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A systematic review of doctoral graduate attributes: Domains and definitions

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Doctoral graduate attributes are the qualities, skills, and competencies that graduates possess, having completed their doctorate degree. Graduate attributes, in general, lack conceptual clarity, making the investigation into and quality assurance processes attached to doctoral outcomes challenging. As many graduate attributes are "unseen" or implicit, the full range of attributes that doctoral graduate actually possess needs to be synthesized, so that they may be recognized and utilized by educational stakeholders. The aim of this study was to establish and describe what attributes graduates from doctoral degrees possess. A systematic review of peer-reviewed, primary literature published between January 2016 and June 2021 was conducted, identifying 1668 articles. PRISMA reporting was followed, and after screening and full text critical appraisal, 35 articles remained for summation through thematic synthesis. The doctoral graduate attribute domains identified included knowledge, research skills, communication skills, organizational skills, interpersonal skills, reputation, scholarship, higher order thinking skills, personal resourcefulness, and active citizenship. Many of the domains were conceptualized as transferable or interdisciplinary, highlighting the relevance of the attributes doctoral graduates possess. The review findings align with existing frameworks yet extend those that tend to focus on generic "seen" attributes, and include a range of "unseen", intrinsic qualities as outcomes of the doctoral degree. The review contributes to the conceptual development of doctoral graduate attributes, by synthesizing actual outcomes, as opposed to prospective attributes or attributes-in-process. Doctoral graduate attributes should be conceptualized to integrate both generic attributes alongside intrinsic qualities that are important for employability. Increased awareness as to the scope of doctoral graduate attributes among stakeholders, such as doctoral supervisors, students, graduates and employers, may facilitate improved educational outcomes and employability. Future research into the contextual relevance of the domains identified and how they are developed may be beneficial. Future research could involve the development of context-relevant scales to empirically measure doctoral graduate attributes among alumni populations, as a quality assurance outcome indicator. Such findings could inform program reform, improving the relevance of doctoral education and the employability of doctoral graduates.

Introduction

Doctoral graduate attributes are defined as the qualities or characteristics of a doctoral graduate, integrating skills, knowledge and competencies with doctoral identity (Yazdani and Shokooh, 2018). Graduate attributes are of interest within the context of higher education quality assurance and the international focus on producing skilled and employable graduates (Bitzer and Withering, 2020). Graduate attributes are typically defined institutionally and embedded in curriculum learning outcomes (Bridgstock, 2009; Mashiyi, 2015). However, doctoral degrees often lack a standardized curriculum, with the primary focus being original research under supervision (Elliot et al., 2016; Molla and Cuthbert, 2016), leaving no formal frame into which doctoral graduate attributes may be embedded. The transferability of graduate attributes is an important consideration for higher education institutions, so that the attributes instilled are relevant to multiple work contexts, enhancing graduate employability (Kensington-Miller et al., 2018). This is particularly relevant in the context of doctoral education, with the shift away from the thesis as the primary outcome, and the increased demand for transferable skills to the increasingly competitive world of work (Denicolo and Reeves, 2014). Doctoral graduate attributes, as outcomes of doctoral education, are important to consider for quality assurance, the employability of graduates, and the relevance of doctoral education.

Graduate attributes are generally critiqued as lacking conceptual clarity (Mowbray and Halse, 2010; Bitzer and Withering, 2020). This conceptual ambiguity is reflected in the "range of adjectives such as "transferable", "generic", "soft", "key", "graduate" and "employability" [that] have been diversely paired with nouns such as "skills", "attributes", "outcomes" and "capabilities"" (Kensington-Miller et al., 2018, p. 1440). In short, the following differentiations between terms may be made: "competence" is a performance-based term, referring to successful or efficient performance whereas "competencies" refers to the knowledge and behaviors that, if utilized effectively, result in competent performance (Potolea, 2013; Durette et al., 2016). "Skills" are typically learned abilities or expertise, but can be more broadly defined to include "the acquisition or development of specific capacities, abilities, aptitudes or competencies" (Gilbert et al., 2004, as cited by Mowbray and Halse, 2010, p. 655). "Attributes" refers to the inherent characteristics or features of someone or something. By extension, doctoral graduate attributes would be the features or characteristics of doctoral graduates, and may thus be an umbrella term that integrates skills, knowledge and competencies, as expressed by Yazdani and Shokooh (2018). This definition allows for the multidimensional and interrelated nature of the qualities and skills doctoral graduates possess (Mowbray and Halse, 2010).

Measuring graduate attributes is complicated, partly due to the conceptual ambiguity noted. Graduate attributes are typically developed longitudinally, making them challenging to operationalize, and context dependent, limiting the generalizability of scales (Hughes and Barrie, 2010; Cavanagh et al., 2015; Nell and Bosman, 2017). Graduate attributes often include a combination of skills, dispositions, values, and competencies that may be more abstract and difficult to quantify (Hinchliffe and Jolly, 2011). Many graduate attributes are "unseen" or "invisible" as they may reflect the qualities of the person, and are not as explicit as those clearly embedded in the curriculum or formal degree processes (Kensington-Miller et al., 2018). These "invisible" attributes are often implied, yet are important to consider for a graduates' overall profile, such as resilience (Kensington-Miller et al., 2018). It is important to synthesize evidence on what attributes doctoral graduates actually do possess, in order to reconsider the scope of what is included in traditional lists of doctoral graduate attributes. In so doing, due consideration may be given to the "unseen" attributes that are outcomes of the doctoral degree. The notion of implicit attributes in parallel to those explicit to the "product" of the degree, aligns with the shift of focus in doctoral education from focusing exclusively on the production of the doctoral thesis, to include the holistic development and tacit learning involved in the doctoral journey (Mowbray and Halse, 2010; Yazdani and Shokooh, 2018). Despite the challenges associated with conceptualizing graduate attributes, they remain pertinent to assess (Bitzer and Withering, 2020).

There has been significant investment in improving postgraduate education, including the implementation of transferable skills development, particularly in the Global North (Denicolo and Reeves, 2014). This has given rise to various models and frameworks related to researcher attributes and doctoral competencies. One of the most widely used frameworks, particularly in the United Kingdom, is the Researcher Development Framework (Vitae, 2010). According to Reeves et al. (2012, p. 4), "the purpose of the framework is to support the development of individual researchers while enhancing our capacity to build a workforce of world-class researchers within the UK higher education research base." As such, it can be used to facilitate qualitative reflection on one's development, and encompasses a wider view of researcher career progression, beyond the doctorate degree. Similarly, the Researcher Skill Development Framework (Willison and O'Regan, 2008/2015), developed in the Australian context, provides a developmental framework of research-related skills and agency, from first year undergraduate studies to established academics. The framework includes a qualitative matrix that may be well suited for developmental use in the context of doctoral supervision, or for curriculum development, rather than as an outcome indicator. The competence model for science, engineering and technology (SET) Ph.D. students and

graduates (Nikol and Lietzmann, 2019), in the broader European context, pertains to the doctorate, yet is focused on SET disciplines only and is curriculum focused, rather than outcomes focused. Notably, all of the above frameworks were developed in the Global North. In general, these models have been used with focus on the development of doctoral education and training, including formal curriculum and transferable skills development programs. They are well suited to use for personal, qualitative reflection on one's skill development. In the South African context, the Council for Higher Education (CHE, 2018) has compiled the qualification standards for doctoral degrees, including a prospective list of graduate attributes, with five knowledge and four skill domains. However, these domains are not theoretically defined or clearly operationalized.

The Researcher Development Framework was validated prior to its launch in 2011 (Reeves et al., 2012). Since then, there has been extensive ongoing work in the field of doctoral education and efforts to develop context and field specific models, such as CHE (2018) and Nikol and Lietzmann (2019). Further, many institutional or governmental frameworks are aspirational ideals of the attributes institutions hope graduates will possess (Kensington-Miller et al., 2018) that do not necessarily reflect the attributes that graduates actually do possess when they graduate. As such, there is a need to identify what recent evidence there is of the attributes doctoral graduates possess after completing their doctorate degrees. The focus of the models above aligns with the typical focus of doctoral education evaluation: the doctoral process and student experiences during the doctorate (Luo et al., 2018). However, doctoral graduate attributes also need to be conceptualized as outcomes, rather than prospective qualities, in order to facilitate good, empirical quality assurance (Harley, 2020). Therefore, the target population for evaluating graduate attributes as outcomes should be graduates who have completed their degree. As noted by Durette et al. (2016, p. 1356):

> Ph.D. students might not be the adequate population to study competencies developed during doctoral training since (1) they have not finished it entirely and (2) Ph.D. students might not be well aware of the competencies they have developed… in particular because they have not had the opportunity to exercise these competencies in other professional contexts.

There is a need to consolidate evidence of doctoral graduate attributes from the perspective of graduates only, excluding student populations. In so doing, a synthesis of the doctoral graduate attributes as outcomes, once the doctorate has been completed, may be possible. This may give preliminary indications of the extent to which developmental models used in curriculum and personal development, such as those identified above, have translated into real outcomes for doctoral graduates.

