

ACCEPTED VERSION

Guerin, C. 2016,
'Connecting the dots: writing a doctoral thesis by publication', in C. Badenhorst &
C.Guerin (eds.), *Research literacies and writing pedagogies for Masters and Doctoral
writers*, Brill, Leiden & Boston, pp.31-50

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Connecting the dots: Writing a doctoral thesis by publication

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Introduction

Theses by publication are becoming more and more common, apparently driven by two main forces: the importance of publications for measuring research output from universities (Aitchison, Kamler & Lee, 2010); and increasing competition on the job market post-PhD (Jackson, 2013). Although much of the related literature focuses on the experience of publishing alongside or from the thesis (Cuthbert et al., 2009; Kamler, 2008), there is a growing move in Australia and elsewhere towards writing the thesis as a series of journal articles and book chapters. A considerable range of research literacies is developed through this process, and many doctoral candidates appear to benefit from taking up the thesis-by-publication format. Yet it would seem that a certain amount of confusion reigns with regard to what examiners will accept as equivalent to a traditional thesis (Hagen, 2010; Kemp et al., 2013), what topics and students this is suitable for, and what the benefits and drawbacks might be (Watts, 2012). Student experiences are starting to be reported, but to date there is little theorising of what this might mean for doctoral pedagogies more generally.

This chapter brings together the limited scholarly literature on the thesis by publication, much of which describes the various formats and regulations that govern existing practices. There is also some reporting of the learning that is afforded by engaging with academic publication during doctoral candidature, though this is often alongside production of a traditional PhD thesis, rather than through the thesis by publication format.

The chapter then goes on to set this knowledge in the context of reports of students writing theses by publication at an Australian university. The data is interpreted through the lens of “connectivism” (Siemens, 2004), considering how familiarity with other forms of creating and publishing knowledge in the digitised twenty-first century might mean that today’s doctoral candidates are more attuned than their predecessors to the idea of publishing their research. This in turn links to the participants’ sense of their emerging scholarly and researcher identities.

Background context of thesis by publication

Although the link between doctoral theses and publication is not new, there is increasing interest in integrating publications into the thesis itself. The “PhD by publication” was introduced to the UK by Cambridge University in 1966 (Badely, 2009; Powell, 2012; Wilson, 2002), but there is a longer tradition along these lines in European and Scandinavian universities (Green & Powell, 2005; Jackson, 2013; Simpson, 1983). In Australia, the PhD by publication has slowly been gathering momentum, so that now most universities offer this in some form (Jackson, 2013). The format of the PhD by publication, or thesis by publication, appears to be partly a response to the massification and internationalisation of doctoral studies more generally, whereby the purpose and form of the doctorate is changing (Go8, 2013; Park, 2007; Taylor, 2012). Not only do we now see a greater diversity in those who undertake doctoral studies and their motivations for doing so, but we also see a greater diversity in the kinds of theses they produce (Watts, 2012). This, coupled with a more

intensely competitive job market that values publication in peer-reviewed journals, means that many doctoral students are encouraged to publish before graduation—and a thesis by publication removes the need to write extra papers on top of the thesis to achieve this. The audit culture currently dominating universities in Australia, New Zealand and the UK (Parker, 2011) further encourages the production of “countable” research outputs, particularly in the form of journal articles and book chapters. So pervasive has the expectation of publication become in some disciplines that research suggests some students believe the inclusion of published papers to be a requirement of doctoral studies (Kemp et al., 2013). Although the drive towards thesis by publication appears to be led by scientists, there is considerable interest in this format in humanities and social sciences too (UKCGE, 1996).

Formats of “thesis by publication”

There is a range of different names and formats for what I am here referring to as “thesis by publication”. In some cases, the publications are used retrospectively by academics to demonstrate that the contribution they have already made to their discipline is equivalent to a PhD; in this case, some universities award what is sometimes known as a “staff doctorate” (Davies & Rolf, 2009; Wilson, 2002) or “PhD by prior publication” (Jackson, 2013). Increasingly, however, the PhD or thesis by or through publications (Niven & Grant, 2012), also known as an article-based PhD (Thune et al., 2012) or publication-based PhD (Sharmini et al., 2015), is undertaken by novice researchers during their doctoral candidature. These “compilation” theses (Dellgran & Höjer, 2012) are generally presented as a series of publications framed by a substantial introductory literature review and concluding discussion (Jackson, 2013). The extensive introductory section (known as a “commentary, summary, report, synthesis, supporting statement, doctoral statement, critique, critical essay, review appraisal [or] analysis” (Green & Powell, 2005, p. 75)) is often used to summarise and critically evaluate the research as a unified body of work. Many universities also allow for a “hybrid” that includes prior publications and new work (Jackson, 2013), or a “combination” that includes both article manuscripts and other chapters that are important for the thesis but not necessarily publishable (for example, extended explanations of methodology are not generally publishable as new work in most disciplines, but provide a valuable demonstration of the candidate’s knowledge and understanding of what is regarded as appropriate in the particular field).

