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DOES PUBLISHING DURING THE DOCTORATE INFLUENCE COMPLETION TIME? A QUANTITATIVE STUDY OF DOCTORAL CANDIDATES IN AUSTRALIA

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ABSTRACT

Aim/Purpose: This paper investigates the association between publishing during doctoral candidature and completion time. The effects of discipline and of gaining additional support through a doctoral cohort program are also explored.

Background: Candidates recognize the value of building a publication track record to improve their career prospects yet are cognizant of the time it takes to publish peer-reviewed articles. In some institutions or disciplines, there is a policy or the expectation that doctoral students will publish during their candidature. However, doctoral candidates are also under increasing pressure to complete their studies within a designated timeframe. Thus, some candidates and faculty perceive the two requirements – to publish and to complete on time – as mutually exclusive. Furthermore, where candidates have a choice in the format that the PhD submission will take, be it by monograph, PhD-by-publication, or a hybrid

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	thesis, there is little empirical evidence available to guide the decision. This paper provides a quantitative analysis of the association between publishing during candidature and time-to-degree and investigates other variables associated with doctoral candidate research productivity and efficiency.
Methodology	Multivariate logistic regression analyses were used to examine the predictors (discipline [field of research], gender, age group, domestic or international student status, and belonging to a cohort program) of doctoral candidate research productivity and efficacy. Research productivity was quantified by the number of peer-reviewed journal articles that a candidate published as a primary author during and up to 24 months after thesis submission. Efficacy (time-to-degree) was quantified by the number of Full-Time Equivalent (FTE) years of candidature. Data on 1,143 doctoral graduates were obtained from a single Australian university for the period extending from 2000 to 2020. Complete publication data were available on 707 graduates, and time-to-degree data on 664 graduates. Data were drawn from eight fields of research, which were grouped into the disciplines of health, biological sciences, agricultural and environmental sciences, and chemical, earth, and physical sciences.
Contribution	This paper addresses a gap in empirical literature by providing evidence of the association between publishing during doctoral candidature and time-to-degree in the disciplines of health, biological sciences, agricultural and environmental sciences, and chemical, earth, and physical sciences. The paper also adds to the body of evidence that demonstrates the value of belonging to a cohort program for doctoral student outcomes.
Findings	There is a significant association between the number of articles published and median time-to-degree. Graduates with the highest research productivity (four or more articles) exhibited the shortest time-to-degree. There was also a significant association between discipline and the number of publications published during candidature. Gaining additional peer and research-focused support and training through a cohort program was also associated with higher research productivity and efficiency compared to candidates in the same discipline but not in receipt of the additional support.
Recommendations for Practitioners	While the encouragement of candidates to both publish and complete within the recommended doctorate timeframe is recommended, even within disciplines characterized by high levels of research productivity, i.e., where publishing during candidature is the "norm," the desired levels of student research productivity and efficiency are only likely to be achieved where candidates are provided with consistent writing and publication-focused training, together with peer or mentor support.
Recommendations for Researchers	Publishing peer-reviewed articles during doctoral candidature is shown not to adversely affect candidates' completion time. Researchers should seek writing and publication-focused support to enhance their research productivity and efficiency.
Impact on Society	Researchers have an obligation to disseminate their findings for the benefit of society, industry, or practice. Thus, doctoral candidates need to be encouraged and supported to publish as they progress through their candidature.
Future Research	The quantitative findings need to be followed up with a mixed-methods study aimed at identifying which elements of publication and research-focused support are most effective in raising doctoral candidate productivity and efficacy.

Keywords cohort program, completion, doctorate, research productivity, time-to-degree

INTRODUCTION

For doctoral students, publishing during candidature can be a challenging and time-consuming process (Björk & Solomon, 2013; Guerin, 2016), and yet both publishing *and* completing on time are expected of them (Pinheiro et al., 2014; Taylor, 2019). Timely dissemination of students' research findings is a priority for industry for the advancement of technological innovations and improvements in practice (Shin et al., 2018). For students, having evidence of the scholarly dissemination of ones' research findings is an asset when entering a competitive job market (Hartley & Betts, 2009; Horta et al., 2019).

Timely completions are also important for industry and students, as they release graduates into the job market (Australian Technology Network of Universities & Nous Group, 2017), and for universities and faculty as student completions free up capacity and resources for incoming applicants. Given that both the timely dissemination of research findings and timely completions are widely sought across sectors, it is important that the process of publishing during a PhD does not adversely extend completion times. Furthermore, because publishing is a time-consuming process, some doctoral students have expressed concerns that publishing during their candidature will slow their time to completion (Hartley & Betts, 2009; Jowsey et al., 2020; Watts, 2013), and yet there is little empirical evidence on which to base such concerns. Given the scant scholarly literature on the relationship between research productivity and efficiency in doctoral graduates, this study aims to examine the association between publishing during a PhD and time-to-degree at a research-intensive university in Australia. The study extends the existing body of literature by examining whether completion time is influenced by doctoral students' research productivity during their PhD, and the effect of discipline, and gaining additional support on publication outputs. The research contributes new insights on the *intra*-discipline effect of gaining additional publication-focused training and support on research productivity and efficiency. The study also provides empirical evidence based on a rigorous statistical approach that minimizes the influence of confounding variables in the analyses.

LITERATURE REVIEW

THE IMPORTANCE OF PUBLISHING DURING CANDIDATURE

Publishing during candidature is important for students, supervisors, the discipline, higher education institutions, industry, and the economy, though for differing reasons. For industry and the economy – in both developed and developing countries – it is the innovative advancements in technology and practice informed by original research that is sought (Australian Technology Network of Universities & Nous Group, 2017; Hayward & Ncayiyana, 2014). It is also important that research findings are disseminated to practitioners for the advancement of discipline knowledge and practice (Shin et al., 2018). For academics, because publishing is integral to the role (Caparrós-Ruiz, 2019) and expected, co-authoring papers with research students serves as a means of increasing their own research productivity (R. Ynalvez et al., 2014). For institutions where funding is linked to research student productivity and efficiency measures, a higher publication output equates to greater income (Hansen et al., 2019; Hicks, 2012; Pinheiro et al., 2019; Williams & Grant, 2018).

A doctoral degree is a learning process. It is, therefore, important that students gain the skill of writing for publication to prepare for their future careers (Caparrós-Ruiz, 2019; R. Ynalvez et al., 2014). It is by going through the process of writing for publication (Robins & Kanowski, 2008) that students learn how to communicate, contextualize (Pinheiro et al., 2014), and respond to critique (Merga et al., 2020); hence students should publish from the outset of their candidature. In turn, students can start to develop a publication track record (Guerin, 2016; Niven & Grant, 2012), build academic credibility (Choi et al., 2021; Merga et al., 2020), and grow in confidence (Sharmini et al., 2015). The

benefits of publishing during the PhD (Sharmini et al., 2015) extend beyond the university experience, with Laurance et al. (2013) and Pinheiro et al. (2014) reporting sustained high research productivity during the post-doctoral careers of graduates from biology, and science, technology, engineering, and mathematics (STEM) fields respectively. Given the value of publications, it is not surprising that in some institutions or disciplines there is the expectation (Mason & Merga, 2018a) or even policy requiring doctoral students to publish during their candidature (Mouton, 2011; Pinheiro et al., 2014). Yet, in contrast, in parts of Africa, university leaders lament that a lack of capacity and inadequate research training (Garwe et al., 2021) not only delays completion times (Mbogo et al., 2020) but also leads to low research outputs (Fisher et al., 2020; Olibie et al., 2015).