Limited empirical research exists attempting to synthesize graduate attributes (Bridgstock, 2009). The Researcher Development Framework is an example of extensive work toward synthesizing doctoral graduate attributes (Reeves et al., 2012). A recent example is the conceptual analysis of "doctorateness" by Yazdani and Shokooh (2018) that included literature published between 1995 and 2016. While the study appears to follow some review processes, it does not reflect the rigor required of a systematic review (Page et al., 2021). The article provides a synthesis of "doctorateness" as a concept, however, the findings were limited to broad categories of attributes, without definitions or detail as to what these domains entail. Further, much literature has been published since 2016 that warrants consideration. Therefore, there is a gap in the consolidation of more recent literature that bears global evidence of the attributes that doctoral graduates possess.

The aim of this review was to establish and describe what attributes graduates from doctoral degrees possess, through a systematic review of recent, high-quality research literature. The objectives of the review were: (1) to identify doctoral graduate attribute domains and sub-domains, and (2) to clarify their theoretical and/or operational definitions.

Methods

Study design

A systematic review is a rigorous, systematic process used to filter and synthesize available evidence on a topic (Laher and Hassem, 2020). There is a need to filter evidence to focus on a specific perspective, i.e., that of doctoral graduates, to the exclusion of doctoral students, in order to consolidate recent evidence of what attributes doctoral graduates actually possess, specifically focusing on the conceptualization of doctoral graduate attributes as outcomes of the doctoral degree. A systematic review is a suitable method to filter the available evidence and synthesize the various definitions and iterations of doctoral graduate attributes. Systematic reviews are recommended for use in scale development, as part of identifying and clarifying the scale construct (Munnik and Smith, 2019), and thus are a suitable method for facilitating conceptual clarity of a constructs, such as graduate attributes.

Review question

The systematic review question was: what attributes do graduates from doctoral degrees possess? The formulation of PEO (population, exposure and outcome) was used (Moola et al., 2020), with doctoral graduates as the population, the doctoral degree as the exposure, and doctoral graduate attributes being the outcome.

Eligibility

Inclusion and exclusion criteria were set *a priori*, to systematically determine which articles to include (Gough et al., 2017). Articles had to meet the following criteria to be eligible for inclusion:

1. The participants were graduates from doctoral degree programs (any discipline, no geographic limitation, no specified timeframe since graduation);
2. A clear focus on the attributes of doctoral graduates must be present (e.g., skills, competencies, abilities);
3. Qualitative, quantitative and mixed-methods research were considered; and
4. Published between January 2016 and June 2021, to ensure that recent literature on the topic was included.

Articles were excluded if they were not published and peer reviewed. Gray literature, such as theses and conference proceedings, were excluded. Articles that were not accessible in full text and in English were excluded. The University of the Western Cape (UWC) library assisted in locating full text and English translations, where necessary.

Information sources

Databases were accessed through uKwazi, a composite search function available through the UWC library. Databases included: Academic Search Complete, Directory of Open Access Journals, EBSCOhost, Emerald Journals, JSTOR, Sabinet, SAGE, Springer, Taylor and Francis, and Wiley. The use of uKwazi allowed for a comprehensive, composite search of all databases simultaneously, using the same search terms and limiters, thus enhancing the systematic nature of the review. The use of this platform automatically excluded duplicate articles, streamlining the screening process.

Search strategy

The PEO model was used to develop search strings, as shown in Table 1. The population of interest was doctoral graduates who completed their degree, thus excluding students, as the focus was specifically on attributes as outcomes. The term "graduate" was used to ensure specificity, as the inclusion of "student" would have resulted in too wide a search. The search terms related to exposure referred to the pursuit of the doctoral degree and was intentionally general to include various formats of doctoral degree study. The search terms included "doctorate OR doctoral OR Ph.D.", which would include any combination of fields of study, for example, professional doctorate, Doctor of Education, or Doctor of Philosophy. This was intentionally

TABLE 1 Search strategy.

PEO	Search string	Search filters
Population	Graduate	Any field
Exposure	Doctorate Or doctoral Or Ph.D.	Subject contains
Outcome	Abilities OR attributes OR capabilities OR capacities OR characteristics OR competencies OR identity OR outcomes OR qualities OR skills	Any field

kept broad, as many studies did not specify what kind of doctorate was reported on or included mixed groupings from various types of doctorates. The outcome of doctorate graduate attributes, for which the search string was kept general, to include various iterations of nouns used in relation to doctoral graduate attributes.

The search strings were compiled into a Boolean phrase, as indicated in Table 1 that was entered into uKwazi for a composite search of all databases simultaneously. The first and third strings were searched in all fields, to include titles, abstract and subject. The second string was searched only in the subject field, to exclude irrelevant articles that were included in the search due to the authors' credentials (e.g., Ph.D.). The composite search was limited to include only articles, available in English, peer reviewed, with full text available online, and published between 2016 and 2021—in alignment with the inclusion and exclusion criteria. These limiters were applied on the search platform as part of the search process, prior to recording the search results.

A second search, using the single search term "doctorateness" (any field) was conducted through uKwazi. The same limiters were applied. The supplementary search was conducted to ensure that potentially relevant articles were not unintentionally excluded.

Study selection

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was followed to ensure methodological rigor and transparency in reporting (Page et al., 2021). The citation information of each article identified in the search was imported into Rayyan, an online systematic review platform (Ouzzani et al., 2016). Rayyan was utilized to streamline the review process and enhance reporting, as it facilitated dual review and tracking of exclusion reasons. Two reviewers independently screened the titles and abstracts for relevance against the inclusion and exclusion criteria. Articles that did not meet all the inclusion criteria or met at least one of the exclusion criteria were excluded. The full texts of all

remaining articles were retrieved and screened for eligibility, against the inclusion criteria. Reviewers independently screened each article, noting reasons for inclusion or exclusion. Disagreements were resolved through discussion.

Quality appraisal tool

The methodological quality of the remaining articles was assessed through the Smith, Franciscus and Swartbooi (SFS) full text critical appraisal tool, version E (Smith et al., 2015). The tool includes three sections: (A) purpose, including problem statement, literature and theoretical framework (22 points); (B) methodological rigor, including design, sampling, data collection, data analysis, results, discussion and conclusion (52 points); and (C), general considerations of publication and peer review status (5 points). A minimum threshold score of 60% (strong to excellent quality) was set that must be met for inclusion in the review (Smith et al., 2015), to ensure that only high quality research was included. The critical appraisals were independently conducted by two reviewers. Articles with scores that differed by five or more points were reviewed through discussion ($n = 4$), until consensus was reached.

Data extraction and synthesis

A self-developed data extraction table was used to extract descriptive data (location, design, sample etc.) and analytic information relating to the doctoral graduate attribute domains and definitions. The review findings were analyzed using thematic synthesis (Gough et al., 2017). Thematic synthesis is the equivalent of thematic analysis in primary research, and follows a similar process of coding and theme development (Gough et al., 2017). The coding process employed was selective, focusing primarily on the findings reported (Gough et al., 2017), for example, the attributes doctoral graduates indicated they possessed after having completed their studies. A hybrid inductive-deductive approach was used, with a primarily inductive approach was used for the initial coding, with codes emerging from the text (Xu and Zammit, 2020). A deductive approach was utilized for subsequent readings of the articles, to identify potential codes that may have been overlooked in the initial coding, and for theme development to group the codes into subdomains and domains. The deductive approach drew on existing literature related to doctoral graduate attributes, such as Vitae (2010), Yazdani and Shokooh (2018), and Nikol and Lietzmann (2019). In order to compare the findings of the review to existing models, selected frameworks were coded, using a deductive approach, to facilitate mapping against the domains and subdomains identified in the review. In some instances, the detail of descriptions differed, and so it was not always possible to map to the models exactly.

Ethics considerations

This review is part of a broader study, which obtained ethics clearance from the Humanities and Social Sciences Research Ethics Committee at UWC (HS21/7/19). Secondary data collection in the form of a systematic review does not require consent. However, consideration of the ethical practice and quality of each article under review, through critical appraisal, ensured the quality of the review findings. The authors of the original work were appropriately cited, so that there was no infringement on intellectual property or copyright. Only sources available in the public domain were utilized, and those that the researchers had legal access to through their institution. Furthermore, permission for the use of the SFS critical appraisal tool was obtained from the author.

Results

The findings of the review include the outcome of the study selection process, the quality appraisal of articles, the descriptive characteristics of the studies in the review, and the doctoral graduate attributes domains, subdomains and descriptions that were identified.

Process results

A total of 1,701 articles were identified in the review (Figure 1). Duplicates were automatically excluded in the comprehensive, integrated search through uKwazi. Duplicates between searches one and two were manually removed ($n = 33$). Studies were manually excluded if they were secondary studies (e.g., reviews; secondary analysis), did not include reporting on primary data (e.g., letter to editor; theoretical papers), were outside of the publication range (first published prior to January 2016 or after June 2021); included the incorrect population (graduates from other degree levels; Ph.D. student populations without any Ph.D. graduates represented; or did not allow for differentiation between graduates and students); the incorrect exposure (e.g., did not explicitly relate to the Ph.D.); or the incorrect outcome (e.g., focus on doctoral experience or attributes needed for completion, without explicit mention of attributes possessed on completion). A total of 35 articles met all criteria and were included in the review.