The number of papers required for a thesis by publication varies according to discipline (Hagen, 2010), but is generally between three and six articles, making it considerably shorter than the traditional format thesis in most cases. “Papers” can take the form of journal articles, book chapters or refereed conference proceedings (Jackson, 2013). The papers can be single-authored or joint-authored with supervisors, and regulations vary regarding how many of those papers must have the candidate as first author (Thune et al., 2012). Some universities insist that papers are not only published before submission for examination, but also dictate the ranking or level of the publication outlet, while others require only that chapters are written as manuscripts suitable for publication.

Connectivism

This study draws on the insights of “connectivism” to help interpret the descriptions here about student experiences of writing a thesis by publication and the implications this has for developing researcher identities. Connectivism describes a pedagogy and a philosophical stance about how learning occurs in the twenty-first century (Cormier &

Siemens, 2010; Downes, 2012; Siemens & Matheos, 2012): “Connectivism is the thesis that knowledge is distributed across a network of connections, and therefore that learning consists of the ability to construct and traverse those networks” (Downes, 2012, p. 9). As a development of social constructivism, connectivism seeks to explain the kind of learning that operates in a digitised world in which learners are connected into networks with each other; where they seek information from each other rather than being reliant on established “authorities” in the field; and where they regard themselves as active participants in creating knowledge. This latter is particularly important to doctoral candidates, whose primary purpose is to create new knowledge for their discipline. Connectivism describes the territory that PhD students have always sought to traverse—they have to make new connections, but also need to demonstrate that they understand the “hierarchy” of knowledge in terms of who the authorities are. Connectivism recognises that some of these behaviours occur informally and earlier in learning than in the past because learners in digital environments have access to a vast array of knowledge.

Downes could almost be describing the synthesis of ideas that constitutes a literature review when he claims that:

Knowledge is literally the set of connections between entities [...] Learning is the creation and removal of connections between the entities, or the adjustment of the strengths of those connections. A learning theory is, literally, a theory describing how these connections are created or adjusted. (Downes, 2012, p. 9)

A PhD is precisely a process of making connections between existing ideas in new ways, adding to those ideas, and communicating those ideas so that they become part of the network of connections that other scholars can in turn link into.

In many ways connectivist learning is a comfortable fit for doctoral studies, in which much of the learning occurs through informal pathways outside structured coursework. The research path relies on the individual following self-developed threads in reading and thinking, loosely guided by supervisors in unstructured discussions, sometimes driven in new directions by chance conversations with colleagues and peers in the home university and at conferences, moving from one idea to another while creating new connections between those ideas. This informal (often “hidden”) curriculum (Gilbert, 2009; Green, 2012) of doctoral education sits well alongside the processes of connectivist learning. Indeed, doctoral work is characterised by expectations of candidates’ autonomy and independence as learners, researchers and creators of knowledge—candidates are expected to find their own way through the vast networks of information in their chosen field, to demonstrate their understanding of the connections between items of knowledge that have been forged by other scholars, and to contribute new knowledge to that field.

