

Navigating power in doctoral publishing: A data feminist approach

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Navigating power in doctoral publishing: A data feminist approach

The prevalence of publication pedagogy in doctoral education has created a hybrid space in which doctoral work is done. The emphasis on knowledge production is increasingly making doctoral students the subject of research performance and productivity measures, creating a borderland which they must cross in order to achieve academic success. Navigation requires critical engagement with power in knowledge production and assumptions about the neutrality of practices in doctoral publishing. To aid in this crossing the paper demonstrates the use of bibliometric techniques for mapping the social and political landscape, using 1216 publications by research masters and doctoral students at the University of Tasmania from 2007 to 2015. A data feminist approach is followed to critically examine power made visible by borderland maps, discuss issues of equity in knowledge production and to engage with bibliometric data.

Keywords: publishing; pedagogy; borderlands; visibility; feminism

Introduction

Today publications are an expectation if not a requirement for completing a PhD, or a thesis by or with publication, which is becoming the norm in many countries and disciplines (Jackson 2013). Recognition of publication-focused doctoral education and the increasing expectation that doctoral students will produce peer-reviewed publications has led to the emergence of publication pedagogy (Aitchison, Kamler, and Lee 2010; Niven and Grant 2012). In this context publication pedagogy seeks to improve the publishing of doctoral research and address the often sporadic and ad hoc approaches to the pedagogical work of writing and publishing at institutions which are now expected to produce ‘published’ graduates (Lee and Kamler 2008). The emphasis which publication pedagogy places on knowledge production in doctoral education has created a hybrid space in which doctoral work is now done. Doctoral students are expected to be both student and academic, they must learn to write and produce research

publications. Even when undertaking a traditional thesis, doctoral students are increasingly subject to expectations and measures of assessment informed by the culture of research performance and productivity which they must also learn in order to be a competitive and successful academic (Horta and Santos 2016).

Performance management systems that evaluate research quality and impact are prevalent in the Australian higher education system, they ‘have “colonized” vast segments of academia and increasingly regulate the conduct of research’ (Martin-Sardesai et al. 2019, 54). At the same time, the data which underpins them may be disconnected from the research reality where it arose (Paul-Hus et al. 2017). Since research ‘is marked by inequality, random chance, anomalies, the right to make mistakes, unpredictability and a high significance of extreme events’ (Bornmann 2017, 776) the disconnect between performance management systems and reality leads to systemic problems, creating contradictory or even perverse incentives and outcomes (Bornmann 2017). These systems have also come to shape academic writing and knowledge production practices in contradictory ways, affecting priorities and choices (McCulloch 2017).

In this context the practices of knowledge production learned by doctoral students are not neutral; decisions about whom to cite, include or acknowledge when writing for publication are inherently political and social (Mott and Cockayne 2017; Kamler 2008). Over time these practices can lead to inequities in academic reward and communication systems that reinforce privilege and oppression, particularly if they become codified and reproduced in measures of academic performance and productivity (Bornmann et al. 2019).

The strategic importance of citation and co-authorship is acknowledged by publishing

pedagogy, yet issues associated with practice have received limited attention in the pedagogical literature. Responsible research practice and research quality are now the subject of a growing international discourse in the research community and are also becoming the focus of performance management systems. In 2019 the National Health and Medical Research Council (NHMRC) in Australia conducted a survey of research practices to aid the development of a research quality strategy. The survey asked researchers about their perceptions of certain knowledge production practices including selective citation and the inappropriate adding or omitting of authors or contributors from publications. Survey results showed that researchers were aware of practices such as selective citation and inappropriately adding or omitting an author or contributor from a publication with some even admitting having done some themselves. The report concluded that training and mentorship about responsible research practices, especially of junior researchers such as doctoral students, was important to ensuring a positive research culture (NHMRC 2020).

Publishing pedagogy needs to make room for doctoral students, supervisors and those who support them to engage conscientiously with knowledge production practices and offer them ways to engage critically with the issues that arise. The aim of this paper is to offer a perspective and approach for engaging with these practices, for thinking about the social and political context which surrounds them and to promote equity in knowledge production. To achieve this the paper draws on feminist thought to reflect critically on a bibliometric analysis of 1216 publications co-authored by 779 research students (masters by course work and doctoral students) at the University of Tasmania between 2007 – 2015. The analysis applies bibliometric techniques to understanding the productivity of co-authors, and visualisations of co-authorship networks to make visible the relationships among them.

The borderlands theory of Gloria Anzaldua (2012) is used to imagine the space in which this doctoral work is done. Doctoral students, their supervisors and those who support them reside in the borderland, a contradictory, intersectional and hybrid space which they must cross on the journey to academic success. Conceptualising doctoral education as a borderland makes it possible to create visualisations from bibliometric data that map the contours of this social and political landscape, revealing the relationships among the borderland residents. The intersectional data feminism of Catherine D'Ignazio and Lauren Klein (2020) provides a lens for reading these borderland maps, allowing the examination of power, and providing a shared language for discussing and challenging it.

The borderland of doctoral publishing

Borderlands theory provides a means of imagining the hybrid space in which doctoral work is done and a lens to both understand and theorise about the experiences of those individuals or groups who reside in the borderland. It is a space where a plurality of dimensions, identities, sources of oppression and resistance intersect and are possible (Anzaldua 2012). Those who reside in the borderland of doctoral publishing have a shared identity, they are both student and academic, producers of knowledge and its subject. The concept of a borderland provides a metaphor for visualising this landscape and navigating its social and political context. The institution, its departments, disciplines and faculty demark a borderland subject to ambiguity and contradiction. These spaces provide the context in which doctoral students, and other borderland residents, experience formal and informal doctoral pedagogies (McAlpine and Amundsen 2012). In this space the boundaries between the institution and performance management systems blur creating a hybrid space that is delineated by metrics and measures of performance and productivity such as publication, citation and

co-authorship. On one side are the published, the cited and the co-authors; on the other are those seeking to join them. Doctoral publishing is increasingly a borderland which doctoral students must navigate and cross in order to achieve this academic success.