Quality appraisal results

All studies included in the review ($n = 35$) exceeded the threshold score of 60% in the quality appraisal stage (Table 2), and thus had strong to excellent methodological quality (Smith et al., 2015). A common methodological gap identified in articles

FIGURE 1
PRISMA flowchart of data collection and screening [Adapted from Page et al. (2021)].
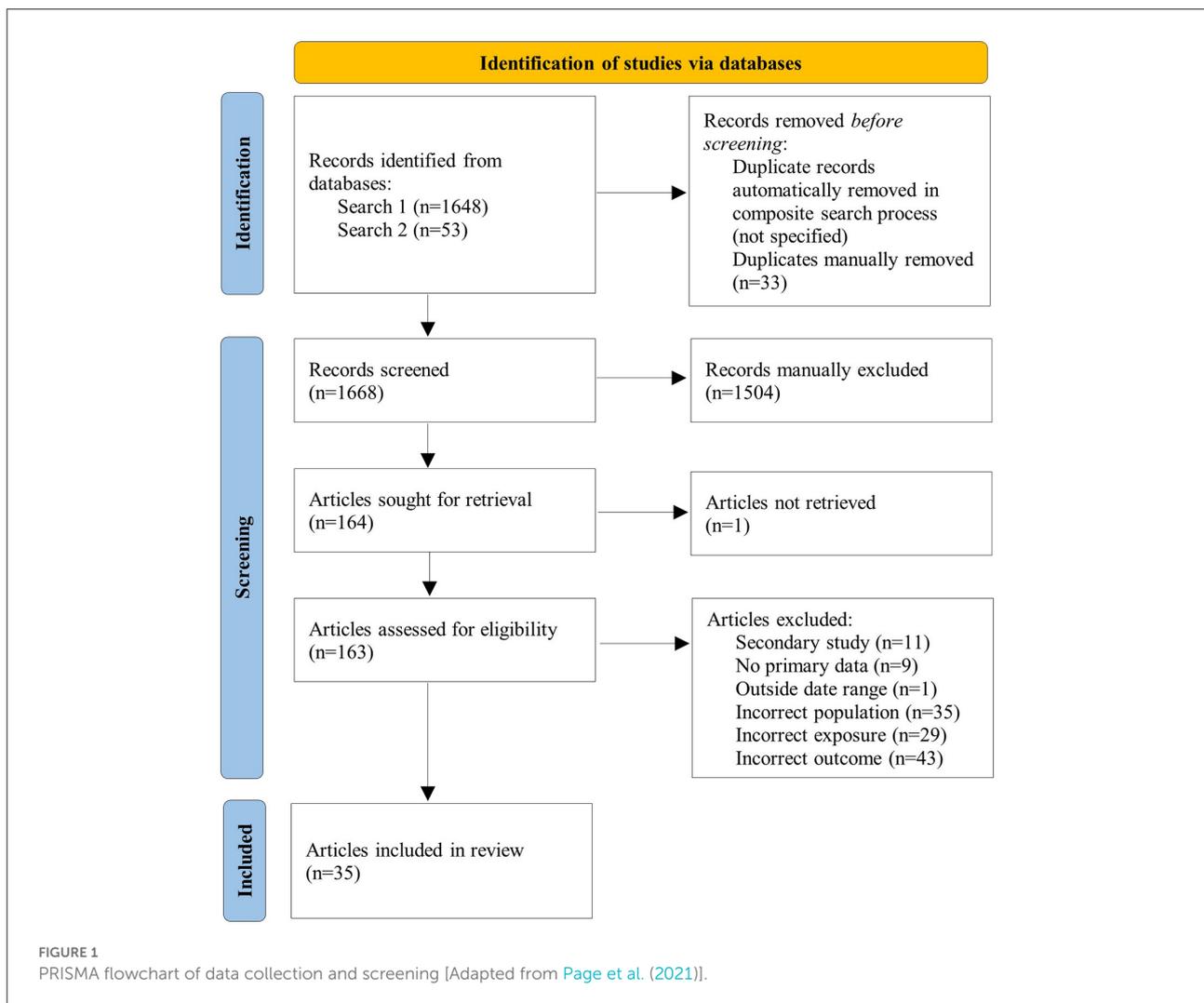
through the appraisal was not reporting on the analysis methods used ($n = 18$). The focus of the review was on the domains relating to doctoral graduate attributes covered, so the actual results of the studies under review were not the primary focus. Further, the review was descriptive, thus the goal was not generalizability. There was sufficient evidence of methodological quality in the articles included for synthesis.

Study characteristics

The studies included in the review ($n = 35$) represented various universities internationally (Table 3). Graduates from universities in the United States of America (USA) ($n = 9$), Australia ($n = 8$), and the United Kingdom (UK) ($n = 7$) were most strongly represented. Graduates from universities across Europe (Belgium, France, Germany, Ireland, Poland, Portugal, Spain, Sweden, Switzerland, and the UK), North America (USA and Canada); Asia (Bhutan, China, Japan, and Malaysia), and

Africa (South Africa) were represented. Most studies focused on a single country ($n = 28$), if not a single university within that country. Cross-country comparisons were evident in seven studies. The studies reflected greater representation of graduates from institutions in the USA, Australia and the UK. This aligns with the USA and UK being among the top producers of doctoral graduates among Organization for Economic Co-operation and Development (OECD) countries (OECD, 2019). There was low representation of graduates from universities in Asia, yet there has been noted growth in doctoral enrolments in China specifically since the early 2000s (Luo et al., 2018). While there was lower representation of graduates from African institutions, it is unsurprising that the two studies included represented graduates from South African institutions, as there has been significant local investment in doctoral education in recent years, and South African higher education institutions attract doctoral students from various African countries (Molla and Cuthbert, 2016). There was no representation of graduates from institutions in the Middle East or South America. Due to

TABLE 2   Quality appraisal scores of included articles.

No.	Author (Year)	Score %	Quality
1	Adham et al. (2018)	80	Excellent
2	Ai (2017)	69	Strong
3	Allgood et al. (2018)	70	Strong
4	Bitzer and Matimbo (2017)	71	Strong
5	Boud et al. (2021)	81	Excellent
6	Boulos (2016)	63	Strong
7	Bröchner and Sezer (2020)	69	Strong
8	Bryan and Guccione (2018)	77	Strong
9	Caretta et al. (2018)	74	Strong
10	Creaton and Anderson (2021)	78	Strong
11	Devos et al. (2016)	77	Strong
12	Draper and Harrison (2018)	60	Strong
13	Durette et al. (2016)	82	Excellent
14	Feldon et al. (2017)	82	Excellent
15	González-Ocampo and Castelló (2019)	75	Strong
16	Goodall et al. (2017)	70	Strong
17	Grab-Kroll et al. (2019)	82	Excellent
18	Granata and Dochy (2016)	78	Strong
19	Greene et al. (2021)	77	Strong
20	Guerin (2020)	75	Strong
21	Hager et al. (2019)	75	Strong
22	Holley (2018)	78	Strong
23	Kennedy et al. (2020)	82	Excellent
24	Kilbourne et al. (2018)	83	Excellent
25	Kowalczuk-Waledziak et al. (2017)	72	Strong
26	Lemon et al. (2020)	83	Excellent
27	Luo et al. (2018)	77	Strong
28	Maxwell (2019)	77	Strong
29	Maxwell and Chophel (2020)	75	Strong
30	McAlpine et al. (2020)	78	Strong
31	Merga and Mason (2021)	78	Strong
32	Merga et al. (2020)	72	Strong
33	Rabe et al. (2021)	69	Strong
34	Shih et al. (2019)	77	Strong
35	Walker and Yoon (2017)	80	Strong

increased trends of mobility and internationalization in higher education (OECD, 2019), it is likely that doctoral graduates from various nationalities were represented in the study, however, the nationalities of graduates were not consistently reported on.

The articles under review reported various methodologies, primarily interviews ($n = 13$), surveys ($n = 11$) or autoethnographies ($n = 7$). Sample sizes ranged from 1 (Boulos, 2016; Ai, 2017) to 2794 (Durette et al., 2016). According to the inclusion criteria, all studies included doctoral graduates. In Table 3, the graduate samples were classified as early career researchers (ECR) who graduated within the 5

years, mid-career researchers (MCR) who graduated between 6 and 15 years prior (Nguyen et al., 2020), and those who graduated more than 15 years prior. Studies focused primarily on ECR and MCR. Samples of only doctoral graduates were most common ($n = 23$). Mixed populations were included, where differentiation of the perspectives of graduates from other participants was possible. Some studies included faculty, supervisors, key persons in higher education, doctoral students and non-completers as participants. Most studies focused on a specific degree ($n = 26$), with education-related fields having the highest frequency ($n = 10$). The remaining studies ($n = 9$) included cross-disciplinary samples of doctoral degrees in science, technology, engineering and mathematics (STEM) and humanities, arts, and social sciences (HASS). There was a range of disciplines and fields represented, with good representation of both HASS and STEM fields. In half of the studies ($n = 17$), the doctoral degrees reported on were Doctor of Philosophy (Ph.D.). Professional doctorates were specified in a fifth of the articles ($n = 7$), indicated by "Doctor of [field name]", for example "Doctor of Education" or "Ed.D". The remaining articles did not specify if it was a Ph.D. or professional doctorate ($n = 11$). Given the greater prevalence of Ph.D. programs in comparison to professional doctorate programs, this may demonstrate good representation of both degree types. Neither type of doctorate nor field of study were gaps in the review. There were no notable trends in the type of doctorate, field of study, geographic location and emerging domains.