For those who are already attuned to using the internet and social media to find out about topics of personal interest, it is an obvious step to integrate this approach into their developing researcher identities, both as a way of discovering existing knowledge and also of disseminating new knowledge. For such individuals, the concept of “personal publishing” (Downes, 2012, p. 24) is already very familiar from the “open participatory practices” (Siemens & Matheos, 2012) that characterise the web 2.0 social software that facilitates learning in which participants create their own content about themselves and their world (e.g., Twitter, LinkedIn, Facebook, Google+, Instagram):

The beginning of web 2.0 is arguably the development of blogging software, which allowed people to easily create web content for the first time. But it's also Twitter, which made creating microcontent even easier, and YouTube, which allowed people to publish videos, and MySpace, which did the same for music, and Facebook and Flickr, which did the same for photos. (Downes, 2012, p. 24-25)

Adding one's own ideas and opinions to social media sites, writing blogs about current interests and collaboratively developing wikis are all forms of making one's thinking public. For today's novice researchers, digital publication might not be regarded with the same kind of awe that "publication" invoked in previous generations more focused on print culture. That is, these individuals are often in the habit of contributing to shared understandings and knowledge as part of a network in other areas of their lives, and this fits comfortably with finding ways of contributing to scholarly knowledge and debates as well. Publishing one's research in an academic journal can be regarded as an extension of connectivist learning, albeit a more structured and formal version than is usual for connectivism. Lee and Kamler (2008) strongly recommend that supervisory pedagogies need to encourage an outward-looking stance in doctoral candidates; clearly, publication is one way of actively engaging with scholars beyond one's immediate research group. I would add that publishing their research suits the learning approach of today's doctoral candidates partly because it facilitates their participation as contributors in a connectivist world of learning and knowledge creation, making them more willing—and perhaps more confident—to put their work out into the public domain.

Methods

The research was carried out at a medium-sized research-intensive Australian university. Email recruitment of participants invited responses from doctoral candidates who had chosen to write a thesis by publication according to the university's guidelines for this format. In the case of this particular university, a thesis by publication allows for published papers, submitted papers and/or unsubmitted manuscripts, all of which have been researched and written during candidature (that is, not based on research performed previously as in the retrospective compilation thesis offered by some universities).

Following ethics approval by the Human Research Ethics Committee, three focus groups (each approximately one hour duration) were conducted with a total of 16 participants. A further six candidates, who were keen to participate but were unable to attend at the focus group times, provided written comments guided by the interview questions, bringing the total to 22 participants. Seven were males, while the remaining 15 were female; and seven were international students. A range of age groups were represented from those who had proceeded directly from undergraduate study into research degrees to those who had returned to study towards the end of their working lives. While some were in the early stages of candidature, others were well along the pathway to completion of their degrees, and yet others had successfully graduated in the past 12 months.

Participants were from the following disciplines: Chemical Engineering; Architecture; Medicine; Reproductive Health; Population Health; Psychology; Molecular Biology; Wine Marketing; Evolutionary Genetics; Environmental Studies; Education; History; and Business Management. This diverse range of participant backgrounds provided a

broad array of motivations for and experiences of writing a doctoral thesis by publication.

The focus group discussions were transcribed, and then together with the written responses were subjected to a general inductive analysis (Thomas, 2006). Some broad themes were initially established from the relevant literature, and further recurrent themes were established after repeated close reading and comparison of the transcriptions to cover areas not included in the original framework (Braun & Clarke, 2006). The analysis also includes discussion of data that falls under the category of what McLure (2010, p. 282) describes as data that “glows”; she validates the inclusion of “some detail—a fieldnote fragment or videoimage—[that] starts to glimmer, gathering our attention”. While such data might not be repeated frequently, they add richness and nuance to our understanding of the field. Illustrative examples are quoted for each of the themes and subthemes that emerged from this analysis.

Experiences of writing a thesis by publication

The thesis by publication offers many possibilities for developing a range of research literacies, that is, the skills required to read, understand and produce research in an academic context. All doctoral studies require candidates to develop research literacies in being able to read and understand others’ research methods and findings, to interpret the ways in which this information is presented in written and oral forms, to assess such information critically, and to undertake and write an account of such research in the forms appropriate to the particular context. The thesis by publication adds the literacies required to negotiate the expectations of academic publishing, and a capacity to understand one’s role beyond the immediate research environment to a broader (often global) context of the discipline. The participants in the current study provided comments and examples of both the advantages and significant challenges they faced in undertaking a thesis by publication. Some of their concerns relate to any publication during candidature, such as issues around assigning authorship to published work, while others are specific to the format of thesis by publication, for example, the role of reviewers and their feedback in the final document submitted for examination.