While the value of doctoral publishing is widely accepted across a range of contexts, contention arises across developed (Sharmini et al., 2015) and developing (Ramlall et al., 2020; van Lill, 2019) nations when comparing new forms of doctoral submissions (such as PhD with publications, or hybrid theses) with traditional theses (Hagen, 2010; Jackson, 2013; Niven & Grant, 2012; Thune et al., 2012). Academic debate around article-based theses largely centers on issues of equity and quality: quality of the students' education (Teferra, 2015), quality of their papers, and the quality of journals (Larsen & von Ins, 2010). Some doctoral thesis examiners consider a thesis favorably where there is evidence of peer-reviewed articles published in good quality journals (Guerin, 2016; Watts, 2013), though this is subject to debate (Sharmini et al., 2015). Further, in Africa, concerns have been raised over the extent of co-author involvement in doctoral student publications, which ultimately form part of the students' doctoral submission, citing concerns over the quality of the graduates (exiting university with a PhD) in such cases (Ramlall et al., 2020; Teferra, 2015). In Europe and Scandinavia, where co-authors have made significant contributions to papers that form part of a PhD submission, it has been suggested that the required number of articles submitted change (Kyvik & Olsen, 2014; Pinheiro et al., 2014; Thune et al., 2012). Besides the debate around the varying quality of journals, there is the debate on equity. Is a monograph thesis equable to a PhD-with-publications? Are the number of articles equable across disciplines (Niven & Grant, 2012)? These issues have led university leaders to call for a policy on publication-based doctoral submissions (Ramlall et al., 2020; Sharmini et al., 2015) and for empirical evidence to guide policy (Merga et al., 2020). While these debates are outside of the scope of this paper, this study aims to provide empirical evidence across four disciplines on whether publishing during a PhD impacts completion time. In this way, the study aims to feed empirical evidence into this contentious space.

Factors Influencing Publishing During Candidature

Despite industry, faculty, and university expectations around publishing, for students, getting published is challenging. Many students report a lack of confidence, lack of ability, or fear of peer-review critique as factors hindering their achievement of publication goals (Cuthbert & Spark, 2008). Universities are, therefore, continually investigating processes or activities which might be effective in assisting students to improve their research skills and outcomes.

Differences in research productivity are frequently attributed to the research "culture" (Watts, 2013), or the "norms" (Mason & Merga, 2018a, p. 148), or expectations (Wildgaard & Wildgaard, 2018), that differ between disciplines. Even within the social sciences, variations in publication norms are evident across different sub-disciplines (Mason & Merga, 2018b). Other studies attribute the differences in productivity to the practice of working collaboratively with peers (Cuthbert & Spark, 2008), mentors (R. Ynalvez et al., 2014), or supervisors (Hartley & Betts, 2009), which tends to characterize particular disciplines (sciences) or methodologies (laboratory-based studies). Analyses of data drawn from a national database in the United States of America (USA) (Pinheiro et al., 2014), surveys in Portugal (Horta & Santos, 2016), and dissertation submissions in Norway (Thune et al., 2012), and other parts of Scandinavia, show differences in the ranking of disciplines, but generally, students in science fields of research (Horta & Santos, 2016), and medical and health fields (Thune et al., 2012), had higher outputs than those in social sciences (Hagen, 2010), and in humanities where monograph

submissions dominated (Thune et al., 2012). Niven and Grant (2012, p. 110) attribute the difference to the tendency of students, in the latter disciplines, to work alone, stating that "in a humanities and education context, PhDs by publications will never be a comfortable epistemological fit." In science fields, students often work on projects that align closely with their supervisor's research interests, resulting in their publishing together (Kyvik & Olsen, 2014). Informal collaboration was a factor associated with increased research productivity in a survey of graduate agricultural scientists in the Philippines (M. A. Ynalvez & Shrum, 2011). Similarly, collaboration with peers (peer-assisted learning) has been shown to raise participants' self-efficacy for writing, and productivity in doctoral students in an arts discipline (Cuthbert & Spark, 2008), and among faculty in an education discipline (Wilson & Cutri, 2021) – the findings in the latter two studies indicate that it may be the power of collaboration rather a discipline phenomenon influencing productivity.

Another measure strongly associated with research productivity is publication-focused training programs for students (Cuthbert & Spark, 2008), faculty (Morss & Murray, 2001), and clinicians, particularly for those who find writing challenging (Murray & Newton, 2008). With reference to faculty rather than doctoral students, Morss and Murray (2001) note a lack of confidence rather than an absence of skill as a factor affecting productivity and highlight the role of training in raising self-efficacy and productivity. Structuring time to write into one's daily workload was also identified as important for raising productivity (Morss & Murray, 2001). However, not all training measures are equally effective; for example, of 16 doctoral training and practice items, and 15 instrumental mentoring practices evaluated by R. Ynalvez et al. (2014) with data from molecular biology students in Japan, Taiwan, and Singapore, only two practices emerged as strong predictors of increased productivity; namely, the practice of writing and submitting papers to journals, and of mentors co-authoring papers with a candidate. Students presenting their work at conferences or seminars led to an increase in manuscript production but did not equate to more publications.

Clearly, no single support measure or training event in isolation will determine research performance (Geven et al., 2018; R. Ynalvez et al., 2019). Rather, where a suite of support measures are in place, not only does research productivity improve (Kogovsek et al., 2011), but also the likelihood of students completing their studies within the required timeframe (van Rooij et al., 2019), both of which are expected of students, and important to universities. Programs in which small groups of students commence their studies and progress through their degree together in a structured and supported way are termed cohort programs (see Bagaka's et al., 2015; Leland et al., 2020). Such multifaceted programs are tailored to the educational needs of the group and provide students with a suite of social support (Gardner & Gopaul, 2012), anxiety-reducing (Nimer, 2009), structural support, and training measures (Bagaka's et al., 2015). By facilitating social integration (collaboration), cohort programs not only increase the likelihood of improved student satisfaction with their university experience (van Rooij et al., 2019), but also raise rates of success (Bagaka's et al., 2015) across disciplines (Gardner & Gopaul, 2012). Cohort programs also include research education, training in writing and publishing, collegial support, and an opportunity for learning through shared experiences and mentoring (Bagaka's et al., 2015; Leland et al., 2020). Given that research productivity has been attributed to the practice of collaboration, to the efficacy of training programs, and to differences in discipline "culture," we are led to question whether research productivity differences are attributable to the collegial effect of working with peers and mentors or to discipline culture. This paper aims to address the question. The authors hypothesize that students who belong to supportive doctoral cohort training programs (such as those described in Bagaka's et al. [2015] and Leland et al. [2020] and tested in this study) are likely to exhibit higher levels of research productivity than their discipline peers outside of such programs.