Scalar information on subscale(s) measuring dimensions related to doctoral graduate attributes were reported in six studies. Subscales addressing teaching (Allgood et al., 2018; Shih et al., 2019) and research skills (Luo et al., 2018; Shih et al., 2019) were used in two studies each. Subscales of general scientific competencies (Grab-Kroll et al., 2019), and universal skills (Luo et al., 2018) were identified. Two other studies (Walker and Yoon, 2017; Bröchner and Sezer, 2020) provided nominal information on the scales utilized, with insufficient detail to identify what domains were covered. The scales were either adapted from other studies (Allgood et al., 2018; Shih et al., 2019; Bröchner and Sezer, 2020), or self-developed for the study (Walker and Yoon, 2017; Luo et al., 2018; Grab-Kroll et al., 2019). Shih et al. (2019) was the only study to report on psychometric properties. Where information was available, subscales had between 2 and 13 items per domain. Items were most often in Likert scale format (Allgood et al., 2018; Luo et al., 2018; Grab-Kroll et al., 2019; Shih et al., 2019). Other formats used included continuous scales (Bröchner and Sezer, 2020) and multiple-choice formats (Walker and Yoon, 2017).

Doctoral graduate attributes

The studies under review rarely defined or mentioned doctoral graduate attributes explicitly, referring more

TABLE 3 Study characteristics.

Author (Year)	University location	Study design/method	Sample size	Participants[a]	Degree
Boulos (2016)	Ireland	Autoethnography	1	Doctoral graduate (ECR)	Ph.D. in Higher Education Research
Devos et al. (2016)	Belgium	Semi-structured interviews	21	Ph.D. graduates (timeframe not specified); non-completers	Ph.D.s in Science and Technology; Social Sciences; Health Sciences
Durette et al. (2016)	France	Open-ended survey	2794	Doctoral graduates (most ECR-MCR, some later)	Doctorates in Exact Sciences or Humanities
Granata and Dochy (2016)	Belgium	Narrative literature review and case study (semi-structured interviews)	14	Doctoral students (final year); doctoral graduates (ECR)	Academic and semi-industrial Ph.D. in faculty of electrical engineering
Ai (2017)	Australia	Narrative autoethnography	1	Doctoral graduate (ECR)	Ph.D.: school of Education
Bitzer and Matimbo (2017)	South Africa	Narrative approach (not specified)	2	Doctoral graduate (ECR); supervisor	Ph.D.: faculty of education
Feldon et al. (2017)	USA	Interpretivist interviews and focus groups	44	Doctoral students; postdoctoral researchers (ECR); faculty	Ph.D. in cellular and molecular biology
Goodall et al. (2017)	UK	Collaborative autoethnography	4	Doctoral graduates (ECR)	Professional doctorate in education (Ed.D)
Kowalczuk-Waledziak et al. (2017)	Poland; Portugal	Semi-structured interviews	16	Doctoral graduates (ECR-MCR)	Ph.D. in educational sciences
Walker and Yoon (2017)	Canada	Interpretivist in-depth survey (48) and interviews (15)	48; 15	Doctoral graduates (MCR-later)	Ph.D. in education
Adham et al. (2018)	UK; Malaysia; Australia	Semi-structured interviews	10	Doctoral graduates, now faculty (ECR-MCR)	Ph.D. in management fields
Allgood et al. (2018)	USA	Survey	569	Directors of graduate studies; departmental chairs; new Ph.D. graduate economists (ECR)	Ph.D. in economics
Bryan and Guccione (2018)	UK	Semi-structured interviews, with pre-screening questionnaire	22	Doctoral graduates (ECR-MCR)	Doctoral degrees in STEM or HASS fields
Caretta et al. (2018)	Sweden; UK; Australia	Collaborative autoethnography	4	ECR and MCR	Ph.D. in Geography
Draper and Harrison (2018)	Australia	Discussion paper with integrated questionnaire	8	Doctoral graduates (timeframe not specified); doctoral candidates	Doctor of Musical Arts (DMA)
Holley (2018)	USA	Longitudinal interviews	9	Doctoral students -> scholars (ECR-MCR)	Interdisciplinary Ph.D. in neuroscience
Kilbourne et al. (2018)	USA	Phenomenology: semi-structured interviews	16	Junior faculty (doctorate holders, timeframe not specified)	Doctorate degrees; not specified (likely athletics training)

(Continued)

TABLE 3 (Continued)

Author (Year)	University location	Study design/method	Sample size	Participants[*]	Degree
Luo et al. (2018)	China	Survey and in-depth interviews	2009	Doctoral students (about to graduate); doctoral graduates (ECR)	Doctoral degrees; not specified (likely agricultural fields)
González-Ocampo and Castelló (2019)	Spain	Structured narratives	61	Supervisors (doctoral graduates, timeframe not specified)	Supervising doctoral theses in HASS fields
Grab-Kroll et al. (2019)	Germany	Survey	188	Doctoral graduates (ECR-MCR) and students	Doctorates in (experimental) medicine
Hager et al. (2019)	Europe (countries not specified); USA	Case study: participant-observer conversations, open-ended survey	2	Doctoral graduates (ECR)	Doctor of Business Administration
Maxwell (2019)	Not specified (participants from Bhutan)	Open-ended questionnaire	25	Doctoral graduates (most ECR-MCR, 2 later); key persons in Bhutan HE	Doctorates in education fields
Shih et al. (2019)	USA	Survey	503	Doctoral graduates (ECR-later)	Doctoral programs in mathematics education
Bröchner and Sezer (2020)	Sweden	Survey	125	Doctoral graduates (ECR-later)	Ph.D. in construction engineering
Guerin (2020)	Australia	Narrative enquiry: semi-structured interviews	12	Doctoral graduates (ECR-MCR)	Ph.D.s in HASS fields
Kennedy et al. (2020)	USA	Semi-structured interviews	11	Doctoral graduates (likely ECR)	Ed.D online program
Lemon et al. (2020)	USA	Hermeneutic phenomenology: semi-structured interviews	9	Doctoral graduates (timeframe not specified)	Doctorate in Marriage and Family Therapy
Maxwell and Chophel (2020)	Not specified (participants from Bhutan)	Open-ended questionnaire	44	Doctoral graduates (most ECR-MCR, 1 later); key persons in Bhutan HE/civil service	Non-education doctorate (sciences, arts, social sciences)
Merga et al. (2020)	Australia	Qualitative, open-ended survey	246	Doctoral graduates (ECR)	Ph.D., thesis by publication in various fields
Boud et al. (2021)	UK; Australia	Collaborative enquiry	11	Doctoral graduates (ECR-MCR); academic faculty	Doctor of Professional Studies
Creaton and Anderson (2021)	UK	Semi-structured interviews	25	Doctoral graduates (ECR-MCR)	Professional doctorates in business and management education
Greene et al. (2021)	USA	Collaborative autoethnography	4	Doctoral graduates (ECR)	DMA music education

(Continued)

TABLE 3 (Continued)

Author (Year)	University location	Study design/method	Sample size	Participants	Degree
Luo et al. (2018)	China	Survey and in-depth interviews	2009	Doctoral students (about to graduate); doctoral graduates (ECR)	Doctoral degrees; not specified (likely agricultural fields)
McAlpine et al. (2021)	UK; Switzerland	Narrative, cross-case approach (survey, interviews, secondary data)	24	Ph.D. graduates (ECR-MCR)	Ph.D.s in HASS; STEM
Merga and Mason (2021)	Australia; Japan	Semi-structured interviews	30	Doctoral graduates (ECR)	Ph.D. in HASS; STEM
Rabe et al. (2021)	South Africa	Collaborative autoethnography	5	Doctoral graduates (ECR); supervisor	Doctorate in Sociology

In ascending order, by publication year, then alphabetically by first author.

[a]Doctoral graduates classified by time since graduation: early career researcher: 0–5 years since completion of doctorate; mid-career researcher: 6–15 years of doctorate completion (Nguyen et al., 2020), and later: 16+ years since graduation.

often to the impact of the doctorate or the experiences of doctoral graduates. Related terms, such as competence, competency and competencies were noted. Greene et al. (2021) defined competence as "knowing negotiated within a single community of practice" (p. 95), suggesting that competence is context specific. Durette et al. (2016) defined competency by differentiating between the output, competent performance, and input—the "underlying attributes required for a person to achieve competent performance" (Hoffmann, 1999, as cited by Durette et al., 2016, p. 1356). Durette et al. (2016) further defined competencies as "the resources available to doctorate holders to act competently" (p.1357). While these definitions differ, they all point to the definition of doctoral graduate attributes adopted for this study, which includes the qualities, skills, and competencies that doctoral graduates possess. Interestingly, of the frameworks and models identified previously, only two articles mentioned the Researcher Development Framework (Bryan and Guccione, 2018; Creaton and Anderson, 2021), and this was in the introduction of the articles. These articles were two of the seven articles reflecting research conducted in the UK context, where the Researcher Development Framework was developed. As such, is appears that none of the articles under review explicitly drew on the conceptual and theoretical development that is evidenced in the existing models.