This is a well-trodden landscape and many scholars have charted its facets and features. On their crossing residents may encounter valleys of criticism, hostile residents (Sanscartier and Johnston 2019) and foreign cultures (Elliot and Kobayashi 2019), get lost in fogs of theory, discover mountain-top vistas of insight and energy, fall into pits of prevarication or off cliffs of despair (Bartlett and Mercer 2000). Less well charted are the landscape's social and political dimensions. Doctoral students and those who support them reside in the borderland, but the only legitimate residents are those in power, individuals or groups such as supervisors who have obtained structural advantage through the accumulation of prestigious resources such as publications, citations and co-authors.

Publishing practices

The number of citations that a publication receives is often used as a proxy for measuring its importance, so the practice of citing another's work can affect how certain groups are represented and included or excluded from a scholarly community. Choices of who to cite - and who is left out - affect the reproduction of knowledge, citing too narrowly, citing only certain groups, forming citation cartels or only citing established scholars can lead to uneven reproduction and unethical hierarchies (Mott and Cockayne 2017). These citation practices can lead to pervasive imbalances in gender, race, socioeconomic status and prestige (Dworkin et al. 2020; Zeng et al. 2016). Over time practices can result in homophily among residents that intrench the hegemonic position of some groups over others (Celis and Kim 2018).

The practice of co-authorship has similar implications, it is often used as a proxy for collaboration and choosing who to include as a co-author and in what order they are listed on a publication is implicated in the production of knowledge and systems of academic reward and recognition. Co-authoring with prestigious researchers (e.g. those who are ‘top cited’) can improve a junior researcher’s chances of publishing in prestigious journals (Sekara et al. 2018), give them a long-term competitive advantage (Li et al. 2019) and improve their chances of success at an academic career (Qi et al. 2017). Thus, working with an outstanding supervisor and socialising with other prestigious borderland residents is essential to doctoral students’ borderland crossing and their future career (Sweitzer 2009; Heffernan 2020).

Competition for social and political advantage, in the form of prestige, through the accumulation of publications, citations and co-authors can be fierce in the borderland with long-term consequences for everyone involved. The Matthew and Matilda effects offer examples of how practices in knowledge production can lead to the reification of, or resistance to, power and oppression among residents. The ‘Matthew Effect’ is a term coined by Merton (1968) that describes a situation where academics of higher status gain disproportionate recognition for their contribution, and where this misallocation of credit leads to the withholding (suppression) of recognition from academics who are less well known. Merton described how the phenomena affects researchers’ careers - by creating inequities in the reward and communication systems of ‘science’ that in turn, lead to the accumulation of talent and resources by prestigious individuals or institutions.

While the Matthew Effect leads to oppression, the ‘Matilda Effect’ offers resistance. It is a term introduced by Margaret Rossiter (1993) to give visibility to women who are often the victims of misallocated credit, a lack of acknowledgment or outright exclusion

resulting from the Matthew Effect. The Matilda Effect describes resistance to oppression by making labour visible (Rossiter 1993). The Matthew Effect is known to be present in systems of academic reward and recognition. As these performance management systems have become more prevalent it is even more important to hold them to account by critically engaging with, examining and questioning their social and political dimensions (Paul-Hus et al. 2017).

Data feminism

The intersectional Data Feminism of D’Ignazio and Klein (2020) provides strategies for thinking about and examining power and oppression in knowledge production. Data feminism ‘seeks to understand how practices of data science [such as bibliometrics] reinforce inequalities and to challenge and change distributions of power’ (D’Ignazio and Klein 2020, 8). In this context data refers to information that is systematically collected, organised and analysed such as numbers, words, stories, or publications and science refers to the systematic methods of observation and experiment (D’Ignazio and Klein 2020).

A data feminist approach is underpinned by seven principles, these are to examine power, challenge power, elevate emotion and embodiment, rethink binaries and hierarchies, embrace pluralism, consider context, and to make labour visible. Data feminism considers power to be ‘the current configuration of structural privilege and structural oppression, in which some groups experience unearned advantage—because various systems have been designed by people like them and work for people like them—and other groups experience systematic disadvantage—because those same systems were not designed by them or with people like them in mind’ (D’Ignazio and Klein 2020, 24).

This paper focuses on the first two principles of data feminism, to examine and challenge power, by naming and explaining sources of privilege and oppression in doctoral publishing that are taken-for-granted or ‘baked in’ to publishing pedagogy. In knowledge production, those in power are the prestigious individuals or groups that have achieved social and political advantage through the accumulation of resources such as publications, citations and co-authors as described by the Matthew Effect. Data is power too, and having it benefits those in power. The goals that drive the collection, storage, and analysis of bibliometric data for extractive systems of performance management are not neutral, and they often do not promote equity among borderland residents.

Making maps for navigation

Supervisors have walked the borderland before, they carry a map of the terrain and possess the knowledge and tools to navigate it. Doctoral students reside in the borderland only temporarily as they make their crossing, without direction and tools such as a compass or map these transients will likely struggle to find safe passage. The metaphor of a borderland lends itself to a visual cartographic representation which can reveal the social relationships between authors and the politics of their practices.

Visualisations of citation and co-authorship patterns drawn from research publications provide a means of exploring historical patterns of co-author relationships and publishing practices. These maps ‘act as traveling aids in the scholarly territory’ (Zuccala 2006, 11), allowing the investigation of past and present relationships, the dominance of key scholars and structures of power in an institution or scholarly community (Zuccala 2006; Walker and Boamah 2019). Such visualising methodologies are often used in the ‘objective’ evaluation of academic impact and performance (Majeti

et al. 2020). Yet, they can equally be used to promote equity and challenge power by giving visibility to inequity in knowledge production through ‘uncovering, revaluing, acknowledging, and making the “unseen” seen’ (Walker and Boamah 2019, 40).

To illustrate the use of visualisation for mapping the borderland of doctoral publishing and making power in knowledge production visible, the results of a bibliometric and co-authorship network analysis of 1216 research publications by research masters and doctoral students (research students) at the University of Tasmania from 2007 to 2015 are presented. The analysis that follows expands on the original research, offering a practical guide which doctoral students and their supervisors can follow in order to map the borderland of doctoral publishing in their institution or scholarly community. The borderland maps which emerge provide a means of examining power.