Factors Influencing Timely Doctoral Completion

The concept of what constitutes efficiency or a "timely" completion will be different in different countries and contexts. Most institutions in Australia, New Zealand, the European Higher Education

Area (EHEA), United Kingdom (UK), and Nigeria favor durations of 3 to 4 years (EHEA, 2009; McGagh et al., 2016; Olibie et al., 2015; Roberts, 2002; Spronken-Smith et al., 2018). Candidacies extending beyond this timeframe may be considered "an inefficiency" (McGagh et al. 2016, p. 30), whereas, in the USA, candidacies tend to be longer. The trajectory and the level of credentials required to gain entry into a PhD in the USA differ from the European and Australian contexts, which may account for the varying expectations in completion times. For example, Zhou and Okahana (2019) report a median of 5.26 years for students in STEM fields and 6.64 years for non-STEM disciplines. Thus, the concept of a timely or "on time" completion is where the students complete their degree within the recommended national or institutional course duration. Notwithstanding the empirical evidence showing reductions in doctoral median time-to-degree over the past few decades (Skopek et al., 2020; Torka, 2020), universities remain eager to improve their proportion of "on time" completions (Geven et al., 2018).

The variables commonly associated with shorter time-to-degree include candidate funding (Spronken-Smith et al., 2018; Torka, 2020); discipline (Caparrós-Ruiz, 2019; Torka, 2020); prior research or Master's degree (van Lill, 2019); and foreign student status (Geven et al., 2018; Spronken-Smith et al., 2018; Torka, 2020; Zhou & Okahana 2019). While much is known about the drivers of shorter completion times, given the arguably equally demanding expectation that students publish as they progress through their candidature, it is worth examining the association between the two variables (research productivity, and efficiency).

The Impact of Publishing on Doctoral Completion Times

R. Ynalvez et al. (2014, p. 321) acknowledge the value of student engagement in research training (for the development of "human and social capital") but suggest that such activities may be an "unintended distraction" that could hinder students' rate of progress. Students too have expressed concern that publishing during candidature will delay their completion time due to the time-consuming nature of getting published (Guerin, 2016). In a UK-based study, in which a third of the participants (n = 58) were from non-English speaking backgrounds, a lengthening effect of publishing during candidature was noted, albeit by four months (Hartley & Betts, 2009). Countering this are the qualitative accounts from doctoral students claiming efficiencies in completion times *because* they published during their candidature (Merga et al., 2020). While both studies (Hartley & Betts, 2009; Merga et al., 2020) have merit in that they record the student's voice, the findings should be regarded with caution due to the small sample sizes.

A number of pivotal empirical studies provide an indication of doctoral student research productivity over varying timeframes, such as the duration of completed PhD candidatures (Hagen, 2010; Mason & Merga, 2018a; Thune et al., 2012) or during candidatures in-progress (R. Ynalvez et al., 2014). R. Ynalvez et al. (2014) record an average of 1.18 papers (published or submitted) over a 12-month period across a range of years of candidature and Hagen (2010) and Mason and Merga (2018a) between 4 and 5 papers per dissertation. However, the latter study, which considered only quantity and not quality, found that two-thirds of the papers included in thesis submissions were not yet in published form, whereas Hagen (2010) enumerated only published articles in their study, finding that students published on average 0.37 papers per dissertation. While the studies provide useful insights into doctoral productivity, they provide little evidence on whether higher research productivity during candidature was associated with longer or shorter completion times. Green et al. (1992) and Horta et al. (2014) are notable exceptions; hence further details are provided forthwith.

A shortening influence of publishing on time-to-degree was found in the studies of Green et al. (1992) and Horta et al. (2019). The shortening effect was identified in doctoral social work students in the USA, where candidates were intent on pursuing a research career following graduation (Green et al., 1992). The study provides a measure of students' perceived preparedness to publish, noting only a positive association with productivity, but offers no details on the actual resultant length of variations in candidature (in years). The average time to complete all components of the doctoral

program was 4.9 years for the sample as a whole (Green et al., 1992). In Portugal, a shortening effect of publishing during candidature on time-to-degree was only seen among students that had adequate funding for the duration of their PhD (Horta et al., 2019). A converse effect of publishing during candidature associated with an increase in time-to-degree was also evident in the same study among STEM and non-STEM students who were not funded. As a whole, funded candidates took longer to complete their degree than non-funded candidates, but the net effect was that funded candidates who published during their PhD completed in a shorter time, whereas publishing tended to increase the time-to-degree of the non-funded candidates. That is, the impact of publishing during candidature on completion time was intrinsically linked to students' funding status (Horta et al., 2019).

Horta et al. (2019) is one of the few papers to provide an analysis of a productivity-efficiency association and to demonstrate the lengthening effect of publishing during candidature, but not in terms of the number of years taken to complete the degree. In short, a question that remains largely unanswered is: is publishing during a PhD associated with a longer or shorter candidature? This paper aims to address this question by examining doctoral completion and publication data across four disciplines at a research-intensive university in Australia. According to Watts (2013, p. 1105), such analyses have the potential "to change institutional policies on publishing in the doctoral context".

Purpose of the Study and Research Hypotheses

With a specific focus on doctoral candidates' publication productivity, this study aims to investigate the association between publishing during a PhD and (a) time-to-degree, (b) discipline (field of research), and (c) engagement in a Cohort Doctoral Studies Program (henceforth abbreviated to cohort program) and also the association between engagement in a cohort program and time-to-degree. The variable assessed in engagement in a cohort program is the effect of candidates receiving "additional" research and publishing-focused training and support, as detailed later in the paper.

Based on the review of literature, the research hypotheses are:

Hypothesis 1: Doctoral candidates who publish journal articles during their candidature complete their degree in a shorter time than candidates who do not publish during their candidature.

Hypothesis 2: The number of peer-reviewed journal articles that a candidate publishes as a primary author is associated with the discipline.

Hypothesis 3: Doctoral candidates who engage in a cohort program publish more journal articles than their discipline peers who do not belong to a cohort program.

Hypothesis 4: Doctoral candidates who engage in a cohort program have a shorter time-to-thesis submission than their discipline peers who do not belong to a cohort program.

Context

All research student administration and training is provided through a centralized Graduate Research School within our university. The single Graduate Research School ensures that equitable training is accessible to all research students regardless of their discipline. All students are required to undergo a suite of research training modules, with additional training (for example, statistics, qualitative data analysis, safe handling of animals) available to students as required. The Graduate Research School also administers progress monitoring procedures that evaluate student progress at the outset (when the research proposal is confirmed), at mid-point, and at pre-completion stages of their candidature and through twice-yearly progress reports. The processes enable the Graduate Research School to identify candidates who are facing issues hindering their progress or who are at risk of not completing within the recommended course duration and set in place measures to redress the obstacles. In addition, research candidates have a supervisory team with whom they enter an "Agreement" on their mutual obligations. A number of processes are associated with improving research student retention

rates (Geven et al., 2018) and reducing completion times and, thus, are becoming more common in tertiary institutions across the globe (Humphrey et al., 2012; Kyvik & Olsen 2014).