The studies addressed a wide range of doctoral graduate attributes identified as outcomes of the doctoral degrees mentioned in the studies. The domains include: knowledge, research, communication, organizational skills, interpersonal skills, scholarship, reputation, higher order thinking skills, personal resourcefulness, and active citizenship (Table 4). Theoretical definitions of the actual domains identified in the studies were sparse, lacking theoretical or conceptual frameworks. These definitions were more general and process-oriented, not linked to a specific domain. Theoretical

definitions for the identified domains and/or subdomains are provided, where available. Thereafter, descriptions of what these attributes entail are provided, i.e., how they may be operationalized.

Knowledge

The first domain of "knowledge" included codes that related to the knowledge doctoral graduates possessed ($n = 18$). This excluded knowledge that explicitly related to "research", as these were included under a subsequent domain. There was no explicit definition of "knowledge" in the articles under review. However, Adham et al. (2018) made reference to explicit and tacit knowledge, differentiating between knowledge that can be communicated or shared with others, and knowledge that is not as easily communicated. Knowledge development was defined as the processing of information within the individuals' "foundations, understanding, experience and beliefs" (Adham et al., 2018, p. 813). The various types of knowledge that doctoral graduates possessed were grouped into the following subdomains: discipline specific knowledge, interdisciplinary knowledge, and professional knowledge. In some instances, doctoral graduates were vaguely noted to possess "knowledge", with no further explanation of what type of knowledge was indicated ($n = 2$). In some studies, doctoral graduates were found to possess discipline specific knowledge, referring to the breadth and depth of their disciplinary knowledge base. Studies found that doctoral graduates' disciplinary expertise included the theoretical knowledge ($n = 14$) and practical or technical skills of their discipline ($n = 3$). Both their research and coursework were noted as sources of these forms of knowledge. In some instances, doctoral graduates had interdisciplinary knowledge from related or complementary

TABLE 4 Doctoral graduate attributes domains and subdomains.

Domain	Subdomains	Source*
Knowledge	Discipline specific knowledge	1, 5, 8, 10, 13, 16, 18, 19, 20, 21, 22, 25, 29, 33
	Professional knowledge	5, 8, 20, 24, 29
	Inter- and transdisciplinary knowledge and skills	5, 18, 22, 27
	Discipline specific techniques and skills	8, 13, 18
	Knowledge (unspecified)	26, 28
Research	Data collection and analysis	1, 5, 10, 15, 17, 20, 21, 23, 27
	Literature skills	1, 10, 14, 17, 21, 23
	Research skills (unspecified)	16, 25, 28, 32, 33, 35
	Research attitude	11, 13, 29, 33
	Research methods	1, 5, 23, 34
	Discipline specific research skills	12, 14, 15
	Research conceptualization	10, 17
	Research expertise	29
	Interdisciplinary research skills	27
Communication	General communication skills (not specified)	8, 10, 12, 13, 18, 27, 31, 32
	Written communication skills	1, 8, 10, 20, 27, 31, 32, 35
	Oral communication skills	7, 10, 12, 17
	Language skills	7, 13, 27
	Interdisciplinary communication skills	10, 18, 31
	Publication skills	29, 31, 32
	Disciplinary communication skills	15, 30
Interpersonal	Teaching	3, 9, 12, 20, 24, 27, 34
	Collaboration and teamwork	7, 13, 18, 22, 30
	Networking	5, 29
	Leadership	12, 29
	Supervision	5, 9
Organizational	Project management	6, 8, 10, 13, 18, 27, 30
	Time management	13, 18, 24
Scholarship	Practitioner scholarship	5, 21, 23, 25, 29
	Identity as scholar	2, 19, 35
Reputation	Credibility	5, 8, 10, 20, 26, 28, 29, 32
	Legitimacy	16, 21, 25, 30
Higher Order Thinking	Critical thinking	5, 8, 10, 25, 29, 30
	Problem solving	7, 8, 13, 17, 23, 27
	Cognitive abilities	8, 10, 13, 33
	Innovation	5, 22, 27
	Creativity and curiosity	13, 26

(Continued)

TABLE 4 (Continued)

Domain	Subdomains	Source*
Personal Resourcefulness	Confidence	4, 5, 7, 10, 12, 16, 23, 26, 27, 28, 29, 32
	Self-efficacy	17, 26, 29, 31, 33, 35
	Autonomy and independence	4, 13, 15, 27, 35
	Resilience	8, 13, 33
	Agency	2, 9, 15
	Adaptability	13, 25, 26
	Self-regulation	5, 11, 15
	General life skills and study skills	8, 27
Active Citizenship	Advocacy	20, 29
	Awareness of injustice and inequality	6, 23
	Social justice-oriented disposition	23

*See Table 2 for corresponding authors of articles.

disciplines ($n = 4$), and had a unique and/or holistic perspective. Interdisciplinarity was defined as "integrating knowledge from two or more disciplines" (Holley, 2018, p. 107). Some studies found that doctoral graduates possessed professional knowledge relating to navigating the administrative and operational functioning of higher education institutions and/or work environment ($n = 5$). The domain of knowledge, as a doctoral graduate attribute, thus includes subdomains of disciplinary and interdisciplinary knowledge, and professional knowledge.

Research skills

The domain of "research" included all codes that reflected skills utilized in the various stages of research, and included competencies related to research methods and processes, and attitudes related to research ($n = 21$). This was labeled as the domain of research skills. There were no theoretical definitions related to research skills provided in the articles under review. In some instances, research skills were generally mentioned, without specific description ($n = 6$). Studies identified that doctoral graduates were noted to possess skills related to the various stages of research: literature review ($n = 6$), conceptualization ($n = 2$), methods ($n = 4$), and/or data collection and analysis ($n = 9$). Literature skills reflected their ability to search, critically evaluate, synthesize, and write a literature review. Skills related to conceptualization included the ability to formulate research hypotheses, understand research ethics, and select suitable methods. Research methods included the knowledge of methods, and the ability to conduct quantitative and/or qualitative research. Data collection and data analysis skills included the context-relevant use of quantitative and/or qualitative data collection and data analysis

methods. Consideration of discipline-specific methods skills (n = 3), such as designing appropriate experimental controls, and the reflexive process of artistic research, and interdisciplinary research skills were noted (n = 1). Doctoral graduates were noted to possess research expertise (n = 1), and a research attitude (n = 4) denoted by a respect for knowledge, a broadened outlook, research ownership and rigor. The domain of research skills that doctoral graduates possess included subdomains of range of methodological competencies, from conceptualization to data analysis, as well as research attitude and research expertise.

Communication skills

The domain of "communication" included codes that referenced various formats and forms of communication (n = 16). There was no evidence of theoretical definitions of communication skills. In some studies, doctoral graduates were noted to possess language skills (n = 3), and were articulate and confident in their communication skills (n = 8). The written communication skills doctoral graduates possessed (n = 8) included academic, scientific and technical writing skills, and being able to construct persuasive arguments. These writing skills (n = 8) were utilized for various purposes and formats of written documents. Further, it was found that doctoral graduates possessed confidence in their written skills. Doctoral graduates' publication skills (n = 3) were differentiated from their general writing skills, as this included knowledge of the journal landscape and publication process, and the skills to prepare an article, work with co-authors, negotiate and manage the publication process, and deal with rejection and reviewer feedback. Doctoral graduates possessed oral communication skills (n = 4), including general presentation skills, and the dissemination of research findings through the presentation of scientific content. As with the domain of knowledge, some studies indicated that doctoral graduates possessed discipline specific communication skills (n = 2), such as interviewing skills, and interdisciplinary communication skills (n = 3), in their ability to communicate with non-academic audiences and produce non-academic outputs. The interdisciplinary nature of these communication skills is linked to the concept of research translation, that is defined as the "multidirectional nature of knowledge exchange between researchers and end-users" (Merga and Mason, 2021, p. 673). Communication skills as a domain thus included various modes and formats of communication, reflected in the subdomains.

Organizational skills

The domain of "organizational skills" reflects the skills that were learnt through managing the thesis project (n = 8). In some studies, doctoral graduates possessed organizational skills, including project management and time management. Project

management was defined as a transferable skill, that is developed "through a range of experiences… [as students] learned to determine priorities and achieve deadlines, became skillful in producing outcomes despite a limited budget, equipment failures or administrative impediment" (Mowbray and Halse, 2010, p. 661). Studies indicated that doctoral graduates were able to manage and run projects, and demonstrated coordinating skills, people skills, and goal-directed vision (n = 7). Doctoral graduates possessed time management skills (n = 3), being able to plan, work to deadlines and balance responsibilities. The organizational skills domain included subdomains of organizational and management skills at both a project and personal level.

