

Four Dimensions of Doctoral Expertise: Graduates' Reflections on Learning During Doctoral Studies

There is an increasing need for advanced expertise in the world to solve complex problems. A high level of education equips both individuals and societies with the expertise required to find solutions. This article examines the nature of expertise developed during doctoral education. The research question is: What kind of expertise is developed in doctoral studies, as experienced by doctoral graduates? The qualitative data consists of in-depth interviews with nine PhD holders. The data was analysed using an inductive approach. According to the results, theoretical expertise was perceived as the strongest and most self-evident dimension of doctoral education. However, practical, self-regulatory, and socio-cultural dimensions of expertise also emerged as key aspects of doctoral expertise. In particular, competence in networking, project work, and internationalisation were identified as crucial skills within the academic field. Nevertheless, flexibility, hybrid expertise, and broad applicability were recognised as core features of expertise regardless of the field. The study suggests that doctoral studies foster diverse and still largely unrecognised forms of expertise. This differentiated expertise should be more consciously integrated into the doctoral process. Doctoral expertise evolves at the intersections of different contexts and across disciplinary boundaries. Raising meta-level awareness of the dimensions and processes of expertise, and engaging in dialogue across different fields, benefits doctoral graduates, doctoral education, and society at large in the development and utilisation of expertise.

Keywords: doctoral education, PhD graduate, academia, university, expertise

Introduction

In Europe, efforts have been made to harmonise and structure doctoral education, while simultaneously aiming to improve the quality of research (Cardoso, 2024; Aittola, 2017). In Finland too, doctoral education has been developed since the 1990s to become more systematic, and doctoral students have increasingly been included in this development process (Aittola, 2017). However, further progress is still needed—for instance, in recognising how doctoral graduates build their careers (Piironen et al., 2025; Maunula, 2023). From 2024 to 2027, Finland is running an educational pilot in which 1,000 doctoral candidates have been recruited to universities for three years with dedicated government funding (Ministry of Education and Culture, 2023). The pilot aims to develop more efficient and flexible practices in doctoral training.

Significantly, the number of doctoral graduates in OECD countries has doubled over the past two decades, and this trend is accelerating (OECD, 2021). In 2019, the average proportion of 25–64-year-olds holding a doctoral degree in OECD countries was approximately 1% (OECD, 2019), and if the trend continues, 2.3% of today's young adults will enter doctoral education (Sarrico, 2022). Globally, doctoral education is facing growing expectations: the knowledge economy,

1 economic growth, and innovation (Cardoso, 2024; Halse & Mowbray, 2011).
2 Doctoral education is expected to efficiently produce an increasingly refined pool
3 of experts with the knowledge, skills, and future-oriented visions required in the
4 digital and global era (McKenna & van Schalkwyk, 2023). At the same time, general
5 understanding of the capabilities of doctoral holders remains limited (Sarrico, 2022),
6 including among doctoral holders themselves, who often lack awareness of the
7 diversity of the doctoral experience (Piironen et al., 2025). This can be seen as an
8 ethical issue within doctoral education (Roos et al., 2021; Cardoso, 2024).

9 The employment of doctoral graduates across wider segments of society has
10 become more common, with over half of doctoral holders in OECD countries now
11 working outside academia (OECD, 2015). Often, those working beyond academia
12 report that their research skills have been developed to an extent that exceeds the
13 demands of their jobs, while their personal efficiency, leadership, and
14 communication skills fall short of what is needed (Waaijer et al., 2017). As such,
15 they may be both overqualified and underqualified relative to the expectations of
16 various employment sectors (Sarrico, 2022). Doctoral education, however, cannot
17 be expected to prepare graduates for every type of work (Sarrico, 2022); employers
18 too must take responsibility for continuous and sustainable training of their
19 workforce, for example through mentoring (Cappelli, 2015; Maunula et al., 2024).