Health Cohort Program

Over and above the standard support offered through the Graduate Research School, in the health discipline, a cohort program exists to provide additional training and support to research students within the discipline of health. Thus, while all candidates, both within the cohort program and external to the program, have access to the services and training offered through the Graduate Research School, not all research candidates in this discipline are included in the cohort program as entry into the program is based on successful application. Active participation in the training is a condition of entry into the program and is closely monitored and documented. The program, which comprises multiple discrete small groups of peers (15-20) who commence their studies at the same time (two groups per year, comprising successful applicants from the discipline of health), was primarily created to meet the needs of candidates within the discipline who were facing known barriers to doctoral achievement such as studying in isolation, not being based on campus, or being employed full-time in a demanding health profession. While places in the cohort program are prioritized for candidates most in need of additional support, the program also admits full-time applicants who are based on campus, but these students are in the minority. The cohort program is only open to candidates enrolled in the discipline of health. The content of training and support is personalized and tailored to the stage of candidature. Training on writing for publication, presenting ones' research findings, editing, peer review, how to respond to critique, time management, and goal setting are sustained throughout the program. Candidates are encouraged to publish from the outset. Practice sessions aimed at facilitating learning are offered through writing retreats, cohort conferences, and a journal club. Peer-assisted learning is encouraged and facilitated. Besides the training components, candidates have access to pastoral care and mentoring from cohort faculty.

METHODOLOGY

Sample, Data, and Approach

The aim of this study is to investigate the association between publishing during a PhD and (a) time-to-degree, (b) discipline (field of research), and (c) engagement in a cohort program and also the association between engagement in a cohort program and time-to-degree. The study adopts a quantitative approach using retrospective data that were collected by the institution. Retrospective data are effective in covering the extent of prolonged part-time candidacies (which may exceed eight years or longer where they include leave of absence periods).

The study is guided by Shin and Cummings (2010) theoretical framework on the determinants of faculty publishing. While Kahn and Scott (1997) developed a model based on doctoral students, the model covers three variables, namely interest in research, career goals, and year in progress (with research training influencing the variables), whereas the model of Shin and Cummings (2010) is more comprehensive and hence is used here. The latter model includes four groups of personal attributes and three groups of institutional attributes. The person-centered predictors in the model include

- Research preference and practice (comprising preference, workloads, and collaboration),
- Academic rank and training,
- Demographics, and
- Discipline.

The institutional predictors in the model are

- Institutional climate (comprising collegiality, support attitudes of staff, and goal orientation),
- Institutional support (faculty, technology, and personnel), and

- Institutional characteristics (mission and size).

The theoretical framework of Kwiek (2018), like the Shin and Cummings (2010) model, also comprises a range of personal and institutional attributes influencing research productivity and similarly is used to predict faculty publishing but, unlike the latter model, is used to predict the *top* 10% of performers rather than research productivity *per se*. However, because our study focuses on the research productivity of PhD candidates (rather than faculty publishing), some of the determinants described in the Shin and Cummings framework (e.g., academic rank, years since PhD, and post-doctoral experience) do not apply in the exact form; hence an amended framework is used here. For example, a doctoral equivalent of "academic rank and training," which comprises rank, years since PhD, post-doctoral experience, and participation in a research project, might be the "training" of students during their candidature. The determinant "research preference" refers to an individual's personal affinity for publishing, essentially asserting that levels of productivity are a matter of personal choice (preference) in how an individual chooses to spend their time amidst their competing workloads (Shin & Cummings, 2010). For faculty, competing workloads might be time spent on teaching rather than research within a faculty role, whereas for doctoral students competing workloads may include part-time or full-time work either within or external to the university. To accommodate the differing workload demands of part-time and full-time doctoral candidates, in this study time-to-thesis submission was converted to full-time equivalent (FTE) time in years.

The three institutional determinants (climate, support, and characteristics) in the Shin and Cummings (2010) model were developed using data from multiple universities across Korea. However, this study is based on data from a single, research-intensive university in Australia; therefore, we have amended the institutional variables in the framework to an *intra*-institutional level. This amendment is in keeping with a need identified by Shin and Cummings (2010) for future studies to provide insights into the effect of the determinants within different disciplines.

In keeping with the Shin and Cummings (2010) approach, the attributes included in this study are: demographics (gender, age group, residency status, and non-English speaking background [NESB]; see Table 1), discipline, number of publications (Table 1), engagement in a cohort program (training), and time-to-degree. The attributes included in the study were limited to those permitted by our ethics agreement (#H7806), following approval from the university's privacy officer, in accordance with the strict privacy rules operational in Australia. In accordance with our ethics approval, all non-public, personal student information was de-identified prior to release to the researchers. An entirely separate dataset, collected by an independent unit within the institution, was used in the publication analyses. The data are also routinely collected by Australian universities for reporting to the national research evaluation agency Excellence in Research Australia (ERA) for institutional benchmarking and funding. The latter data comprise article citations arising from research student projects. The authors of the articles are named (identifiable), and the citations are publically available. Once the publication dataset was verified (by the researchers), the data were released to the Data Analytics Unit within the university to marry the time-to-thesis submission dataset with the publication dataset, which was again de-identified prior to release to the researchers for statistical analysis (in accordance with our ethics permission); as detailed later.

The data collection period extended from 1 January 2000 to 1 January 2020. The timeframe was governed by the availability of a complete dataset, which provided a sufficient sample size of doctoral graduates to provide meaningful statistical validity. Data were filtered to form a subset (n = 1,143) who started their PhD prior to 1 January 2015 (to allow sufficient time for thesis submission) and who had submitted their PhD by the data collection date (1 January 2020). Students who had withdrawn from the course or who were absent without leave were excluded from the analysis (i.e., they had enrolled before 2015, had not submitted a thesis by 1 January 2020, and were not enrolled in 2019). Also excluded from analysis were candidates who completed a doctorate by prior publication (i.e., a portfolio of publications produced prior to enrollment). Complete publication data were available for 707 graduates (Table 1), and time-to-degree data on 664 graduates.