Interpersonal skills

Interpersonal skills as a domain reflects a group of attributes that relate to interpersonal interaction in some form or another (n = 14). Doctoral graduates possessed a range of interpersonal skills including collaboration and teamwork, networking, leadership, teaching and supervision. Collaboration was defined as "any type of joint effort of two or more people pursuing a common goal" (Granata and Dochy, 2016, p. 998). Collaboration and teamwork (n = 5) were identified as being transferable skills. Doctoral graduates in the studies were able to demonstrate internal and external collaboration and teamwork, with clients, experts and industry. This involved the ability to work with people from different sectors and across research boundaries, including "working daily with close colleagues, data exchange with external partners and joint publications of findings with researchers in other faculties and universities" (Granata and Dochy, 2016, p. 998). Some doctoral graduates were able to network and connect with the scientific community (n = 2), resulting in access to resources and information. Other studies highlighted that doctoral graduates demonstrated leadership capacity (n = 2), which was cross-cutting of some other domains, including articulate communication skills (both written and verbal), the ability to work within structure, discipline of thought, investment in research, and university visibility through publication and collaboration. Doctoral graduates in some studies were noted to possess teaching skills (n = 7), including being prepared to teach, the ability to deal with students, teaching at undergraduate level and facilitating groups effectively, and supervision skills (n = 2) at under- and/or post-graduate level. The domain of interpersonal skills that doctoral graduates possessed, included subdomains that reflect various skills for collaborative engagement with others, for work, research and teaching.

Scholarship

The domain of "scholarship" included codes related to scholarly practice and identity that doctoral graduates possess

($n = 8$). Studies mentioned scholarship in relation to doctoral graduates' practitioner scholarship and identity as scholar. Practitioner scholarship was defined as "professionals who bring theoretical, pedagogical, and research expertise to bear on identifying, framing and studying problems of practice and leading informed change in their [professional] contexts" (Adams et al., 2014, p.366, as cited by Kennedy et al., 2020, p. 654). Practitioner scholarship was not exclusive to those who completed professional doctorates, but was also mentioned by a study focusing on an academic doctoral program (Kowalczuk-Waledziak et al., 2017), and a study that did not specify the type of doctorate, but included a variety of fields (Maxwell and Chophel, 2020). Theoretical definitions of processes related to scholarship and identity were noted. Professional identity development was defined as taking place through developmental networks. Similarly, socialization was defined as the process through which students "gain the knowledge, skills, and values necessary for successful entry into a professional career requiring an advanced level of specialized knowledge and skills" (Weidman et al., 2001, piii, as cited by Feldon et al., 2017, p. 2574). Some studies identified that doctoral graduates demonstrated practitioner scholarship in their critical and reflexive approach to practice which is informed by theory and research, and using scholarship and research to respond to local needs ($n = 5$). In some instances, doctoral graduates' scholarly identity included their independent academic identity as scholar, and, in some instances, balancing and navigating multiple roles as scholar and practitioner ($n = 3$). The domain of scholarship thus speaks to the subdomains of the identity of doctoral graduates as scholars and professionals.

Reputation

The domain of "reputation" included codes relating to the perceived shift of their reputation that doctoral graduates experienced, which may have shifted due to the title of "Doctor" ($n = 12$). Conceptually, professional credibility was noted to have a positive impact on professional relationships with colleagues and clients. As a result, doctoral graduates were respected, with colleagues and students "looking up" to them. There was a level of status, prestige and respect associated with having achieved the doctoral degree. Doctoral graduates in some of the studies possessed academic, experiential and professional credibility, respect, and professional standing ($n = 8$). This was linked to their experience of legitimacy, in terms of the recognition they received, and the internally perceived legitimization of graduates' role, work, and participation in the academic community ($n = 4$). The domain of reputation relates to the impact of the doctorate on how graduates are received and/or perceived due to their doctoral title, reflected in the subdomains of credibility and legitimacy.

Higher order thinking skills

The domain of "higher order thinking skills" was defined by codes that reflected cognitive abilities and reasoning skills ($n = 14$). Higher order thinking skills was an intrinsic doctoral graduate attribute that emerged in the review. While no theoretical definition for this domain was present in the review, articles in the review identified problem solving, cognitive abilities and innovation as transferable skills. In some instances, doctoral graduates possessed critical thinking skills ($n = 6$), including critical reflection and analysis, questioning, justifying, and reflective and reflexive abilities. They possessed problem solving skills ($n = 6$), being able to discover, analyze and solve problems, split problems into sub-problems, and having a problem-solving mindset. Doctoral graduates' cognitive abilities ($n = 4$) included academic reasoning ability and the ability to construct an argument. Studies noted that doctoral graduates possessed the capacity to advance innovation, think outside the box and develop innovative research questions ($n = 3$). Similarly, some doctoral graduates possessed creativity and curiosity ($n = 2$), in their openness to new ideas, questioning stance and unique perspective. The domain of higher order thinking skills included various subdomains of cognitive skills, problem solving, critical thinking, innovation, creativity and curiosity.

Personal resourcefulness

The domain of "personal resourcefulness" collates various intrapersonal attributes and individual qualities that doctoral graduates possessed ($n = 22$). Personal resourcefulness was defined by Mowbray and Halse (2010, p. 657) as:

> The acquisition of skills that enable students to become more assertive, confident, resilient, persistent and resolute in determining how to progress their Ph.D. while balancing their other commitments. Consequently, personal resourcefulness is the reflexive, perceptual, emotional and contextual capacity that students develop during their Ph.D. that they used to discern and guide their actions.

Personal resourcefulness, resilience and independence were defined as transferable skills. Doctoral graduates had self-efficacy ($n = 6$), which is theoretically central to perseverance, because, according to Bandura (1989, p. 1,176, as cited by Merga and Mason, 2021, p. 681), "the acquisition of knowledge and competencies usually requires sustained effort in the face of difficulties and setbacks, it is resiliency of self-belief that counts." Self-efficacy was demonstrated through persistence, self-discipline, self-organization, and dedication. Similarly, doctoral graduates in some studies had strategies for resilience, determination and tenancy that allowed them to persevere despite challenges ($n = 3$). It was these personal

qualities that facilitated the development of all other skills and knowledge.

Confidence was the subdomain with the second highest frequency count overall ($n = 12$). Confidence was referred to in two ways: sources of confidence and the resultant confidence for action. Firstly, in some instances, doctoral graduates had confidence due to having experienced success in completing the doctorate, confidence in their research skills and knowledge, and confidence due to having successfully published. Secondly, and as a result of the first, doctoral graduates' achievements resulted in a sense of confidence in their professionalism, confidence to pursue innovative research, to defend their ideas, and confidence, in some instances, to bridge academic and professional worlds.

A group of intrapersonal qualities that are linked to doctoral graduates' organizational skills include agency, autonomy, adaptability and self-regulation. In some instances, doctoral graduates were noted to possess agency ($n = 3$) in their decision-making capacity to manage priorities and work responsibilities, that may be reflected in their organizational skills. Some were autonomous ($n = 5$), able to work independently as a scholar and researcher. Others were adaptable and flexible ($n = 3$), with the versatility to manage and transition between multiple roles. Self-regulation was mentioned ($n = 3$), and was theoretically defined based on the feedback loop model of self-regulated learning (Devos et al., 2016), that included goal setting, goal operating and goal monitoring, thus referring to the ability to move toward a goal, adjusting behavior over time in order to achieve that goal. Doctoral graduates had the capacity to self-regulate, through goal setting, being able to see the big picture, and to manage stress. Their ability to self-regulate would thus be closely linked with the enactment of their organizational skills, such as project and time management. General life skills and study skills were nominally noted as attributes that some doctoral graduates possess ($n = 2$). While not explicitly linked to self-regulation, these may be skills that facilitate or are used in self-regulation. The intrinsic qualities of doctoral graduates possess are thus closely linked to the skills they demonstrate. The domain of personal resourcefulness thus includes the subdomains of resilience, independence, agency, self-efficacy, confidence, self-regulation and general life and study skills.

Active citizenship

A cluster of attributes identified in the review were grouped under the domain "active citizenship," although this term was not explicitly used in the articles ($n = 4$). In other literature, active citizenship is defined as "knowing and practicing your rights as well as uplifting others in the realization and practice of theirs" (Isaacs et al., 2016, p. 103), and often refers to issues of transformation and empowerment (Gal and Gan, 2020). Some doctoral graduates demonstrated active citizenship in their advocacy through

strategic planning and policy development ($n = 2$), and increased awareness of injustice and inequality ($n = 2$). Some doctoral graduates were noted to have a social justice-oriented disposition ($n = 1$), that is defined as a proactive stance, or a "disposition of action that [drives] change efforts result[ing] from graduates' increased awareness and knowledge… regarding educational inequity, marginalization and White privilege as motivating their persistent efforts to address problems of practice" (Kennedy et al., 2020, p. 658). There is preliminary evidence of social justice-related subdomains, indicating a broader domain of active citizenship. The domain of active citizenship, while underdeveloped, include potential subdomains of advocacy, awareness and a social-justice oriented dispositions.

Mapping of findings against existing models

The coverage of the review findings and its alignment to existing models was investigated by mapping existing models onto the review findings, as shown in Table 5. The models were coded, using a deductive approach, to identify instances of the domains and subdomains of the review. In some instances, models had indications of broad categories that may imply inclusion of some of the subdomains in the review. The mapping of attributes illustrates that there is variation in the existing models, including the level of detail provided, likely indicative of the common issue of conceptual ambiguity around graduate attributes. There is evidence of each of the domains identified in the review, reflected in each of the models, showing good alignment. However, the present review highlights subdomains that were either not included in previous models, or not delineated in detail.