20 The contexts of doctoral graduates vary between countries at systemic,
21 institutional, and individual levels. Labour markets, academic disciplines, and
22 personal circumstances all shape individual career trajectories (Sarrico, 2022). This
23 article focuses on Finnish doctoral education and the experiences of newly
24 graduated or soon-to-graduate PhDs regarding the dimensions of their expertise.
25 Finnish doctoral education has evolved systematically in line with global trends,
26 with an emphasis on increasing efficiency, improving quality, enhancing
27 internationalisation, and preparing professional researchers (Ministry of Education
28 and Culture, 2017; 2023). These developments have influenced the various actors,
29 practices, and values across the levels of doctoral education (Piironen et al., 2025;
30 Jauhiainen & Nori, 2017). Discussions have also emerged regarding academic
31 knowledge capitalism and its relevance (Hannukainen & Brunila, 2017). Based on
32 this context, the research question of this study is formed: What kind of expertise is
33 developed in doctoral studies, as experienced by doctoral graduates? The article
34 proceeds by presenting previous research on doctoral education and expertise,
35 followed by a description of the study's methodological choices, findings, and
36 discussion.

37 38 39 **Literature Review**

41 Doctoral education has undergone significant transformation in recent decades,
42 shaped by both global policy agendas and changing expectations of doctoral
43 graduates. In response to societal demands for innovation, interdisciplinarity, and
44 employability, the purpose and structure of doctoral training have expanded beyond
45 traditional academic pathways. This literature review explores prior research on the
46 reform of doctoral education, the evolving expectations placed on doctoral

1 candidates, and the theoretical understanding of expertise as a dynamic, multi-
2 dimensional process. These perspectives form the conceptual foundation for
3 analysing how doctoral expertise is constructed across diverse contexts.

4 **Reforming Doctoral Education**

6
7 Doctoral education in Europe is subject to high expectations, and the number
8 of PhDs being trained continues to grow (Cardoso, 2024; OECD, 2015; 2019; 2021;
9 2023). At the same time, the criteria for admission into doctoral programmes have
10 become more stringent, with a clearer emphasis on the quality and feasibility of the
11 research plan, as well as the applicant's demonstrated research skills and activity
12 (Jauhiainen & Nori, 2017). However, higher education systems have been criticised
13 for their weak connections with the labour market (Sarrico, 2022; Roos et al., 2021),
14 and there is a global call for doctoral education to become more practical,
15 innovative, and connected to real-world challenges (e.g. Costley & Lester, 2012).
16 Thune (2009) highlights the importance of shared objectives and ongoing
17 interaction between universities, public authorities, and industry. A bold
18 reorganisation of doctoral education, including broader skills applicable to diverse
19 contexts, is seen as an opportunity amid the transformation of knowledge and work
20 (Sarrico, 2022). Already 25 years ago, Etzkowitz et al. (2000) argued that doctoral
21 education should focus more on employability, entrepreneurial activities, and
22 collaborative capacities extending beyond academia. Today, such themes are
23 increasingly integrated into traditional doctoral programmes to better align PhD
24 expertise with societal expectations.

25 At the European level, higher education has been harmonised through
26 initiatives such as the Bologna Process and the Lisbon Strategy (Bitusikova, 2009).
27 Nonetheless, international comparisons continue to show country-specific features
28 of the doctoral experience (Auriol, 2007; Sarrico, 2022). From the perspective of
29 European universities, intensified financial pressures and competition are central
30 themes (Enders, 2005; Hannukainen & Brunila, 2017). The doctoral training system
31 is continuously streamlined, with only the most promising candidates being
32 admitted and emphasis placed on supervision, international networking, and
33 funding acquisition skills (Jauhiainen & Nori, 2017). Universities now aim to
34 efficiently produce not only doctoral degrees (e.g. Hannukainen & Brunila, 2017),
35 but also multi-skilled academic researchers and innovative experts attuned to the
36 needs of working life (Gu et al., 2018), especially those capable of engaging in
37 dialogue across different domains (Laalo et al., 2019). Despite this, universities
38 commonly assume that graduates will pursue academic careers, resulting in
39 insufficient preparation for non-academic paths (Bardner & Doore, 2020; Jaksztat
40 & Gross, 2024).