Table 1. Publication data for 707 graduates

Demographic	Variable	No.	Proportion of the variable	Total publications per variable	Proportion who published	Average publications per student
		n	%	n	%	
Gender	Male	353	49.9	977	74.2	3.73
	Female	354	50.1	909	72.3	3.55
Age group	<30 years	388	54.8	1042	76.8	3.50
	30-50 years	291	41.2	783	69.1	3.90
	>50 years	28	4.0	61	67.9	3.21
Residency Status	Domestic	440	62.2	1194	75.2	3.61
	International	267	37.8	692	70.0	3.70
Home Language	Not English	207	29.3	490	65.7	3.60
	English	500	70.7	1,396	76.4	3.65
Discipline	Health	164	23.2	496	73.2	4.13
	Biological	294	41.6	849	79.3	3.64
	Agricultural, Environmental	147	20.8	368	70.7	3.54
	Chemical, Earth, Physical	102	14.4	173	59.8	2.84
Total number of participants		707				
Total number of publications				**1,886**		

The enrolment and thesis submission timeline data were transformed to ensure comparability between part-time and full-time candidates and to exclude leave of absence periods. That is, the time from enrollment in the degree to the date of thesis submission was converted to FTE years. In this paper, the terms "time-to-degree" and "completion time" are used synonymously and refer to the time (FTE years) to thesis submission. Thesis examination periods are excluded because they are outside of the influence of the candidate or the institution, and, according to Thune et al. (2012) and Spronken-Smith et al. (2018), can vary significantly (2-7 months). Assumptions underpinning the study are that part-time (8 years) and full-time (4 years) candidatures are equable hence their conversion to and reported as full-time equivalent (FTE) years; all PhDs, regardless of discipline, are equable in workload; and all doctoral students within the institution have equable access to research training provided by a centralized Graduate Research School. The Graduate Research School established its training program in a way that equably accommodates external and internal modes of student learning.

To facilitate data analysis, data were categorized into groups as follows: the time-to-thesis submission was considered as 0 to 3.99 FTE years (i.e., the "ideal" duration in this context), 4.0 to 4.99 FTE years, and 5 or more FTE years. Publications published during candidature were considered in three groups: zero publications, one to three publications, and four or more publications. Eight fields of research (FoR) were grouped into four disciplines as follows: (1) biomedical, clinical (FoR: 32) and health sciences (FoR: 42) were abbreviated to health; (2) biological sciences (FoR: 31); (3) agricultural (FoR: 30) and environmental sciences (FoR: 41); and (4) chemical, earth, and physical sciences (FoR:

34, 37, and 51, respectively). The fields of research are as described in the Australian Bureau of Statistics (2020), which align with the Organization for Economic Co-operation and Development (OECD) fields of research and development descriptions (OECD, 2015).

Publication Parameters

Publications included in the analyses were restricted to (a) PhD candidate as primary author, (b) peer-reviewed journal articles that were based on the doctoral project, and (c) articles published during PhD candidature and up to 24 months after thesis submission. The rationale for the limitations is the following:

(a) Restricting the publication count to those where the student was the primary author was to avoid counting non-PhD publications in a similar field that may have been completed through Research Assistantship employment, though these are less likely to have the student as the primary author. Other studies have included all co-authored articles without regard for the order of the doctoral candidate, or have given consideration to the relative contribution of co-authors (Hagen, 2010; Kyvik & Olsen, 2014; Thune et al. 2012), with excessive co-author listings excluded, or have assigned weightings to some or all co-authors (Green et al., 1992; Hlebec et al., 2011; Laurance et al., 2013; Pinheiro et al., 2014).

(b) For quality control, publications were limited to peer-reviewed journal articles only (classified as C1 publications by ERA). Likewise, Horta et al. (2019) considered peer-reviewed articles only in their research productivity—time-to-degree analysis. Green et al. (1992), Hlebec et al. (2011), Kogovsek et al. (2011), and Shin et al. (2014) included non-peer-reviewed publications (book chapters, books) in their analyses, but the former three works weight peer-reviewed publications higher in their calculations. While excluding book chapters, books, and conference papers will under-represent the research productivity of candidates who choose to disseminate their findings via non-journal means (see Shin et al., 2014), it was deemed necessary by the authors in this study to provide quality and volume control. The total number of dissemination items which the 707 doctoral graduates (participants in this study) produced within the study timeframe numbered 7,737 outputs. The outputs included conference presentations, books, chapters, and reports, as well as papers where the student was not the primary author. The excessive volume necessitated the use of inclusion/exclusion criteria in the study. Once the inclusion/exclusion criteria were applied, a total of 1,886 papers met the criteria. That is, the 707 candidates (Table 1) produced (during and up to 24 months after their thesis submission date) a total of 1,886 peer-reviewed journal papers in which they were the primary author.

(c) To accommodate for lengthy delays in the peer-review publication process (Björk & Solomon, 2013; Robins & Kanowski, 2008), articles on the PhD topic that were published up to 24 months after thesis submission were included in the data.

Data Validation and Analyses

A total of 1,886 publications met the inclusion criteria (a, b, c). The screening process entailed manually validating the publication data provided by the institution against publicly available data from the graduates' online profiles, online thesis repositories (PhD-with-publications list the articles included for thesis examination), Research Gate, and via a Google Scholar search (using author name, institution, date-range, and keywords). Of these, Google Scholar is the database of choice in this study because it has a broader coverage of publications across numerous disciples compared to Scopus or Web of Science alone (Larsen & von Ins, 2010; Martín-Martín et al., 2018) and was used for data validation purposes only. If known publications did not present in Google Scholar, then Scopus and Web of Science were consulted. With the number of predatory journals ever-changing and increasing (Larsen & von Ins, 2010), limiting article searches to databases such as Web of Science (Horta et al.,

2019; Pinheiro et al., 2014) or Scopus can serve as a means of quality control. Where necessary, journal websites were also consulted to verify whether papers underwent peer-review.

Once the publication data were verified, the research productivity tallies were released to the Data Analytics Unit to amalgamate with the time-to-degree data. The amalgamated data were then de-identified (in accordance with ethics agreement #H7806) before being released to researchers for statistical testing.

To determine the association between the measured variables (age group, gender, discipline, domestic or international student status, belonging to a cohort program) and doctoral outcomes (number of articles published, time-to-thesis submission), initial univariate analyses using Chi-square tests were performed. Multivariate logistic regression analyses were used to examine the factors predictive of the same doctoral outcomes and the likelihood of being an "ideal" student (i.e., publishes four or more articles and also submits in under 3.99 FTE years). Significance is reported as $p < 0.05$, $p < 0.01$ or $p < 0.001$ and confidence intervals are presented where appropriate. Statistical software R v4.1 was used for all analyses.

RESULTS

THE ASSOCIATION BETWEEN THE NUMBERS OF ARTICLES PUBLISHED AND TIME-TO-DEGREE

Time-to-degree and publication results for all graduates (n = 664), domestic (n = 373), and international graduates (n = 291) are given in Table 2. A third (33.1%) of all candidates published four or more papers during and up to 24 months after their thesis submission, with the proportion of domestic and international students not dissimilar at 34.8% and 30.9%, respectively. A slightly higher proportion of international candidates than domestic students were both research productive (four or more papers) and efficient completers (0−3.99 FTE years), at 25.09% and 19.03%, respectively. The hypothesis (#1) that doctoral candidates who publish journal articles during their candidature complete their degree in a shorter time than candidates who do not publish during their candidature was tested for the sample (n = 664) as a whole and also for domestic (n = 373) and international (n = 291) candidates separately. Chi-square analyses revealed (Table 2) a significant association between the number of publications and shorter time-to-degree (0−3.99 FTE years) in all three analyses (all graduates: $\chi2$ (4) = 31.58, $p < 0.001$; domestic graduates: $\chi2$ (4) = 18.23, $p = 0.001$; and international graduates: $\chi2$ (4) = 28.58, $p < 0.001$). Likewise, there is a significant association between publishing four or more articles and median time-to-degree (median = 3.76 FTE years, IQR = 0.76, $p < 0.001$; Table 2). Graduates with the highest research productivity (four or more articles) also exhibit the shortest time-to-degree; hence Hypothesis 1 is accepted.