Data provenance

The University of Tasmania provided information about research publications co-authored by research students enrolled at the university between 2007 and 2015. This information was used to create a sample of publication metadata records retrieved from the Scopus abstract and citation database by Elsevier. At the time the Scopus database was chosen for its ease of access, the format in which search results could be exported and its support for complex queries through the web interface. The search query TITLE (“article title”) was used to match publications in the Scopus database with those listed in the dataset. Publication titles with three words or less were excluded from the search, else many related publications were also retrieved by the search. The search results were then cross referenced with the University of Tasmania data to confirm search matches. Titles and co-authors were compared using a bigram algorithm (an n-gram of 2) and matches with greater than 85% similarity were retained. In some cases,

publication titles and co-authors did not match exactly, for example, where a surname had changed since a publication had been published, these were highlighted for further inspection. It is worth noting that co-authors who change their names, such as those who marry during candidature or after, made it difficult to track and match some co-author names on associated publications. Some research students were also working for the University of Tasmania which further blurred the distinction between research student and academic work. This process returned a sample of 1216 publications published by research students between 2007 – 2015 (Table 1). The sample contained 3024 unique co-authors, of whom 779 were research students and 2245 were non-students (supervisors or other collaborators).

Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
#	2	181	158	144	178	183	193	157	20

Table 1: The number of publications for each year. Publications were identified with assistance from the University of Tasmania and metadata was retrieved from the Scopus database for analysis.

Describing co-authorship and productivity

Productivity, the number of publications that an individual co-authors, is a sign of prestige and a core measure of academic performance. Figure 1 shows the distribution of co-authorship, most of the 3024 co-authors in the sample of 1216 publications co-authored with 3 others or on average 17 and a median of 6 (Table 2). In comparison research students co-authored with an average of 6 and a median of 4 (Table 3). The reason for this variation is likely that some publications had a significant number of co-authors (in some cases greater than 100) which creates a skewed distribution, and therefore the median value is more reliable than the average when comparing the distribution of co-authors. Figure 2 shows the proportion of co-authors

that were listed on a publication classified with a certain Field of Research (FOR) code. Field of Research codes are part of the Australian and New Zealand Standard Research Classification (ANZSRC) framework, there are 22 two-digit codes in the 2008 version which reflect major fields from Mathematics (FOR 1) to Philosophy and Religious Studies (FOR 22) (Australian Bureau of Statistics 2008). The most prevalent codes are the Biological Sciences (FOR 6) and Medical and Health Sciences (FOR 11) but the dataset contains publications from all of the 22 disciplines.

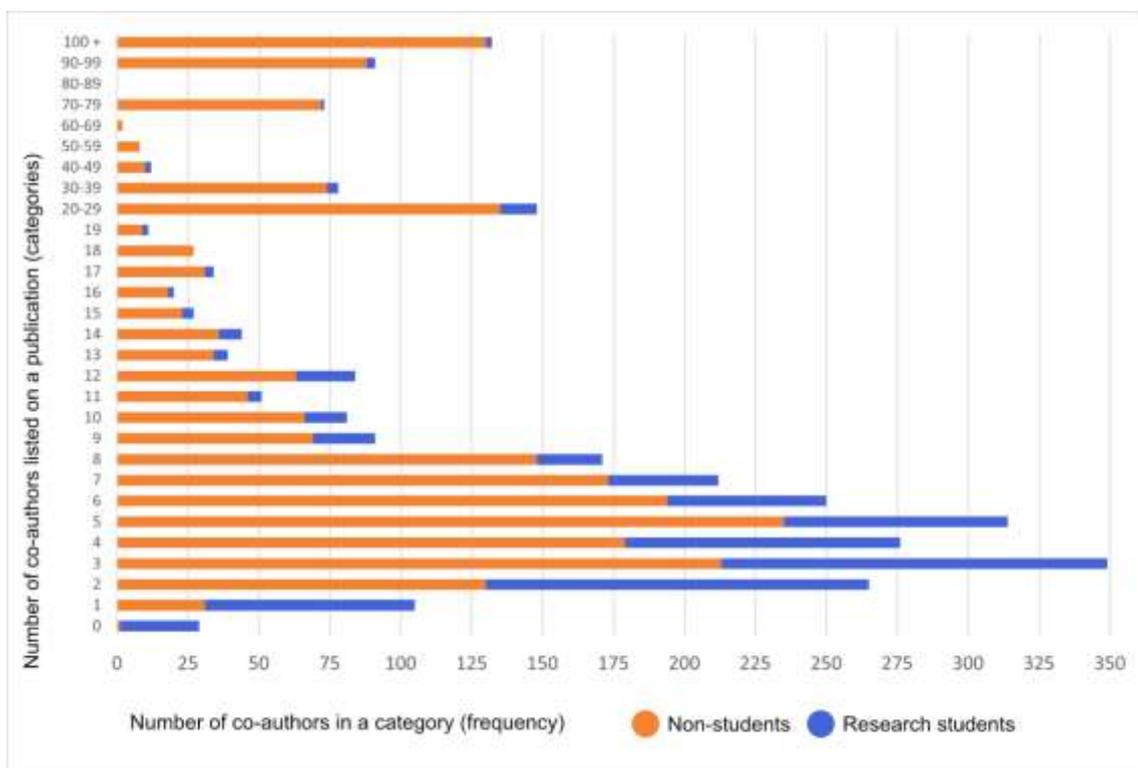


Figure 1: Shows the frequency with which the 3024 co-authors published with a certain number of other co-authors.