There were some domains identified in the selected frameworks that were not mentioned in the articles under review. However, these aspects are aligned to the domains and/or subdomains, as indicated in Table 6. While these attributes may indicate potential "gaps" in the coverage of the present review, these attributes are easily integrated under the domains identified, and thus may rather provide additional detail as to the scope of the domains and subdomains identified.

Discussion

The review synthesized high-quality literature on the attributes that doctoral graduates possess, identifying various doctoral graduate attribute domains, subdomains, and definitions. The findings of the review are discussed, in relation to the "seen" and "unseen" nature of

TABLE 5 Alignment of findings to existing frameworks.

Doctoral graduate attribute	Subdomains	The researcher development framework (Vitae, 2010)	The researcher skill development framework (Willison and O'Regan, 2008/2015)	Competence model for SET Ph.D. students and graduates (Nikol and Lietzmann, 2019)
Knowledge	Knowledge (unspecified)	/	✓	/
	Discipline specific knowledge	✓	X	X
	Discipline specific techniques and skills	X	X	X
	Inter- and transdisciplinary knowledge and skills	X	X	✓
	Professional knowledge	X	X	X
Research Skills	Research skills (unspecified)	/	X	/
	Literature skills	X	X	X
	Research conceptualization	X	X	✓
	Research methods	X	X	X
	Data collection and analysis	✓	✓	X
	Discipline specific research skills	X	✓	X
	Interdisciplinary research skills	✓	✓	✓
	Research expertise	✓	✓	X
	Research attitude	✓	X	X
Communication	General communication skills	✓	X	✓
	Language skills	✓	X	✓
	Disciplinary communication skills	X	X	X
	Interdisciplinary communication	✓	✓	✓
	Oral communication skills	✓	✓	✓
	Written communication skills	✓	✓	✓
	Publication skills	✓	X	✓
Organizational skills	Project management	✓	✓	✓
	Time management	✓	X	✓
Interpersonal skills	Collaboration and teamwork	✓	X	✓
	Networking	✓	✓	✓
	Leadership	✓	X	✓
	Teaching	✓	X	✓
	Supervision	✓	X	X
Scholarship	Practitioner scholarship	X	X	X
	Identity as scholar	X	X	X
Reputation	Credibility	✓	X	X
	Legitimacy	X	X	X
Higher Order Thinking Skills	Critical thinking	✓	✓	✓
	Problem solving	✓	X	X
	Cognitive abilities	✓	X	X
	Innovation	✓	✓	✓
	Creativity and curiosity	✓	X	✓
Personal Resourcefulness	Confidence	✓	X	X
	Self-efficacy	X	X	X
	Resilience	✓	X	X
	Autonomy	✓	X	✓
	Agency	X	X	X
	Adaptability	✓	X	X

(Continued)

TABLE 5 (Continued)

Doctoral graduate attribute	Subdomains	The researcher development framework (Vitae, 2010)	The researcher skill development framework (Willison and O'Regan, 2008/2015)	Competence model for SET Ph.D. students and graduates (Nikol and Lietzmann, 2019)
	Self-regulation	X	X	X
	General life skills	X	X	X
	Study skills	X	X	X
Active Citizenship	Advocacy	✓Other subdomains	X	X
	Awareness of injustice and inequality	mentioned, related to	X	X
	Social justice-oriented disposition	domain	X	X

✓clearly mentioned; X not mentioned.

TABLE 6 Attributes not mentioned in the review.

Doctoral graduate attribute	The researcher development framework (Vitae, 2010)	The researcher skill development framework (Willison and O'Regan, 2008/2015)	Competence model for set Ph.D. students and graduates (Lietzmann and Nikol, 2019)
Professional knowledge	Professional conduct related sub-domains Career management, continuing professional development	/	Finance, legal and economic skills
Technical skills	Numeracy	/	Digital competence
Project management	Research strategy, risk management	/	Third party funding
Research skills	Enthusiasm and integrity	/	/
Communication	Public engagement	/	Science marketing
Interpersonal skills	Equality and diversity People management	Ethical, cultural, social and team considerations Team management	Counseling and consultation skills Intercultural competence
Higher order thinking	Intellectual insight and risk	/	/

attributes, conceptual development and evidence for the relevance of doctoral graduate attributes. Thereafter, the strengths, limitations, implication and recommendations are presented.

"Seen" and "unseen" doctoral graduate attributes

The review findings are well-aligned with other models of research-related and doctoral graduate attributes. In general, existing models had a stronger focus on the knowledge, research, communication, organizational skills, interpersonal skills, and higher order thinking domains. These attributes are more easily "seen" (Kensington-Miller et al., 2018), as they are explicit competencies observable in doctoral graduates. Doctorate degrees involve an advanced level of original research, with a novel contribution to knowledge in their field (Denicolo and Park, 2013; CHE, 2018). It follows that doctoral graduates

would possess depth of knowledge and expertise in their field of study (discipline specific knowledge), and a range of research skills, that may facilitate and/or result from their doctoral research. Existing models, with the exception of the Researcher Development Framework (Vitae, 2010) had a greater focus on "seen" as opposed to "unseen" attributes.

The present review includes the intrapersonal domains of personal resourcefulness, scholarship and reputation. The review extends previous models, with a more comprehensive view of the attributes that doctoral graduates possess. The "unseen" or "invisible" attributes of the doctorate are those which reflect the qualities of the person and are often implied in the educational process (Kensington-Miller et al., 2018). Existing models generally focused more on the seen attributes, with less focus on the intrinsic qualities, such as personal resourcefulness. This was particularly evident in models that are more curriculum focused, such as Nikol and Lietzmann (2019). The evidence of intrinsic qualities aligns with research on doctoral education that has highlighted the shift in viewing

the doctorate as a product or commodity, to viewing it as a developmental process (Mowbray and Halse, 2010; Durette et al., 2016; Creaton and Anderson, 2021). Individual identity development and personal qualities are considered equally as important as the research product (Denicolo and Park, 2013; Ai, 2017). The importance of intrinsic development was reflected in the emergence of various intrapersonal domains and subdomains in the review. The qualities graduates possess were sometimes framed as being developed because of the challenges endured in the doctorate (Devos et al., 2016; Lemon et al., 2020; Merga et al., 2020; Rabe et al., 2021). This aligns with the findings of Mowbray and Halse (2010) and their definition of personal resourcefulness as being developed through balancing competing responsibilities and challenges. The internal capacity of the student/graduate to endure the challenges of the doctorate is particularly pertinent in a context of high attrition and extended degree duration (McKenna, 2017; Lemon et al., 2020). However, these intrinsic factors need to be supported externally, for example, through good quality supervision, and peer and institutional support (Granata and Dochy, 2016; Lemon et al., 2020). The intrapersonal domains identified thus reflect the personal growth and qualities the individual develops and/or utilizes during the doctorate process. The domain of reputation speaks to the perceived credibility that graduates have as doctorate holders. There is preliminary evidence that the sense of credibility and legitimacy stems from graduates' perceived competence and status as doctorate holder. Graduates' perceived credibility then informs their interpersonal interactions, such as pursuing opportunities, networking and/or collaboration (Bryan and Guccione, 2018). Reputation may be a mediating attribute that connects or informs the realization of other attributes. The domain of reputation reflects the confidence with which graduates implement their learnings, and by extension, the broader impact of the doctorate. This domain is somewhat different than the other domains, as it has both an externalized and internalized component. Reputation is typically considered to relate to how others view the individual, but the focus of this domain, as expressed in the articles under review, related more to how the individual perceived this as a result of having completed their doctorate degree, which resulted in an improved internal sense of credibility and legitimacy. The emerging domains identified reflect more of the "unseen" dimensions of doctoral education, and thus areas that students and supervisors need to be made aware of, in order to ensure their active investment in their educational process and identity development (Kensington-Miller et al., 2018).

There was preliminary evidence of subdomains that fall under the domain of active citizenship, yet it did not emerge strongly in this review. There is some alignment with existing models, as the Researcher Development Framework (Vitae, 2010) has subdomains of engagement and impact that align with the definition of active citizenship. In the doctoral context, active citizenship is aligned with the expectation or requirement that research impact should extend beyond academia, especially in applied fields (Creaton and Anderson, 2021). There is evidence of active citizenship as a graduate attribute (UWC, 2009), however, active citizenship as a doctoral graduate attribute requires further investigation and exploration.