Table 2. Time-to-degree and publication results for 664 graduates

	Median time-to-degree	**0 – 3.99 FTE years**		**4.0 – 4.99 FTE years**		**5.0+ FTE years**	
	(IQR)	n	%	n	%	n	%
All graduates							
0 publications	4.13 (1.23)	75	42	68	38	36	20
1-3 publications	4.00 (1.1)	122	46	91	34	52	20
4+ publications	3.76 (0.76)	144	66	60	27	16	7
p-value	<0.001		χ^2 (4) = 31.58, $p < 0.001$				n = 664

	Median time-to-degree	0 – 3.99 FTE years		4.0 – 4.99 FTE years		5.0+ FTE years	
Domestic							
0 publications	4.22 (1.5)	33	40	25	30	25	30
1-3 publications	4.18 (1.39)	60	38	54	34	46	29
4+ publications	3.97 (0.9)	71	55	45	35	14	11
p-value	0.001	χ^2 (4) = 18.23, p = 0.001					n = 373
International							
0 publications	4.12 (1.08)	42	44	43	45	11	11
1-3 publications	3.91 (0.74)	62	59	37	35	6	6
4+ publications	3.56 (0.51)	73	81	15	17	2	2
p-value	<0.001	χ^2 (4) = 28.58, p < 0.001					n = 291

The Association Between the Numbers of Articles Published and Discipline

As shown in Table 3, the number (n) and proportion (%) of candidates who published four or more papers in the discipline of chemical, earth, and physical sciences was lower (15.7%) than in the three other disciplines tested, which ranged from 32.0 to 37.8%. The majority of candidates in biological (43.2%); agricultural, environmental sciences (38.8%); and chemical, earth, physical sciences (44.1%) produced one to three publications, but in health, the majority of candidates (37.8%) produced four or more papers (Table 3). The hypothesis (#2) that the number of peer-reviewed journal articles that a candidate publishes as a primary author is associated with the discipline was examined across eight fields of research grouped into four disciplines (Table 3) as health, biological sciences, agricultural and environmental sciences, and chemical, earth, and physical sciences. Chi-square analyses revealed a significant association between the field of research and the number of publications published during candidature ($\chi 2 = 4.38$, $p = 0.036$), with candidates from chemical, earth, and physical sciences less likely to publish four or more articles than those from the other fields of research; hence Hypothesis 2 is accepted.

Table 3. Publication results for candidates in four disciplines

Discipline	0 publications		1–3 publications		4+ publications	
	n	%	n	%	n	%
Health	44	26.8	58	35.4	62	37.8
Biological	61	20.7	127	43.2	106	36.1
Agricultural, Environmental	43	29.3	57	38.8	47	32.0
Chemical, Earth, Physical	41	40.2	45	44.1	16	15.7

The Association Between Engagement in a Cohort Program and the Number of Articles Published

Chi-square analyses were used to test the hypothesis (#3) that doctoral candidates who engage in a cohort program publish more journal articles than their discipline peers who do not belong to a cohort program. The number (n) and proportion (%) of doctoral graduates within (Y) and without (N) of a cohort program (CP) in the discipline of health that published zero, one to three, or four or more articles compared to all candidates across the four disciplines is given in Table 4. A markedly higher proportion (60.0%) of candidates who belonged to a cohort program published four or more papers compared to their discipline peers outside of the program (34.7%). The proportion of doctoral graduates producing four or more papers across all disciplines was similar to the non-cohort health candidates (32.7%) (Table 4). As the results show a significant association between gaining additional publication support and training and the number of articles published ($\chi 2 = 8.58$, $p = 0.003$), Hypothesis 3 is accepted.

Table 4. Publication results for candidates within and without a cohort program

Discipline	CP	0 publications		1 – 3 publications		4+ publications	
		n	%	n	%	n	%
Health	Y	0	0	8	40.0	12	60.0
	N	44	30.6	50	34.7	50	34.7
All disciplines	-	189	26.7	287	40.6	231	32.7

The Association Between Engagement in a Cohort Program and the Time-to-Degree

Chi-square analyses were used to test the hypothesis (#4) that doctoral candidates who engage in a cohort program have a shorter time-to-thesis submission than candidates who are not in a supportive group within their discipline. Table 5 shows the median time-to-degree, IQR and the proportion (%) of graduates who submitted their thesis within 3.99 FTE years, 4 to 4.99 FTE years, and 5 or more FTE years, within (Y) and outside (N) of a cohort program (CP) in the discipline of health compared to doctoral graduates from the other three disciplines tested. Candidates receiving support to publish in the discipline of health had a median time-to-degree of 3.35 FTE years (IQR 1.46), whereas their discipline peers outside the cohort program exhibited a median time-to-degree of 3.97 FTE years (IQR 1.38). For candidates within the cohort program both the median time-to-thesis submission ($p = 0.020$) and the proportion of individuals that submitted their thesis in under 3.99 FTE years were significantly different ($\chi 2 = 5.22$, $p = 0.022$) to the efficacy of non-cohort health graduates, hence Hypothesis 4 is accepted. The proportion of graduates in biological sciences (50.7%), agricultural and environmental sciences (46.5%) and chemical, earth, and physical sciences (55.9%) that submitted their thesis within the shorter time period (0 to 3.99 FTE years) was similar to non-cohort health candidates, as was the median time-to-degree at 3.99 (IQR 0.87), 4.00 (IQR 1.19) and 4.00 (IQR 1.00) respectively.

Predicting The "Ideal" Student

To predict which of the variables is most likely to be associated with a student who is *both* productive and efficient, a logistical regression was conducted. In purely productive terms, the "ideal" doctoral candidate is one who both publishes four or more articles during their candidature and completes within the shorter time period ($\leq$3.99 FTE years). The results show a strongly significant effect of belonging to a cohort program and yielding the ideal student ($\chi 2 = 38.167$, $p < 0.001$).