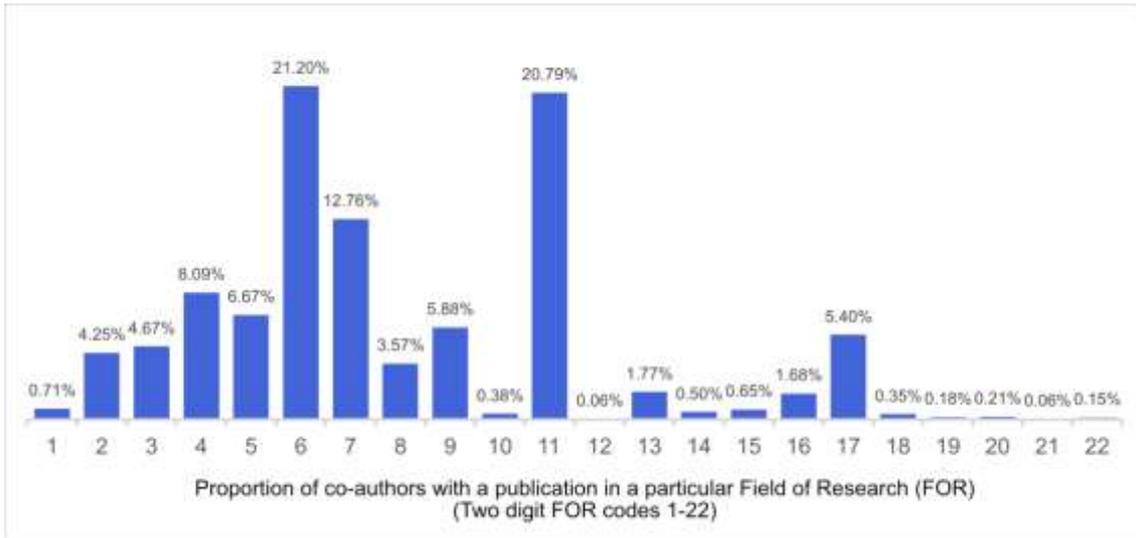


Figure 2: Shows the proportion of co-authors that were listed on a publication classified with a certain two-digit Field of Research (FOR) code (codes 1 to 22).

Non-students	Mean	Median	Max	Min	Mode	StdDev
Years published	1.46	1	8	1	1	1.01
Publications	1.91	1	35	1	1	2.35
First Authored	0.41	0	13	0	0	0.82
Co-authors	17.47	6	136	0	3	30.31

Table 2: Measures of central tendency for co-authorship characteristics for all co-authors.

Research students	Mean	Median	Max	Min	Mode	StdDev
Years published	1.44	1	6	0	1	0.79
Publications	1.77	1	17	1	1	1.42
First Authored	1.07	1	13	0	1	1.14
Co-authors	5.76	4	133	0	3	10.09

Table 3: Measures of central tendency for co-authorship characteristics of research students only.

The frequency with which a co-author appears on publications over time provides further insight into their productivity and the growth of an academic's co-author network (Price and Gürsey 1975). In a timeseries dataset co-authors can be categorised

by the frequency that they publish (appear on a publication) prior to and after a given year. In Figure 3 a framework by Braun et al. (2001) was used to classify co-authors publishing in a given year into the following four categories:

- Transients – those co-authors publishing in the given year but neither before nor after;
- Newcomers (New) – those co-authors publishing in and after the given year but not before;
- Terminators – those co-authors publishing before and in the given year but not after;
- Continuants (Continuing) – those co-authors publishing before, in and after the given year.

Additionally, the category of ‘Break’ was added to capture those co-authors taking a break in a given year. The framework needs at least three years of publication data to make accurate classifications based on year to year publishing patterns, due to the small number of publications in 2007 and 2015 the years 2008 to 2014 were selected for this analysis. The middle year (2011) is considered the most reliable with the first (2008) and last year (2014) being the least reliable (Braun, Glänzel, and Schubert 2001, 503).

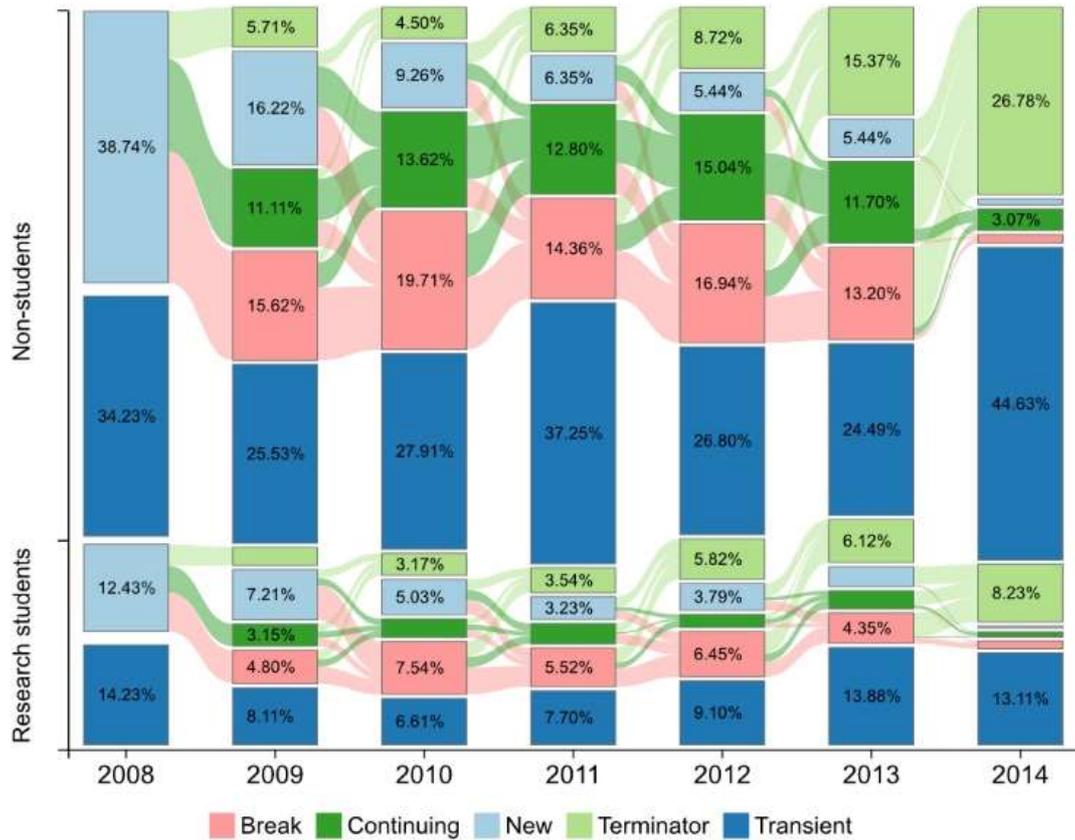


Figure 3 An alluvial diagram showing the movement of co-authors between authorship categories from 2008 to 2014, the categories are new, continuing, those on break, transient and terminating co-authors. Proportions smaller than 3% are not shown.

Years appearing	1	2	3	4	5	6	7
Research students	529	162	54	18	1	1	0
Non-students	1653	276	120	68	36	22	10

Table 4: A frequency table of the number of years that research student and non-student co-author appear on publications.