41 As part of the Salzburg Process initiated by the European University
42 Association and the ongoing reform of doctoral education, universities have begun
43 incorporating transferable skills into their doctoral programmes. The goal is to better
44 prepare doctoral candidates for career options outside academia (Hasgall &
45 Paneoasu, 2022; Hasgall et al., 2019). This reform is significant, as only 32% of
46 doctoral students reported having studied transferable skills during their PhD

1 training (Janger et al., 2020). Supervisors play a key role in presenting various career
2 paths and opportunities (Goldan et al., 2023; Gu et al., 2023). The diversification of
3 doctoral careers can be seen as an opportunity to revise doctoral training and
4 supervision to better reflect new realities (Coates et al., 2020). Transitioning from
5 academia to non-academic work is not always easy, and the cultural differences
6 between institutions can even be a shock for some doctoral graduates (Skakni et al.,
7 2021). Piironen et al. (2025) identify how doctoral career paths begin to diverge
8 already during the PhD process and highlight the importance of recognising the
9 individual and systemic boundary conditions shaping these trajectories.
10 Recognising such conditions makes the hidden practices of academia more visible
11 and open to development, while enriching the discourse on the doctoral researcher's
12 position.

14 **Doctoral Education and Expertise Development as a Process**

16 The process of earning a doctorate fosters the development of multiple areas of
17 expertise, both domain-specific and general professional skills. Expertise is
18 multidimensional and evolves through a process (Ericsson et al., 2006; Hakkarainen
19 et al., 2004). These authors define expertise as a mode of practice that consistently
20 produces high-level performance. It entails a dynamic attitude aimed at continual
21 improvement in increasingly complex tasks. Chi et al. (1988) emphasise that expert
22 knowledge integrates seamlessly with existing mental models, thereby reinforcing
23 overall understanding. Bereiter (2002) adds that experts flexibly utilise both formal
24 and informal knowledge, including experiential, intuitive, and self-regulatory
25 dimensions.

26 A widely accepted view holds that expertise comprises four core dimensions:
27 theoretical, practical and experiential, self-regulatory, and socio-cultural knowledge
28 (Bereiter, 2002; Erault, 2004; Ericsson et al., 2006; Lehtinen et al., 2012; Tynjälä,
29 2010). Theoretical knowledge can be expressed in text or speech. Practical
30 knowledge is developed through doing and experiencing and includes both skills
31 and embedded knowledge. Often tacit, this kind of knowledge is linked to various
32 processes but can be made explicit through reflection. Such reflection gives rise to
33 self-regulatory knowledge, which includes metacognitive and reflective awareness
34 of one's own work habits, thinking, and learning. When reflection extends beyond
35 the self, expertise becomes situated in broader contexts such as one's professional
36 community. Lehtinen et al. (2012) stress that socio-cultural expertise includes
37 implicit rules, norms, and cultural knowledge, which can only be accessed through
38 participation in community practices. The shift from individual to collective
39 expertise is gaining pace (Lindén & Annala, 2016). In expert performance, the
40 various components of knowledge merge into a seamless and meaningful whole.

41 While the components of expertise are presented separately—into theoretical,
42 practical, self-regulatory, and socio-cultural domains—they are in fact deeply
43 interconnected in high-level expertise (Bereiter, 2002; Tynjälä, 2008). Earlier
44 understandings of expertise focused on individual cognitive processes such as
45 exceptional abilities in acquiring and processing information. However, this
46 perspective has expanded to include participation and identity development,

1 highlighting the evolving process of expertise and the creation of new knowledge.
2 The development of new practices and innovative knowledge communities relies
3 heavily on the interactive growth of individuals and communities (Hakkarainen et
4 al., 2004).

5 The development of expertise during doctoral studies requires conscious
6 awareness of these dimensions and their integration (Tynjälä, 2010). Hancock
7 (2019) stresses the importance of early-stage doctoral supervision that recognises
8 the different skill requirements for different career paths. Doctoral researchers
9 increasingly expect career guidance to reflect broader, non-academic career
10 landscapes and to support the development of versatile expertise (Gu et al., 2018).
11 Expertise thus entails not only mastery of disciplinary practices but also innovation
12 and the ability to adapt and anticipate within changing conditions (Hakkarainen et
13 al., 2004; Ericsson & Pool, 2016).

14 15 16 **Methodology** 17

18 This article explores the capital of expertise developed during doctoral
19 education, as experienced by recent doctoral graduates and current doctoral
20 candidates. The research question is: *What kind of expertise is developed in doctoral*
21 *studies, as experienced by doctoral graduates?*

22 The focus group comprised recently graduated or soon-to-graduate doctoral
23 researchers (N=9). They were interviewed about their experiences of doctoral
24 education and the expertise they felt had emerged during their doctoral journey. For
25 the sake of simplicity, they are referred to throughout the article as doctoral
26 graduates.

