisor approaches to supervision and this partnership from the supervisor's perspective.	Interviews with 12 supervisors; group discussion with PhD students; framework created by examining literature on supervision (Lee 2007a) through filter of interviews with supervisors.	Science, technology, humanities, applied social science. United Kingdom	Framework for development of individual supervisors. Creates language that co-supervisors can use to negotiate roles.	Literature review and interviews iteratively informed development of concepts. Five approaches to supervision: Functional, Enculturation, Critical thinking, Emancipation, and Developing high-quality relationship. Supervisors' own experiences (as students) had significant impact on how they supervise. Doctoral supervisor can enact mentoring role in two ways: responsible for doctoral students; and overseeing probationary staff as co-supervisor.
14. Malingre, with, Serres, Sainsot, & Men (2013)	Assess benefits of online education in doctoral programs, specific working conditions and learning methods; identify how doctoral students have appropriated the tool and its resources.	Tutorial focussing on individualization, adaptability to needs of audience, and interaction with tutors and peers.	International Doctoral College France	Multiple ways of accessing content of Form@doct: self study, access to information, free open training website. Diversity of access best way to ensure system reflects diverse working methods of doctoral students and learning styles. Video clips support textual learning content.	Form@doct is technical and organisational online training system that could be asset for PhD students. Instrumental approach to online resource without pedagogical framework. Enables accessing information and interaction via Q & A, offer easier navigation through tutorial and adapt different user approaches.

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15. Manathunga, & Lant (2006)	Examine two stages of developing and implementing Research Student Virtual Portfolio (RSVP), an online suite aimed at investigating issues for inter-disciplinary research for higher degree students.	Action learning methods involving interviews and communications with individual students and supervisors.	Chemical Engineering Australia	RSVP	Reflective process. Dialogue between student and supervisor. RSVP provides clear, explicit, workable framework for students to use to direct their learning. RSVP acts as catalyst for ongoing dialogue between students and advisors about students' professional and personal development during candidature, strengthening advisor–student relationship. RSVP seeks to enhance quality of student learning through additional activities to broaden interdisciplinary skills and knowledge. Highly interactive, participatory form of action learning.
16. Stelma (2011)	Examine experiences of doctoral students to exemplify aspects of ecological model of researcher competence; understand doctoral students' uses of research software to support doctoral research.	Interviews with three past and present doctoral students. Reflection-in-action and reflection-on-action to develop researcher competence.	Education United Kingdom	Linked (web) pages inserted into Blackboard to avoid constraint of standard content structures of Blackboard.	Network of intentions from actors in doctoral student's environment. Integration of engagement with resources and expectations in research environment and individual exploration of software. Online discussion forums in which participants' postings provide ideas and insights.
17. Rockinson-Szapkiw (2011)	Examine use of SharePoint and its ability to support distance doctoral candidates socially and academically, in comparison with traditional dissertation facilitation methods.	Online questionnaire to 92 doctoral candidates in online doctorate in education.	Education USA	Microsoft Office Sharepoint.	Collaborative web-based workspace used to support doctoral candidates socially and academically to deliver a sense of connectedness and increase satisfaction. Student-to-student and student-to-faculty connection.

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18. Whitelock, Faulkner, & Miell (2008)	Identify pedagogical processes that encourage creativity. Examine students' and supervisors' perceptions of creativity during doctoral studies, how supervisors might encourage creative thinking, and how students might support and develop creative thinking.	Interviews with supervisors and students. Case study in Open University.	Education, educational technology, and psychology United Kingdom	Online and face-to-face dialogues.	Supervisors provide guidance while promoting autonomy; build confidence through positive feedback; encourage risk taking; filter knowledge and identify problems; model and share practice. Help to create professional identity. Reflective writing and sharing with peers. Supervisors encouraged creativity by sharing their own practice and experiences. Provide tasks such as working on supervisors' data or jointly presenting shared work at conferences.