Figure 3 shows that most co-authors (74%) published in only a single year, some (15%) published in two and a handful (11%) go on to publish in three or more years. Between 2008 – 2014 the number of co-authors who stopped publishing (exited) each year was on average relatively low (18%) compared to the average number of transient co-

authors (49%), for research students the average number exiting each year was 22% and the average number of transient co-authors was 47%. Around a third of all co-authors establish and maintain a pattern of continuous co-authorship over multiple years, the proportion of continuant co-authors each year was on average 32% or 30% for research student co-authors, but most (57%) of these continuants published in only 2 years. Table 4 shows the number of years that co-authors published in, while most publish in a single year some co-authors, including research students, appear on publications in nearly every year.

Visualising co-authorship networks

A cartographic approach was followed to map the borderland of doctoral publishing at the University of Tasmania (Guimera and Amarla 2005). A co-authorship network graph was created from information contained on each publication's metadata record. The network graph consists of co-authors represented as nodes, and the relationships between them represented as edges. A relationship is inferred when two co-authors are listed on a publication together (referred to as co-occurrence). Edges are weighted based on the number of times that two co-authors appear on different papers together. The weight of an edge is used to determine its thickness in the diagrams presented in this paper. The number of edges (relationships) between a co-author and other co-authors is commonly referred to as their degree, links, or connections.

The Gephi software package (version 0.9.2) was used for the presentation and analysis of co-author networks (Bastian, Heymann, and Jacomy 2009). Lists of nodes and edges were generated by scripts written in R programming language and formatted following the Gephi graph file format. A name disambiguation algorithm was used to resolve co-author attribution in cases where co-authors had the same or similar names in the

creation of the node and edge lists (Milojević 2013). The structure of author names on publications is a critical issue for this kind of analysis, and one that anyone wishing to create these kinds of maps should be mindful of: differences in name formatting conventions mean that co-author names are hard to accurately match using automated means. For example, Jones E. can also be Jones EL, Jones E.L. or Elise JL, Elise LJ etc. depending on the source and which publication was referenced.

The dataset of 1216 publications produced a co-author network graph with 26416 edges between the 3024 co-authors. The network's giant component, the largest group of connected co-authors, contained 83% of all co-authors, which included 640 research students and 1880 non-students with 23021 edges between them (Figure 4). The analysis presented here focuses on the network's giant component. The R statistical software package and the 'igraph' package for complex network research were used to analyse the giant components global properties (R Core Team 2016; Csardi and Tamas 2006). The giant component had an average clustering coefficient of 0.87 and a graph density of 0.007, the average clustering coefficient indicates the degree to which nodes in a graph create densely connected groups, and the graph density shows the extent to which a network is connected. The high clustering coefficient and low density indicate that the network consists of many tightly knit but dispersed groups of co-authors.

Between these global network properties and the characteristics of individual co-authors sit the groups (or teams) of co-authors. Looking at the interconnectivity within groups of co-authors and the connectivity between them can reveal important structural and functional distinctions on networks (Velden, Haque, and Lagoze 2010).

To conduct an analysis of these groups and understand the role of co-authors on the network an information-theoretic clustering algorithm was used to organise the giant

component into clusters – groups of closely interconnected co-authors. The clustering algorithm returned 162 groups of co-authors (Rosvall and Bergstrom 2007). The nature of the clusters that are identified depends on the clustering algorithm used, the information-theoretic algorithm was chosen because it is able to identify clusters that approximate functional research teams (Fortunato and Castellano 2012; Velden, Haque, and Lagoze 2010). Co-authors were then categorised into a series of seven universal roles (Table 5Table 5). This was done by comparing the number of edges between a co-author and other co-authors in the group (in-degree) using a z-score (z) and the distribution of a co-author's edges to co-authors in other groups (out-degree) using a participation coefficient (P) (Guimera, Sales-Pardo, and Amaral 2007). Results of role assignment show that research students primarily occupy bonding (homophilic) non-hub roles (roles R1 to R3) within groups while non-students tend to occupy the hub roles which connect groups across the network (roles R5 and R6). Roles R4 and R7 are kinless: these co-authors possess a significant number of connections both within and between multiple groups but do not belong to any of them. On the network, bonding roles act as the local organisers while hub roles act as the bridges, brokers, and gatekeepers to other groups on the network. Results of the clustering and role assignment confirm a dispersed network of many tightly knit groups with sparse connections between them.