Table 5. Time-to-degree results for candidates within and without a cohort program

Discipline	CP	Median time-to-degree	0 – 3.99 FTE years		4.0 – 4.99 FTE years		5.0+ FTE years	
		(IQR)	n	%	n	%	n	%
Health	Y	3.35 (1.46)	15	78.9	4	21.1	0	0
	N	3.97 (1.38)	74	53.2	47	33.8	18	12.9
Biological	-	3.99 (0.87)	138	50.7	97	35.7	37	13.6
Agricultural, Environmental	-	4.00 (1.19)	66	46.5	47	33.1	29	20.4
Chemical, Earth, Physical	-	4.00 (1.00)	57	55.9	26	25.5	19	18.6

DISCUSSION

RESEARCH PRODUCTIVITY AND EFFICACY

The aim of this study was to investigate the association between publishing during a PhD and completion time. The effects of discipline and of gaining additional support through a doctoral cohort program were also explored. To this end, Hypothesis 1 tested whether doctoral candidates who publish journal articles during their candidature complete their degree in a shorter time than candidates who do not publish during their candidature. The results show that doctoral candidates who published four or more journal articles during their candidature (i.e., the highest category of research productivity tested in this paper) also completed their degree in the shortest time (≤3.99 FTE years), exhibiting a mean of 3.76 FTE years. Although a similar association between research productivity and shorter time to degree was seen in the empirical studies of Green et al. (1992) and Horta et al. (2019), the association between the two variables was largely tied to compounding variables (for example, funding, or career intentions). Our data did not include the funding status of students, and thus, we were not able to test the effect (of student funding); rather, our results demonstrate a significant association between the two variables in a dataset comprising both funded and non-funded students together.

In keeping with the frameworks of Shin and Cummings (2010), Kwiek (2018), and Kahn and Scott (1997), where preference, research orientation, or interest in research, respectively, are strong determinants of research productivity, the variables are likely applicable to our data. The variables (research preference, research orientation, or interest in research) may thus not only account for the finding that candidates who produce more papers complete in a shorter time, but also that those who publish fewer papers (one to three, or zero) take a longer time-to-degree (4 or 4.13 FTE years, respectively; Table 2). Preference may also account for the discipline-related differences in productivity, discussed in the next section. It may be that highly motivated doctoral students (Geven et al., 2018; Kogovsek et al., 2011; R. Ynalvez et al., 2014), with high levels of self-efficacy in research (Kahn & Scott, 1997), are the top tier students who gain funding (Horta et al., 2019) and also choose to spend many more hours per week working on their publications and, thereby, outperform their peers (Kwiek, 2018). Kahn and Scott (1997), Horta et al. (2019), and Kwiek's (2018) studies measured the attributes of self-efficacy in research, funding status, and hours spent on research, respectively, these data were not available in this study, but are worthy of further investigation.

An unexpected finding in this study was the higher proportion of international (25%) than domestic (19%) students who were both research productive (four or more papers) and efficient completers. It

is well documented that international students, regardless of whether they are studying in the UK, Australia, Scandinavia, New Zealand, Europe, or the USA, tend to be faster completers than domestic students (Geven et al., 2018; Spronken-Smith et al., 2018; Torka, 2020; Zhou & Okahana, 2019). What is noteworthy is that in our study population 29.3% of the doctoral students did not list English as their primary language, and yet 65.7% of them published one or more papers, with an average of 3.60 papers. There was a negligible difference in the average output of papers between students who did not speak English at home and those who did, at 3.60 and 3.65 papers (per publishing student), respectively. Adding weight to this finding is that only peer-reviewed journal articles deemed of quality by ERA that candidates published as a primary author were included in the dataset. This finding is likely to be of interest to prospective international students considering studies abroad in that it shows that a student's country of origin or home language need not be a barrier to high levels of achievement, with the caveat that they are recipients of high-quality researcher training and support. This finding adds gravitas to the concerns raised in Africa by Fisher et al. (2020) and Olibie et al. (2015) around inadequate researcher training hindering student productivity.

Discipline-Related Differences in Outputs

This study examined the association between publishing during a PhD and discipline. Based on a review of literature, the authors hypothesized that the number of peer-reviewed journal articles that a candidate publishes as a primary author is associated with the discipline (Hypothesis 2). The results show that research productivity is associated with discipline, which was the expected result, and is in keeping with Shin and Cummings' (2010) model in which discipline is one of the predictors of research productivity. Our results rank the discipline of health ahead of biological sciences, agricultural and environmental sciences, and chemical, earth, and physical sciences, respectively, in terms of the proportion of candidates that produced the higher category of publications (namely, four or more).

Not only was a higher proportion of candidates in health fields of research (37.8%) more productive, but a lower percentage of candidates in the discipline failed to publish during their candidature, compared to candidates in chemical, earth, and physical sciences where the converse occurred (15.7% and 40.2%, respectively). To account for these results, we draw on the scholarly findings of forerunners in the field while providing the perspective of a research-intensive university in Australia. Our finding, which ranked the proportion of candidates in health fields of research as more productive than other science disciplines roughly aligns with a pattern seen in Norway. The comparison must be guarded with caution, as the Norwegian study was an analysis of the proportion of article-based PhD formats, whereas our study focuses on the proportion of candidates that published four or more papers and includes a 24 month period following thesis submission. While the results are not directly comparable, nonetheless, the rankings of the proportion of article-based PhDs in Norway in 2010 placed health and medical fields (99%) above STEM disciplines (85%), whereas, in humanities monographs dominated (Thune et al., 2012). Hagen (2010) also ranked medical and health sciences above fisheries and natural sciences.

There are a number of likely reasons for discipline as a predictor of productivity that apply here. Pinheiro et al. (2014) attribute the high rates of publishing among STEM students in the USA to their co-authoring with a supervisor, noting "these rates nearly reaching 70% in some fields, such as chemistry and earth and atmospheric sciences" (p. 61). Likewise, at our institution, the majority of the papers published during the students' candidature, regardless of discipline, were co-authored by one or more of their supervisory team, which, with reference to the health sciences (Wildgaard & Wildgaard, 2018), increases the likelihood of success. Second, in certain disciplines, there is a sense of urgency to publish ones' findings ahead of others. Timely dissemination of knowledge may be the dominant driver of publishing for candidates in the discipline of health where results quickly become outdated, which would account for their outstanding results in this study. The findings of Eckmann et al. (2012), Guerin (2016), and Hauss (2020) reiterate this opinion with reference to health and also computer science. It can be argued that if speed of dissemination is the priority, conferences allow

for more rapid dissemination of findings (Björk & Solomon, 2013), but it is not uncommon for conference presentations to precede journal publications (Hauss, 2020). Although this study did not assess conference presentations, which may skew our results against some disciplines (Hauss, 2020), the findings of Mason and Merga (2018a) may indicate otherwise in that their analysis of theses submitted for examination showed that 86% of all the papers within the theses (humanities and social sciences fields in Australia) were journal articles whereas conference proceedings, book chapters, and other forms of publications comprised <10%. Regardless of the reasons, publishing will likely enhance career advancement prospects and, therefore, should be encouraged and supported through targeted support and training programs.

A third factor accounting for discipline-related differences is the motivator behind timely publishing. Preference for publishing or "interest in research" (see Kahn & Scott, 1997) is likely different for candidates in the discipline of health compared to those in other disciplines. In our study, anecdotal evidence indicates that students who are well-established in health professions have research translation into practice as their primary interest in doing research. Research translation has also been identified as the driver of clinician-scientist publishing in Canada (D'Alimonte, 2016) and Germany (Monzer et al., 2019). Research translation into practice to improve patient health outcomes is the primary concern of the major funding body of health research in Australia (the National Health and Medical Research Council [NHMRC], 2018). The NHMRC recommends that health practice be informed by rigorous evidence-based research, best achieved through timely dissemination via reputable journals.