Motivations

The data makes clear that a candidate’s motivations for undertaking a PhD should be taken into consideration when deciding whether a thesis by publication is the appropriate route for a specific project. Publication is not beneficial to all students; for example, publications may be irrelevant to those working on a professional doctorate in order to be promoted in their position in industry or government. For those seeking academic careers, however, the publication route can be very useful. Several participants explained that their choice to write a thesis by publication was a means of fast-tracking their career as academics or researchers: *“I have started a bit late in my career and would like to catch up and get ahead, which means I get a publication and I get a thesis as well”*. Other participants, including experienced researchers pushed into embarking on a PhD to keep their current university job, regarded a thesis by publication as an efficient way to satisfy the reporting requirements of the funding body or their dual responsibilities to the doctorate and their employers:

I need to produce reports and publications so it’s easier to satisfy my reporting requirements via this method. My bosses don’t want to wait 3/4 years for a thesis;

they're much happier with papers.

For those already working as researchers who are obliged to publish their findings, using a specific project as their PhD is a way of adding an extra motivation to their daily work:

It's certainly far more engaging to have my paid work as my PhD; I'm working far harder on the papers than I would've done if I had no personal stake in it.

It is also possible for candidates to feel that they are pushed into this format for the benefit of the supervisor who needs to maintain a good level of publication outputs—a doctoral student's publications with the supervisor named as co-author can be very advantageous to some academics. The participants in this project recognised that, although there might be advantages to others from their work being published, this did not detract from their own interests being served simultaneously. One explained that *"financially it would help the University. I don't know that it was ever an option to do a dissertation instead"*, indicating her understanding that, in the Australian system, funding for universities is linked to publication outputs and track records of successful research. However, the student did not present this as a problem in relation to her own choice of preparing a thesis by publication.

Publication during candidature can provide a positive motivation for candidates who might otherwise lose momentum (Francis et al., 2009). Several participants explained that the endpoints represented by completing articles for publication helped them manage big projects:

I have preferred having deadlines and the direction/focus that each of the three papers has brought.

The feeling of gaining something/satisfaction whilst completing the PhD. It does not feel like you are treading water throughout.

I find "bite sized chunks" of work far easier to deal with than one enormous behemoth. I'll just freeze and panic at the thought of producing one entire book.

It is possible that this could also be an effective method for maintaining motivation for part-time doctoral candidates, whose projects are conducted over extended periods (usually at least six years, often considerably longer), and may well be disrupted for weeks or months at a time when other planned or unplanned work and life commitments take precedence. Organising the work into more discrete sections may make it more straightforward to pick up the research after long breaks.

Time management

Closely related to maintaining momentum is time management. A number of participants regarded a thesis by publication as having considerable advantages in this

respect:

Given that I want my work published in journals anyway, I see this format as less work overall than first compiling a thesis, then having to re-format and re-write great chunks of text to convert thesis chapters into journal articles.

Writing during candidature, less pressure about writing at the end.

Unexpectedly, one participant also explained that by writing journal articles she was able to attract more timely support from her supervisor, given the priority placed on publications in the contemporary university setting:

Others in my lab group have reported 3 month waiting times on thesis chapter drafts, and I cannot afford that sort of delay so ANYTHING that speeds up the process of getting feedback from supervisors is a good thing to exploit!!

However, as the discussion regarding feedback below indicates, the work required to respond to reviewer feedback on articles submitted to journals may sometimes mitigate against these apparent time efficiencies.

Authorship

In terms of developing an understanding of how to successfully negotiate the research environment, experiences of co-authoring provide useful learning opportunities for many doctoral candidates. One participant explained that co-authoring trained her in the skills required to negotiate writing decisions with colleagues:

I did not experience any significant problems in co-authoring the articles. Merely it taught me to be forward in arguing in regards to feedback where one co-author disagreed with amendments that another co-author had made.

Another explained the broader benefits of co-authoring:

I find it's helping me build networks by working more closely with people who have contributed to the work in some way if they also help with feedback for paper submission.

Building these networks or connections with other scholars helps doctoral candidates to develop a confidence in the authority of their own research. Experiences of co-authoring developed a good understanding of the culture of research environments, contributing to the emerging researcher identity of doctoral candidates and aiding an appreciation of the implications of choices made in that environment.

Nevertheless, it is important to recognise that the question of authorship becomes more complicated when papers form part of the thesis by publication (Sharmini et al., 2015; Christianson et al., 2015). Examiners need to be provided with clear information detailing the candidate's own contribution to each paper, and concerns can arise regarding the extent to which the supervisor or co-author has "written" the paper in order to get the material up to a suitable standard for publication. This means that any single-authored sections, such as the literature review or introductory overview of the

field, take on even greater importance in demonstrating the candidate's understanding of the discipline and their project's place within the existing knowledge of the topic.