27 The data were collected through thematic interviews, with broad themes
28 covering the entire trajectory of their academic and professional lives—doctoral
29 studies, career development, and the formation of expertise. The interviews lasted
30 approximately 60 to 90 minutes. All were audio-recorded and transcribed. The
31 material is personal and offers a nuanced view of academic practices and doctoral
32 expertise. Participants were affiliated with three different Finnish universities and
33 represented a range of disciplines, including social sciences, education, economics,
34 sport sciences, social policy, psychology, and mathematics.

35 To answer the research question, the analysis began with a hermeneutic
36 approach, where the researchers first familiarised themselves with the data and
37 engaged in dialogue using researcher triangulation (e.g., Patton, 2002). This was
38 followed by a theory-driven thematic content analysis guided by the four
39 dimensions of expertise: theoretical, practical, self-regulatory, and socio-cultural
40 expertise (Ericsson et al., 2006). This approach allows researchers to draw
41 reproducible and valid inferences from the data in relation to their contextual
42 meanings (Patton, 2002). The process entailed a hermeneutic dialogue between
43 researchers, theory, and data, and through abductive reasoning, an overarching
44 understanding was formed. The research material was in Finnish; only the
45 quotations presented in the results section were translated into English.
46

1 The validity of this qualitative study is supported through triangulation and
2 critical reflection by the researchers throughout the research process. The article
3 clearly outlines the study's starting points and contextual framework, enabling
4 readers to interpret its significance appropriately. The dataset is extensive and
5 typical in scale for qualitative research. A critical reader is invited to independently
6 interpret the material and reflect on its implications relative to the study's aims.

7 8 **Limitations of the Study**

9
10 As with all qualitative research, this study is context-specific and based on the
11 experiences of a relatively small group of participants (N=9) from Finnish
12 universities. While the sample was diverse in terms of disciplines and institutional
13 backgrounds, the findings cannot be generalised to all doctoral graduates or national
14 contexts. The focus on recently completed or nearly completed doctoral candidates
15 may also exclude insights from those who left doctoral education early or who have
16 accumulated further expertise in later career stages. Additionally, the interviews
17 relied on self-reported reflections, which are shaped by individual perceptions,
18 memory, and context. Another limitation concerns the lack of systematic
19 comparison between disciplines or institutional policies, which may influence
20 doctoral experiences and opportunities for expertise development. Despite these
21 limitations, the study provides valuable insights into the multi-dimensional nature
22 of doctoral expertise and highlights important areas for further research and
23 development within doctoral education.

24 25 26 **Findings – Four Dimensions of Doctoral Expertise**

27
28 This section presents the key findings of the study, which explores how doctoral
29 expertise is experienced and constructed during doctoral education. Based on the
30 analysis, four main dimensions of expertise emerged: theoretical, practical, self-
31 regulatory, and sociocultural. These dimensions reflect the complex and evolving
32 nature of expertise as perceived by the doctoral graduates. Each dimension is
33 discussed in detail below, illustrated with participants' own reflections.

34 35 **Theoretical Expertise**

36
37 According to the doctoral graduates, the expertise developed during their
38 doctoral studies consisted of structured and multifaceted knowledge within their
39 academic field. This included a broad theoretical foundation in their discipline as
40 well as deep, specialised expertise related to their specific research topic. Their
41 expertise was primarily rooted in their dissertation research and had evolved over
42 an extended period of time.

43
44 *My expertise is based on the fact that I've worked and written a dissertation on a*
45 *specific topic. I continue to research within the same area, so it is, of course, essential.*
46

1 The doctoral graduates emphasised that they were experts in their specific
2 research field, but this did not exclude their ability to manage and contribute to
3 broader, interdisciplinary contexts. At times, they expressed frustration with
4 misconceptions that portray PhDs as narrowly specialised theorists disconnected
5 from practice.