Conceptual development of doctoral graduate attributes

Graduate attributes, in general, are noted to lack conceptual clarity (Mowbray and Halse, 2010; Bitzer and Withering, 2020). In the review, this was evidenced by the general lack of theoretical definitions for the graduate attributes discussed and/or measured. While extensive work has gone into developing models and frameworks, the review highlights that published journal articles do not necessarily make reference to or explicitly draw on these models, when referencing the outcomes of doctoral degrees or defining the attributes of doctoral graduates. This may be because frameworks are more often utilized by researchers in their own or their students' development, or by policy makers, trainers and curriculum designers in the development of doctoral education training, as indicated, for example, by the target groups specified for the Researcher Development Framework (Reeves et al., 2012). As such, there is a need to connect these developmental frameworks to outcomes-focused research, such as the studies included under review. This would provide theoretical and conceptual grounding to such research, and a good base on which graduate outcomes could be compared and/or measured. The nominal reporting of psychometric properties relating to scales used in the quantitative studies, gives further evidence of the lack of conceptual grounding of the studies under review. As scale development and validation requires conceptual clarity (Munnik and Smith, 2019), this provides further indication of the noted conceptual ambiguity relating to the measurement of graduate attributes. The review contributed a synthesis of recent evidence of the doctoral graduate attributes and the domains in which they are operationalized. These domains were well-aligned to existing models, despite the articles not making explicit mention of these models. The review itself contributed to the conceptual development of what these attributes are, extending the common themes in existing models, to include additional "unseen" attributes alongside the "seen" or more traditionally conceptualized attributes. The review findings may provide tangential evidence of the developmental impact that existing models may have had on doctoral education, as many of the studies took place in the UK and Australia, where the Researcher Development Framework and the Research Skill Development Framework, respectively, are used. However, a

further exploration of the use and impact of these frameworks is warranted.

Relevance of doctoral graduate attributes

The employability of graduates is a concern for higher education institutions, and thus the transferability of graduate attributes is an important consideration (Kensington-Miller et al., 2018). This review highlighted a range of transferable and interdisciplinary attributes that doctoral graduates possess, in alignment with other models. Studies explicitly identified subdomains of communication, organizational skills, interpersonal skills, higher order thinking skills and personal resourcefulness as transferable skills. This review extends previous research that narrowly conceptualized the knowledge base of doctoral graduates as being discipline specific expertise, to include transferable interdisciplinary knowledge and professional knowledge. The inclusion of research translation and communication with various audiences aligns with the increased focus on interdisciplinarity in doctoral education for improving employability (Holley, 2018). There is good evidence that doctoral graduates are "T-shaped" individuals, with depth of knowledge and skills in their discipline, and cross-cutting transferable skills (Granata and Dochy, 2016). This finding reflects the shifts that took place in doctoral education to include the "development of broader workplace skills and experiences" (Bryan and Guccione, 2018, p. 1,125), and is in alignment with previous work, highlighting the importance of transferable skills for doctoral education and training (Denicolo and Reeves, 2014). However, stakeholders may not yet be aware of the shift and the improved transferability of doctoral skills. Further, there are contextual differences, at a national and institutional level, which may account for gaps in training relevance and doctoral employability. The range of skills and qualities evidenced in the review provides evidence against the critiques of the doctorate being overly specialized and lacking relevance to the workplace (Boulos, 2016; Maxwell and Chophel, 2020). This concern reflects a lack of awareness from employers and graduates themselves, as to the wide range of skills and qualities doctoral graduates possess (Durette et al., 2016). It is important for graduates to first be aware of the range of skills they have developed, in order to market their skills, not just their specialized field of study (Denicolo and Reeves, 2014; Holley, 2018).

Strengths and limitations

The focus of the review on a specific perspective of doctoral graduate attributes, i.e., the attributes that doctoral graduates actually possess, is a strength. The findings synthesize actual outcomes, as opposed to prospective attributes or attributes-in-process. Therefore, the findings may translate into quality assurance outcome indicators, for example, through the development of scales to measure doctoral graduate attributes. The review findings are well aligned with previous literature and models, and thus provides good evidence that the attributes identified in the review are common across contexts and disciplines. The wide range of literature sources accessed indicates good scope. All reviews are by nature limited to the search criteria used. In order to include only highest quality evidence, potentially relevant gray literature and non-peer reviewed literature was excluded, based on the search criteria and exclusion criteria. For example, much of the work around doctoral education and training, particularly utilizing models and frameworks for improving curriculum and skills development, may have taken place more informally or been published in technical reports, and thus would have been excluded from the present review.

Implications and recommendations

The synthesis of recent evidence of the domains, subdomains and definitions in the review provides preliminary evidence of the impact of the frameworks that are used to improve doctoral education and training, as there is good alignment between the review findings and some of these frameworks. The review therefore contributes to the conceptual development of doctoral graduate attributes. As such, the review findings may support efforts to measure and assess doctoral graduate attributes, for example, for quality assurance. Institutions can use these domains and definitions to develop context-relevant charters of doctoral graduate attributes and use these to guide curriculum development and support programs for doctoral students. These doctoral graduate attributes can be used at an institutional level as part of quality assurance and institutional marketing.

The lack of awareness among doctoral education stakeholders as to the wide range of doctoral graduate attributes possessed needs addressing. The "unseen" nature of many doctoral graduate attributes requires greater support to increase awareness in order to facilitate development (Kensington-Miller et al., 2018). Increased awareness as to the scope of doctoral graduate attributes among stakeholders, such as doctoral supervisors, students, graduates and employers, may facilitate improved educational outcomes and employability (Denicolo and Reeves, 2014). Supervisors should consider appropriate support for the multifaceted and holistic development of doctoral graduates in supervision. Students' awareness and active engagement in their attribute development may facilitate growth and their capacity to market themselves in their curriculum vitae and/or in job interviews. The various tools

available related to the Researcher Development Framework (Vitae, 2010; Denicolo and Reeves, 2014) and the Researcher Skills Development Framework (Willison and O'Regan, 2008/2015) could be used to support such activities. Prospective doctoral students will be able to enter the doctoral program with more realistic expectations of what growth they can anticipate during the process and can use the attributes to benchmark their progress throughout the degree. Employers' awareness of the multifaceted attributes associated with completion of a doctorate may counteract the misconception that the doctorate has limited relevance or transferability beyond discipline-specific knowledge (Boulos, 2016; Maxwell and Chophel, 2020). Doctoral graduates are key knowledge and innovation creators (Molla and Cuthbert, 2016). Therefore, it is important to ensure that doctoral graduates are equipped and positioned to actively engage in good quality and contextually relevant research that benefits society at multiple levels. Increased awareness among stakeholders may improve the mobility of doctoral graduates across fields, disciplines and workplaces, thereby improving employability.

Future research around doctoral education should utilize existing models or frameworks as conceptual frameworks, adding much needed grounding and cohesion to the literature on doctoral graduate attributes. The review draws on many contexts yet is descriptive in nature and so the findings are not generalizable. Further research into doctoral graduate attributes is recommended for underrepresented contexts in the review, including Africa, Asia, South America, and the Middle East. Given the contextual differences in doctoral education and higher education systems, research in these varied contexts needs to be conducted and shared. The focus on doctoral education in the African context reflects the policy imperative to improve the capacity of the higher education sectors, the national systems of innovation, and facilitate engagement in the knowledge economy (Molla and Cuthbert, 2016). In this context, there is an ongoing need to increase doctoral outputs. However, in the Global North, such as Australia, the academic job market is nearing saturation. Therefore, the questions around doctoral graduate production shift to employability, particularly beyond academia (Guerin, 2020). In line with the recommendations of other authors (Durette et al., 2016; Yazdani and Shokooh, 2018), it is recommended that context-relevant, conceptually sound scales be developed, to reliably and validly measure doctoral graduate attributes among alumni populations. Such scales could be used as quality assurance outcome indicators, or in graduate tracer study research (Senekal and Munro, 2019), to explore issues of employment, employability and the relevance of the doctorate within specific contexts. Further contextual investigation into how the identified domains in this review are developed, including the supportive factors and potential barriers may further inform supervisory practice and institutional support

provision. Research into the reflection of these doctoral graduate attributes in thesis examination processes may be useful, to develop more holistic examination guidelines.

Conclusion

Doctoral graduates (across disciplines and countries) possess a wide range of attributes, including knowledge, research, communication and organizational skills, and a variety of inter- and intrapersonal skills. Many of the attributes identified are transferable and inter- or transdisciplinary. Doctoral graduates—from a wide variety of disciplines and countries—possess a broad range of transferable knowledge and skills that align with those required for the workforce, in both academia and beyond. The review adds to the body of research by consolidating recent findings on the topic, including descriptions and definitions not just domains, and conceptualizing doctoral graduate attributes as outcomes—from the perspective of graduates. The domains identified represent the attributes that doctoral graduates actually do possess, as opposed to an aspirational list of what stakeholders hope students will develop. Doctoral graduate attributes include both the "seen" generic attributes that are more commonly identified in graduate attribute frameworks, such as disciplinary expertise, research skills and communication skills, together with "unseen" intrinsic qualities, such as personal resourcefulness. Doctoral graduate attributes should be conceptualized to integrate both the generic attributes, together with the intrinsic qualities that are invaluable both during the doctoral degree and beyond.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

Author contributions

JS contributed to the conceptualization of the review, fieldwork, data extraction, data analysis, draft write up, revisions, editing, writing and technical aspects of the article, and approved the submitted version. EM and JF contributed to the conceptualization of the review as well as the coordination of the review processes, provided leadership and input to the review team at each stage of the project and the conceptualization of the manuscript, contributed to the write up and technical aspects of the article, and approved the submitted version. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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