Quality and integrity of research

There are concerns that the nature of the thesis by publication encourages doctoral candidates to write only short pieces of research, which in turn works against them learning the skills of sustaining an argument across a large project. Indeed, theses in this format are usually significantly shorter than those taking the traditional format (Thune et al., 2012)—but certainly not easier (Niven & Grant, 2012). Counter arguments to the objection that students fail to “think big” while writing a series of articles point out that the coherence of the overall project is absolutely dependent on a single line of argument connecting the different parts of the research. This overarching argument must be directly articulated in the introductory section of the thesis itself, and is sometimes reinforced with short “inter-chapters” between the papers that explain how the separate parts are linked (Dowling & Guerin, 2012). On being asked about this aspect of creating a thesis from a compilation of articles, one participant responded:

I know I'll have to outline the thread of the papers' arguments, and draw them together. I imagine I'll have space to possibly unpack some issues, relationships and assumptions that might underpin the papers. Now I'm thinking about it, maybe a commentary between the papers might be useful as link? I might do that.

In deciding whether the thesis-by-publication route is appropriate for a particular project, it is necessary to acknowledge that some doctoral projects simply don't break up neatly into article-sized “chunks”; trying to force them into this format is detrimental to the integrity of the thesis. In those situations, a traditional format provides a much more effective form for mounting and defending the overall argument of the research project. Further, there is also a concern that the difficulties associated with publishing negative results (that is, results that refute the research hypothesis: Fanelli, 2012; Matosin & Engel, 2014) can skew the kinds of projects undertaken at doctoral level (Kemp et al., 2013).

Reviewers and feedback

Entering into peer-reviewed publication provides the mixed blessing of receiving feedback on doctoral research from experts outside of the supervisory team. In some instances the feedback can reassure candidates that their research meets the standards required of doctoral work. Many see advantages in accessing “*extra reviewers to give draft feedback, professionals in relevant topics*”. There is a general sense that the feedback improves the final product:

When I got some feedback from reviewers, we add a few more details, information. If I didn't send it for the review, if I didn't make a publication, I would never include that particular data in the chapter. So that's an additional advantage I got from that.

I would prefer to have reviewer feedback before that [i.e., examination] though, so it can improve the quality!

In these situations, connection into the research community provides valuable and validating learning.

For others, however, negative feedback from reviewers can be deeply discouraging, adding further to the cacophony of voices already advising on doctoral writing (Aitchison, 2014; Guerin & Green, 2013):

There are reviewers and there are reviewers. [...] Some do really help you, picking out a lot of mistakes that are there that you overlook, and also some of the reviewers tend to be a bit too narrowly focused, and there are many reviewers that may be very specialised, too specialised in their field [...] send one paper to 10 different reviewers and they give 10 different things.

Importantly, the process of receiving feedback from anonymous reviewers can often be quite confronting at first, particularly when the response is negative, critical or not presented constructively, and both supervisors and candidates should consider this in advance of sending out material for review: “*Multiple rejections can be difficult to take, as can harsh feedback*”. Candidates who are unprepared for such a response might find the experience very damaging, losing confidence in their own abilities and the project, possibly even withdrawing from the programme altogether.

Other participants described the frustrations of managing reviewer feedback in terms of the sequencing of their own thinking about the research. While the feedback might be useful in improving the quality of the final product, delays in receiving that feedback can mean returning to elements of the research that had been regarded as finished:

Completing a PhD by publication has been an interesting and at times, a stressful experience. Trying to get an article published whilst continuing on with other work can be difficult when journals return your article a year later with a rejection [...] Furthermore, it can be time consuming having to revise the journal article each time. Having to pause other work to give attention to the revision can be frustrating.

Another participant described this situation as playing “whack-a-mole”—a computer game in which one repeatedly smacks down a mole that keeps popping up all over the screen. This powerful image of the returning irritant is a reminder that publication is rarely a smooth process, and that it can be a time-consuming and potentially distracting aspect of doctoral candidature.