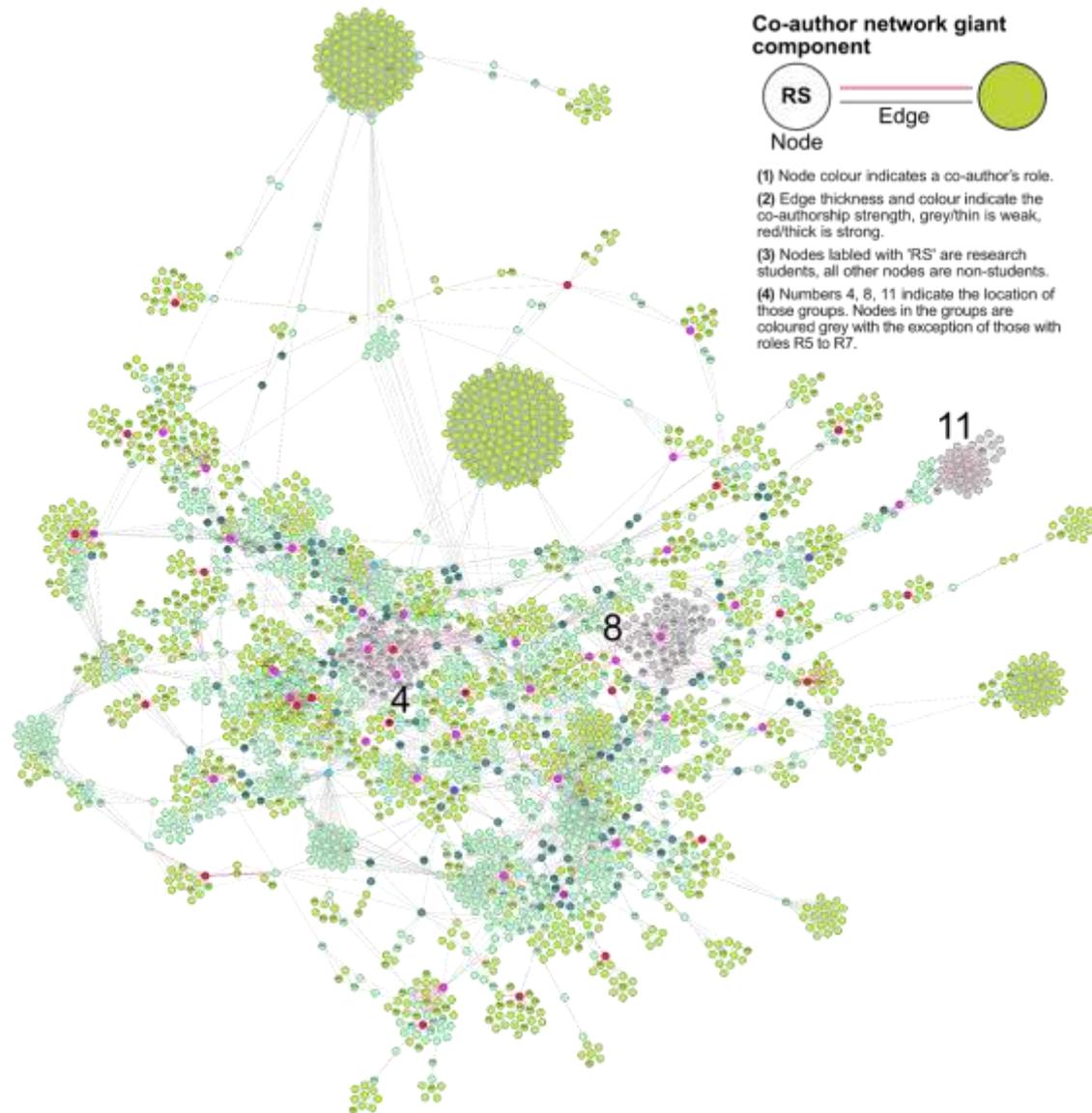


Figure 4: Co-author network diagram of the giant component where nodes are co-authors and edges the frequency of co-authorship between them. Groups 4, 8 and 11 are highlighted. The node colour indicates its role (See Table 5), the node label ‘RS’ indicates a research student. Edge colour indicates the strength of the relationship between co-authors based on the frequency of co-authorship, grey is weak and red strong. The Force Atlas 2 Continuous Graph Layout Algorithm in Gephi was used to organise the layout of the network graph (Jacomy et al. 2014).

Role	Role name	z-score thresholds	Coefficient P thresholds	Research student co-authors	All other co-authors
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R1	Ultra-peripheral	$z < 2.5$	$P \leq 0.05$	353	1075
R2	Peripheral		$0.05 < P \leq 0.62$	248	684
R3	Satellite Connector		$0.62 < P \leq 0.8$	35	66
R4	Kinless		$P > 0.8$	0	2
R5	Provincial hub	$z \geq 2.5$	$P \leq 0.3$	2	20
R6	Connector hub		$0.3 < P \leq 0.75$	2	31
R7	Global hub		$P > 0.75$	0	2

Table 5: The frequency of universal roles R1 to R7 calculated for the co-author network's giant component, with z-score and Coefficient P thresholds shown (Guimera, Sales-Pardo, and Amaral 2007, 6).

The presence or absence of roles within groups of co-authors indicates different styles of collaboration, while the presence or absence of a hub role indicates how well a group is connected to other groups on the network. Figure 5 presents three groups highlighted in Figure 4 which show different styles of collaboration among co-authors. Group 4 is characterised by multiple hubs working together, Group 8 is ego centric with a single dominant hub and in Group 11 there is no hub—co-authors work closely together with a single research student. Both Group 4 and Group 8 have a high ratio of research students to non-students and all groups have co-authors that continue to publish over multiple years. Figure 5 presents a series of three network diagrams for each group. The first series presents the co-author roles, clearly showing that Group 4 and 8 are centred around the hub nodes while Group 11 is evenly distributed. The second series shows co-author continuance and transience, showing that many research students are transient, and that continuants work closely together forming the core of each group. The third series shows co-author publication frequency and group disciplinarity using Field of Research (FOR) codes. It shows that continuants and those co-authors in hub roles co-

author the most publications in Groups 4 and 8. Group 11 is again an exception where publications are reasonably well distributed. Table 6 shows key characteristics for the groups, it highlights that Group 4 and 8 have a high ratio of research students to non-students while Group 11 only has two research students and a small number of transients.