A reason for students not publishing is that they may be working in a field in which meaningful data are only produced after a protracted period. Publishing-as-you-go is not universally suitable for all fields of research (Robins & Kanowski, 2008), which may account for the high proportion of students in agricultural and physical sciences in this study who produced no publications. The findings of Jowsey et al. (2020) support this stance. In Poland, the preferred practice in humanities and social science disciplines is for faculty to disseminate their research findings via books rather than journal articles, thus, Kwiek (2018) reflects the preference by giving greater weight to books (above articles) in the study methodology. A key variable determining the top 10% of faculty research productivity within disciplines, was the amount of time that faculty spent working on their research (that is, their preference for publishing) compared to the time they spent on competing academic activities (such as teaching) (Kwiek, 2018). Notwithstanding the cultural and discipline-related differences, Kyvik and Olsen (2014) report a growing trend in publication-based theses in disciplines traditionally associated with monograph submissions.

The Effect of Research-Focused Training and Support

To investigate the association between engagement in a cohort program and both publishing during a PhD and completion time, two hypotheses were tested. Namely, doctoral candidates who engage in a cohort program publish more journal articles than their discipline peers who do not belong to a cohort program (Hypothesis 3) and also have a shorter time-to-thesis submission than their discipline peers external to a cohort program (hypothesis 4). The results show a significant difference between cohort students and their peers within the discipline in the proportion of students publishing four or more papers (60% and 34.7%, respectively) and median time-to-degree (3.35 and 3.97 FTE years, respectively). By keeping the analysis intra-discipline, the possible effect of compounding variables was minimized; that is, the culture and the structuration were uniform, and many of the supervisors in the discipline oversee both candidates within and external to the cohort program. Essentially what was tested was the cohort effect (of gaining additional mentoring, research and publication-focused training, working collegially, and peer-assisted learning). Examining the data within the discipline of health allows the authors to respond to a question raised earlier in the paper, namely, are research productivity differences attributable to discipline "culture" or to the collegial effect of working with peers and mentors? By removing the possible confounding variable (discipline "culture"), the results

indicate that the latter effect (of gaining additional mentoring, research and publication-focused training, working collegially, and peer-assisted learning) appears to exert a stronger influence on the productivity and efficacy of students than discipline culture. If no significant differences were found (between the students within and external to the cohort) then the performance of the students would likely be attributable to a discipline phenomenon.

Building on the findings of Ehrenberg et al. (2007), Green et al. (1992), R. Ynalvez et al. (2014), and Horta et al. (2019), this paper *quantifies* the effect of gaining additional research-related training, not in terms of graduation versus attrition, but as a measure of the number of peer-reviewed journal papers published as a primary author. Furthermore, of greater relevance than the statistical significance of the cohort effect are the implications of this finding for practice. If working collaboratively and peer-assisted learning leads to improved research outcomes, we argue that these factors might apply across a number of disciplines. Working collaboratively does not need to be limited to specific disciplines. In our study, all candidates had access to research training through a centralized Graduate Research School, but it was the candidates in receipt of "additional" support, peer-assisted learning, and training that exhibited significantly higher levels of research productivity and efficacy than their discipline peers. As with Laurance et al. (2013), who demonstrate raised productivity among biology students who publish early in their PhD, our students are required to produce a publication plan at the outset of their candidature and are encouraged to publish from an early stage. Publishing-as-you-go provides students with manageable short-term goals (in keeping with their submission deadline). By the end of data collection, students who have published find that much of their thesis is already written, which, for hybrid formats, reduces the time-to-thesis submission. Doctoral cohort programs have a role to play in encouraging and building student motivation to publish. In short, the cohort mentors help students to help themselves. The results point to the potential value of adopting this research-focused training and support approach (cohort model) across *multiple disciplines* but tailored to the norms and needs of the students within the particular fields of research.

Study Limitations

Despite the significant findings, a shortcoming of our study is that, as a purely quantitative study, we were not able to assess which of the "support to publish" components or other training and personal support elements in the cohort program exerted the greatest influence on research productivity and efficiency. It is difficult to disentangle the compounded effect where a suite of measures is in place, as in the cohort program. The complexity of variables influencing doctoral performance is captured by Hlebec et al., (2011, p. 167) who comment:

> "Some doctoral students may be very motivated and have excellent study skills, but do not receive much support from their supervisors or colleagues. Some others might have a conflictive or ambiguous relationship with their supervisors, but compensate for the lack of support from their supervisor with support from their colleagues. Other doctoral students might be more vivacious, more outgoing, have an excellent relationship with everybody, but lack the motivation to work systematically on demanding job tasks".

It may be that different elements of the cohort program in the discipline of health at our institution met the different needs of various students at specific points in time, or it may be that it is the combined effect of all that the program delivers which is effective in raising productivity and efficacy. Notwithstanding the limitations of our research, the authors aim to address the shortcomings outlined above by conducting a qualitative study with the same cohort graduates. While we plan to assess the strength of the effect of the individual support and training components comprising the program, we recognize the complexity of this endeavor.

CONCLUSION

This paper sheds light on how important it is to publish during doctoral studies. Both publishing during doctoral studies and completing within the recommended time are of value to candidates and universities alike, but, to date, there has been a paucity of empirical evidence addressing the combined effect of the two variables. This paper addresses a gap in the literature by providing quantitative evidence of the association between publishing during doctoral candidature and time-to-degree in the disciplines of health, biological sciences, agricultural and environmental sciences, and chemical, earth, and physical sciences. The finding that publishing four or more articles was associated with a shorter time-to-degree should be of interest to students who have a choice on the format of their ultimate PhD submission, particularly where there are concerns that publishing may extend their candidature. The clear evidence that engaging in a supportive cohort program led to both higher research productivity and greater efficiency is a significant finding of relevance to faculty responsible for researcher training. The authors postulate that it is the combined effect of having a strong emphasis on both timely completion and timely publishing, backed up with concomitant, appropriate research and publication-focused training, that sets the cohort program graduates apart from their discipline peers and those from other fields of research. This finding should be of interest to university policymakers and faculty involved in researcher training, regardless of their discipline, institution, or global locality as it highlights the potential to elevate doctoral student outcomes. Within fields of research where publishing during candidature is the "norm," the results presented show that providing candidates with targeted additional support can further raise research productivity and efficiency.

There has been much research into programs or approaches aimed at improving the experience, wellbeing, or completion rates of doctoral students, but the findings of this paper advance past research by providing insights on the predictors of scholarly efficiency with productivity. While it may be that candidates who work within cohort programs characterized by a strong performance orientation, surrounded by highly research productive colleagues, are stimulated to raise their own performance above the median, on a cautionary note, there is a balance to be achieved to avoid burdening scholars with the pressure to publish. For this reason, encouragement towards timely achievements is best delivered in care and with concern for student wellbeing and personal growth. While these elements characterize the cohort program, it is important that these characteristics are further investigated via follow-up qualitative investigations. The quantitative findings presented in this paper provide a sound baseline of statistically significant evidence from which to design a qualitative study.

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