Academic publication practices

Despite these concerns, novice scholars can learn valuable lessons about how the academic publishing industry operates if they choose to write a thesis by publication (Dowling & Guerin, 2012; Robins & Kanowski, 2008). Important research literacies are developed through preparing a written account of research that is acceptable to the disciplinary community (as represented by journal editors and reviewers). Of course, such literacies can be learnt through publishing alongside the traditional thesis (see,

for example, the chapters in this book written by Ferreira, Habibie, Maher & Say, and Smirnova) and also by participating in the editing and organisation of an academic journal (Hopwood, 2010; Thomson et al., 2010).

Publishing parts of the thesis provides opportunities to experience first hand the whole process of academic publishing from targeting an appropriate journal; identifying predatory journals; understanding the journal's aims and scope; considering its ranking and the implications that has for the likelihood of being accepted, and if so, the time to actual publication; preparing a paper according to the author guidelines; negotiating submission procedures; and proofreading and editing a final document. For those engaged in publishing book chapters, equally complex research literacies are involved, possibly including the initial approach to publishers through a book proposal; consideration of the potential audience for the book and subsequent marketing; corresponding with editors and meeting their deadlines; and presenting the research to ensure alignment with the book's focus (which may be slightly tangential to that of the thesis).

A number of the participants in this study indicated that their experience had helped them understand the processes they were expected to engage in when publishing:

[Consider target journals] preferably early on—choose 2 journals, format for the first (US/UK English, headings, lengths specified).

I've published once before and now know how long the process can take, mostly out of your own control.

You have experienced publishing and are aware of the downfalls and difficulties that can be faced.

Engaging in the process of peer review is also an important learning opportunity, as described in the previous section: understanding how to respond appropriately to reviewer comments, to rewrite in light of that feedback or make a case for not following the advice, and how to communicate those changes to editors and reviewers, are necessary skills for those intending to embark on academic and research careers.

Examination

Many of the participants in this project believed that they would be at an advantage when it came to the final examination of their thesis if it contained papers that had already been published in high-ranking, peer-reviewed journals. In their words:

When you have some publications, then it would be easy for you to impress the examiner, the thesis examiners, and then they know that someone has already reviewed that new work.

The advantage, however, is that on completing the thesis, little argument can be given

in regards to the markers in relation to the material being submitted.

Articles are peer reviewed, and so gives you an idea of how your thesis will be viewed.

That their research is already in the public domain, that it is now perceived by peers as contributing to the knowledge that others in the extended disciplinary network can now draw upon, is expected to have a positive influence on examiners' impressions of their research.

A cautionary note should be sounded here, however. One participant warned:

Some of the examiners, they are against publication [...] they say it's too simple [...] So just mindful if you are submitting a thesis, sometimes the examiner, they are just used to the traditional format. [Make sure] they at least know something about it.

This is particularly important for those attempting to write a thesis by publication in areas of Humanities and Social Sciences where examiners may be less familiar with this format than those working in Sciences (Thune et al., 2012), or from countries where the format has only recently started to gain popularity. In these situations, candidates are advised to be very explicit in the Introduction about the ways in which their research meets the examination criteria.

Employment options

Participants were unanimous in their belief that a publication record would improve their chances of gaining employment as researchers in their chosen field on graduation. They were also aware that it is important which journals they publish in, adding to their understanding of how the academic research world operates:

I think having some publications during your PhD candidature is fantastic. It helps to build a competitive CV when applying for post-PhD positions.

Having published papers would surely improve employment prospects. Being accepted by well-regarded journals in particular provides external validation that one's work is sound and significant.

Publications are still the measure of a scientist's value (despite everyone agreeing that this is an imperfect system) so if I finish my PhD without publications then I think I'd be pretty much unemployable in this sector.

It allows the candidates' name to be recognised prior to the completion of their PhD, which may be useful in looking for work after completion.

Clearly, for anyone wishing to work as an academic or a researcher on completion of

their PhD, publications are regarded as a necessary component on their resumé (at least by this group). As we have seen above, the thesis by publication is one way of achieving this, but there are mixed opinions about whether or not this is a time-efficient way of producing those publications.

Researcher identity and connection

As well as demonstrating how a thesis by publication can be an effective means to gain employment in academia and the research world, participants also indicated that their publications contributed to their sense of themselves as scholars and researchers:

My personal view is that publishing peer-reviewed scientific papers is what has made me a scientist. I see the thesis itself as a formal/bureaucratic requirement and burden. My papers are my contribution to scientific knowledge, whereas I barely see anyone ever reading my thesis (aside from my supervisors and examiners). I acknowledge this view may be outdated (or soon to be outdated), as electronic publishing of theses will greatly increase their accessibility to other scientists.