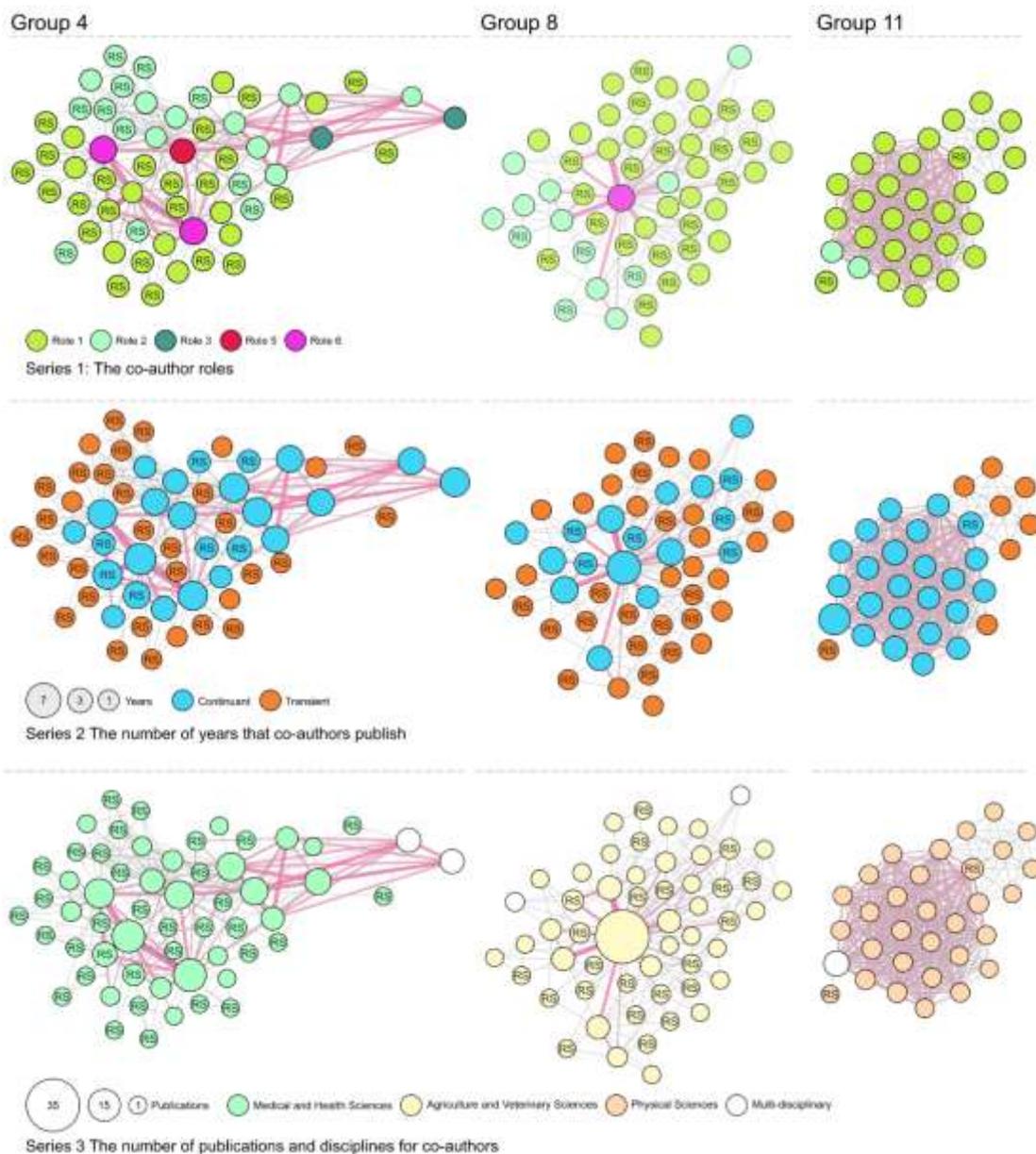


Figure 5: Shows three groups, 4, 8 and 11. Each series visualises different characteristics, series one shows co-author roles, series two shows the number of years that a co-author publishes, and series three shows the number of publications for a co-author and their Field of Research (discipline).

Group	Research students	Non-students	Continuants	Transients	In-degree	Out-degree
4	34	24	25	33	231	94
8	22	34	17	37	172	40
11	2	30	24	8	334	18

Table 6: Frequency counts for key characteristics of groups 4, 8 and 11. In-degree is the number of edges between co-authors within a group, out-degree is the number of edges to co-authors in other groups.

The relationships among co-authors (edges) in a group are also insightful. Continuing co-authors are more likely to cooperate when publishing and often mediate relations among co-authors (Braun, Glänzel, and Schubert 2001). Co-authors networks often revolve around co-authors that continuously publish, a phenomenon known as preferential attachment which is linked to cumulative advantage (Cabanac, Hubert, and Milard 2015). The groups presented in Figure 5 are no exception. Figure 6 shows the number of edges between research students and non-research students, and between continuants and transient co-authors. It reveals that research students in these groups rarely co-author together, preferring instead to co-author with non-students. This pattern is characteristic of team-based supervision where one or more supervisors co-author with a single research student on a publication related to their project. It also shows that a high proportion of continuants co-author together or with transients, rarely do transients co-author with one another. This confirms the patterns observed in Figure 3, the co-author network revolves around a core group of co-authors who continuously publish between 2008 and 2014.

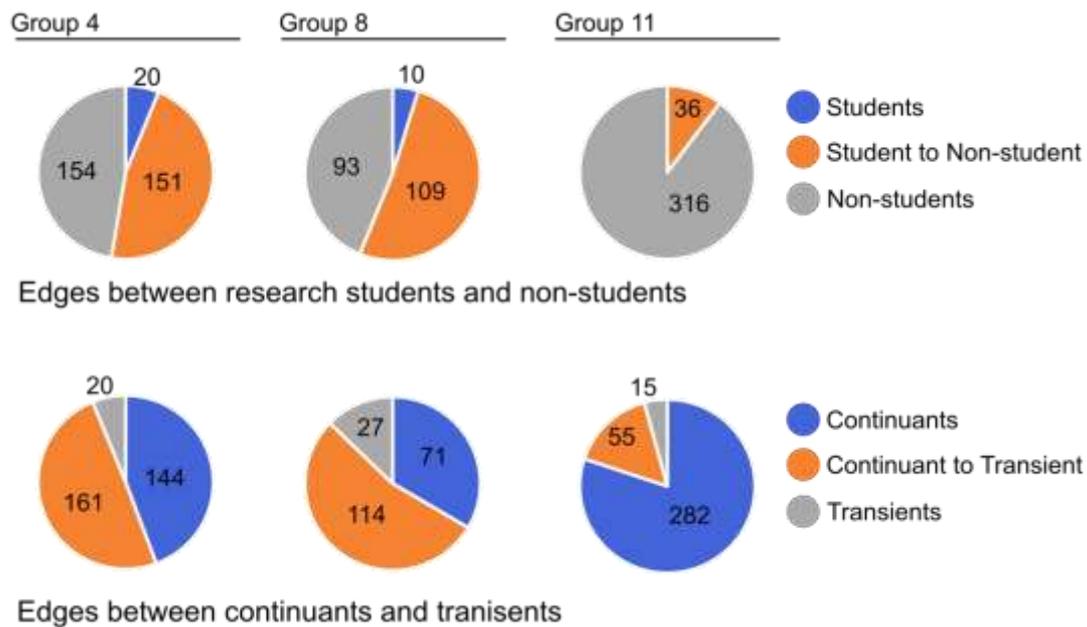


Figure 6: The number of edges between research students and non-students, and continuants and transients in groups 4, 8 and 11,

Examining power

Following a data feminist approach an examination of power begins by naming and explaining sources of oppression and privilege in and around data. The original purpose of the analysis presented in this paper was to examine the extent of collaboration by research students at the University of Tasmania. Research performance management systems in Australia such as the Excellence in Research for Australia (ERA) or Engagement and Impact (EI) assessment exercises run by the Australian Research Council (ARC) collect and contain contributions by research students but do not identify these contributions. This means that the labour of research students is often invisible, and they are not recognised or rewarded for their contributions to research and development in Australia through these exercises. The research sought to challenge this by quantifying and making visible their labour.

Undertaking the research raised even more questions, particularly about equity in

knowledge production. However, the bibliometric data used for analysis was sanitised of identity and context, individual characteristics such as gender, age, race, and nationality were not available which prevented consideration of these important factors. It turns out that information about individual co-authors is not made available by databases such as Scopus or Google Scholar and this is a recognised limitation of available bibliometric datasets. Studies interested in examining gender often rely on an author's name to infer gender in large datasets, along with a combination of other statistical techniques. This approach has many limitations such as reinforcing gender binaries and stereotypes and for this reason no attempt was made to infer gender or other missing information (Mihaljević et al. 2019). The co-authorship information on research publications also has its own limitations: it only captures instrumental collaboration, mostly overlooking social and informal collaboration that occurs between people in everyday contexts (Lewis, Ross, and Holden 2012). That which is visible, such as the order of co-author names on a publication, shows only part of the picture and is likely subject to borderland politics which may involve strategies or acts of resistance such as the Matilda Effect or civil disobedience (Penders and Shaw 2020). Even in the absence of this information we know that inequality does exist in knowledge production, evidenced by the Matthew Effect and an extensive body of literature on the implication of citation and co-authorship practices. With these limitations in mind an examination of power in the analysis presented here can still give visibility to co-authorship practices with implications for equity, raise awareness of issues associated with the bibliometric data, and provide a means of navigating power in doctoral publishing.

Discussion of results

The co-author network map (Figure 4) shows a borderland made up of many dispersed groups of residents centred around prestigious individuals in hub roles whose relationships span the network. Most borderland residents are transient, publishing only once or appearing only for a brief period of time. A core group of highly productive residents publish numerous papers and work across multiple years. Over time some of these residents come to occupy influential hub positions on the co-author network, giving them access to the prestigious resources of co-authors and publications.

Analysis identified 57 hub roles and as expected most are held by supervisors or other co-authors, and only two are held by research students. Hubs act as gate keepers to their groups of co-authors and as bridges to other groups on the network; collaborating with them can give a co-author access to their networks and a share of their prestige or in some circumstance's hubs can suppress them. Analysis of groups 4, 8 and 11 (Figure 5) shows that some hubs clearly dominate the landscape. Group 8 is centred on a single ego-centric hub who works with a significant number of co-authors to produce numerous publications over time, but only a few co-authors are present over multiple years, and none appear to gain access to the hub's networks or prestige. This contrasts with Group 11 where no hub is present, and co-authors appear to work collaboratively over multiple years to produce a few publications. Group 4 sits in between these two extremes: the group is led by a core of three hubs who work with many co-authors to produce publications over multiple years.

Most research students in these groups are closely connected with the more prestigious residents, their supervisors and other co-authors (Figure 6). In Group 4 some even appear to have laid claim to networks and prestige, by working closely with hubs to accumulate publications and co-authors over several years (Figure 5). However, few

research students collaborate with one-another, an observation which can potentially be explained by the individual nature of the research projects that masters and doctoral students undertake.

This analysis suggests that different kinds of publishing practice will lead to significantly different network outcomes which in this case are related to different styles of collaboration. If the observed patterns of collaboration are related to publishing practices, such as those arising from team-based supervision or the nature of a research project, what does ‘good’ collaboration look like and what are its implications? Two important characteristics of collaboration are inclusivity and openness. An inclusive team is one that prioritises reciprocity and acknowledgement of others’ contributions, promotes mutual accountability, and a commitment to interconnected outcomes. An open team is one that acknowledges power dynamics and privilege through an ethos of positivity and goodwill leading to improved participation among its members (Verhoeven et al. 2020). From a structural perspective an inclusive team is one where connections among team members are evenly distributed. An even distribution demonstrates equal contribution and recognition of team members. In an open team co-authors will have connections to multiple other teams, but there won’t be significantly more connections outside of the team than there are within (Pentland 2012; Deb et al. 2020). Groups 4, 8 and 11 do not fulfil all the requirements of inclusivity and openness. The connections within Group 4 are not evenly distributed, Group 8 is ego-centric with limited connections among co-authors, and in Group 11 the connections to other groups are limited. Each group has something to learn from this analysis, and these observations can help co-authors reflect on their individual publishing practices, supervision style, or the disciplinary differences that might be at play and how they might impact the advancement of other co-authors.

Overall, the high level of transience and low number of hub roles on the network suggests that borderland crossings are frequent and that there are few ‘legitimate’ residents in the borderland described. However, this does not make them any less significant. Knowing who they are and having the benefit of co-authoring with them is still advantageous due to the resources that they have accumulated. As for the two research students who occupy hub roles, these are potentially two individuals at an advanced stage in their own careers, with established networks and accumulated prestige. If this is the case, what role could mentorship and collaboration among research students play, particularly by those in the later stages of their careers? Could it promote equity, inclusion, and openness in doctoral publishing by encouraging ‘legitimate’ residents to act as guides for the less well established?

While this examination of power has focused on what borderland maps reveal about individual or group level practices the maps themselves should also be the subject of critique. Visual works that represent and communicate ideas or data are also accompanied by processes that arranges bodies and things as the visual artefact is shared and circulated (Dávila 2019). Power can be depicted and exercised in both dimensions. Maps draw power from their perceived objectivity, which can also lead to oppression and dominance of the represented. These are spaces that do not necessarily privilege democratic shifts or gravitate towards justice, this is often contingent upon the emergence of specific configurations and historical trajectories (Gurumurthy 2011).

Conclusions and future inquiry

The purpose of this paper was to provide an approach for doctoral students and those who support them to engaging with power in knowledge production and challenge power in the interest of equity. Borderlands theory provided a conceptual means of

imagining the space in which doctoral work is done, enabling the social and political dimensions of doctoral publishing to be visualised and discussed. A data feminist approach enabled the examination of power in borderland maps, providing ways of critiquing the bibliometric data and analysis that underpins them. Through the application of borderlands theory and data feminism the paper demonstrates the use of visual methodologies for examining power in knowledge production and providing a foundation for challenging power in the interest of equity.

Teams in doctoral publishing emerge as an important area of inquiry. Future work may involve comparing the outcomes of team-based publication and sole author strategies in doctoral education. Investigating what historical patterns of co-authorship can reveal about team publishing in doctoral education. Understanding how bibliometric data, analysis and visualisation can be better grounded in their institutional, social and political contexts, such as through connecting them to the subjects lived experience through borderlands theory. And examining how strategies such as mentorship or team-based supervision can challenge power and promote equity by prioritising inclusivity and openness in doctoral publishing.

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