Thesis by publication seems like the natural choice because as a scientist my work is designed to be published anyway (and it's required by our funding partners) so doing a thesis in the traditional format would just be a duplication of effort, not to mention the fact that if my research isn't good enough for peer reviewed publication then I wouldn't consider it worthy of a PhD!

A number of the participants made it clear that publication is simply what researchers do. Dissemination of their newly created knowledge is central to their conception of the purpose of research and of the PhD itself. As Lee (2010, p. 18) puts it, “the PhD by publication arguably has the concept of addressivity [i.e., the quality of directing an utterance to someone] hard-wired into its structure and *raison d'être*”. These novice researchers see themselves participating in what could be described as a virtuous circle: they publish their findings because they are researchers in the discipline; they are *bona fide* members of the discipline because they publish in their field. Publication provides them with legitimising connections into their disciplinary communities as they take up the role of knowledge creators:

Publishing this way has allowed me to get interesting experimental results both into my thesis and out to other scientists.

Strategic publication is regarded as beneficial both to themselves and to the advancement of the discipline:

Producing papers during a PhD rather than afterward allows results to get out into the literature earlier, increasing the pace of scientific progress. It also reduces the probability of someone else publishing similar results before me, greatly hindering subsequent publication prospects.

I do think it's important to publish, it's the best way to get the research out there for other scientists to build on so that we can manage [the problem]. My research alone won't help, it's just a small part of the bigger picture of saving our environment. Publishing in other formats for the general public is important too, since our research is nothing if not supported by the masses, although that is a less "academic" pursuit and so arguably less relevant to a thesis.

This last quotation introduces the idea that these researchers seek connections not only with the formal research community, but also with the wider general public. It would seem, then, that the priority placed on publication by the thesis-by-publication format, on contributing to the discussions in one's discipline and beyond, can encourage a more outward-looking stance in novice researchers, promoting a sense of connection with and contribution to knowledge in the discipline. Although participants do not use the language of connectivism directly, the seeds of this style of learning and communicating are evident in their conceptions of how they go about their research.

Conclusion

Do doctoral candidates appear to be connecting the dots between their own learning in a digital world in which they form connections between knowledge "entities" (Downes, 2012) and their own capacity as knowledge creators publishing their research? Is this an added reason why they are increasingly taking up the option of writing a thesis by publication? Does learning that is characterised by access to digital networks mean that today's doctoral candidates are more attuned to publishing than their predecessors were? Or is the rise of the thesis by publication simply a response to the audit culture that demands countable research outputs? While it is much too soon to establish causal connections for the increase in this thesis format, especially with such a small and disparate group of participants, connectivism does at least provide us with some different kinds of insights into the developing research literacies of doctoral students. In particular, this theory focuses our attention on students' experiences of connecting bodies of information in new ways, of creating new networks of ideas, and of contributing new knowledge to their disciplines; as such, publishing the results of doctoral research right from the beginning seems an obvious step to many of today's students.

This participation in public knowledge creation in turn contributes to these doctoral candidates' sense of having a scholarly researcher identity. Part of becoming a scholar or researcher is learning to enact that identity: what we know and what we do are central to our sense of identity (Baker & Lattuca, 2010; Guerin, 2013). This includes the expectations of participating in the conversations and debates within disciplines in virtual forums as well as in person through conferences and seminars. These beliefs and behaviours are consistent with the rhizomatic researcher identities I have described elsewhere (Guerin, 2013), in which researchers are characterised by the traits of flexibility, multiplicity, collegiality, and connection; and they work in heterogeneous, non-hierarchical, networked rhizomatic research cultures. It would seem that the thesis by publication facilitates doctoral candidates' sense of themselves as legitimate researchers who are capable of positioning themselves as active, creative nodes in the network of knowledge in their fields, of seeing themselves as dynamic participants in knowledge creation.

By better understanding what doctoral candidates can learn, and what strategic advantages they can gain, from the format of a thesis by publication, both supervisors and doctoral candidates are better placed to make decisions about what is most useful to the individual student. This must surely help to keep the PhD relevant in the ever-changing contemporary knowledge landscape.

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