6
7 *I see that, as an expert, I possess skills that would be valuable to many other*
8 *organisations beyond universities. I wish there were more of a shift in attitude—so that*
9 *more organisations besides universities would more readily consider hiring doctoral*
10 *graduates.*

11
12 The process of developing theoretical expertise was described as at times
13 challenging, yet highly motivating. When research did not progress, it led to
14 frustration and self-doubt regarding one's level of expertise. In difficult situations,
15 the doctoral researchers coped by refocusing on the broader picture of their research
16 and breaking it down into smaller, manageable parts. The doctoral degree itself was
17 not considered a sufficient motivator due to the title alone; rather, they were driven
18 by the pursuit of substantive, content-based expertise. The doctoral graduates
19 viewed their published scientific articles as a key indicator of their theoretical
20 development. Theoretical expertise was regarded as important and became a central,
21 almost self-evident, dimension of the doctoral journey.

22 23 **Practical Expertise**

24
25 According to the doctoral graduates, practical expertise was closely intertwined
26 with theoretical knowledge in their discipline and could not be separated from it.
27 Practical expertise was framed as general academic skills and competencies. It
28 developed through the practical phases of the dissertation process and across
29 different contexts. Taking part in the practical aspects of research made the
30 multifaceted nature of scholarly work more tangible.

31
32 *There was so much else to do—you couldn't just write the dissertation. You had to*
33 *publish other papers and get involved in many other activities too.*

34
35 Research was described as a multi-phase process, the progress of which could
36 not be reliably predicted in advance. Doctoral studies had helped them develop a
37 better understanding of research processes and a readiness to analyse critically—
38 also across disciplinary boundaries. They had also learned to take criticism as a tool
39 for improving the quality of their work. In addition to their critical stance, they
40 described having grown into a culture of critical thinking.

41
42 *Feedback on my research is helpful—it gives me more and more confidence in critical*
43 *thinking.*

44
45 One of the key practical skills was writing project funding applications, both
46 independently and as part of a team. Many said they had learned from failed
47 applications and gained perseverance needed for the process. The importance of

1 applying for funding was emphasised, as both research activity and employment
2 prospects required proactivity and an entrepreneurial mindset. Some participants
3 had strong capabilities and success in securing funding and were skilled in
4 presenting their research in an engaging and understandable way to non-expert
5 audiences. Others acknowledged that this was an area they needed to improve.

6
7 *I would say that within the study framework, my project application skills remained*
8 *poor—they could have improved much more.*

9
10 *From the very start, I was part of a research group, and we were constantly applying*
11 *for funding. I've been in a very good training environment from the beginning. Of*
12 *course, it took time, but this is the kind of skill and knowledge you need when building*
13 *your research profile.*

14
15 The significance of practical project expertise varied. For some, it was one of
16 the most essential skills; others found it frustrating and bureaucratic and did not want
17 it to be part of their future job role. Most participants saw a meaningful and organic
18 connection between the content of their expertise and project work. Working on
19 projects also helped them envision their expertise in more practical professional
20 contexts and contributed to understanding potential career paths beyond academic
21 research.

22 Language proficiency was mentioned as a practical skill, enabling international
23 networking, in-depth research collaboration, and publication in international
24 journals. Doctoral education also strengthened the ability to transfer their skills
25 across contexts, learn new things, and grasp complex systems. The nature of
26 academic work was characterised as a continual process of learning new research
27 practices and finding new applications. These abilities were seen as helpful for
28 expanding one's competencies and navigating future work in different contexts.

29 Practical expertise was also associated with the processes of scientific writing.
30 The ability to write and review academic articles was considered central. Academic
31 productivity and publishing in prestigious journals were seen as indicators of both
32 theoretical and practical expertise. Doctoral candidates were eager to publish
33 actively to distinguish themselves from their peers. Understanding the logic of
34 publishing and learning from it continuously was viewed as a critical academic skill.
35 The publication process was described as lengthy, demanding, and exhausting, yet
36 instructive and ultimately rewarding.

37
38 *I read research with interest and can assess reliability, sample size, and those basic*
39 *elements. In many ways, that foundation has helped me.*

40
41 Some doctoral graduates had extended their practical expertise through
42 pedagogical studies, seeing teaching as a possible though not primary career path.
43 Doctoral studies had also enhanced their skills for more hands-on work. Those who
44 transitioned from academic degrees into non-academic fields expressed a particular
45 interest in combining research and practical application in their work.

46

1 *I'd like to combine working life with research. Researchers are often blamed for*
2 *handing down advice from their ivory towers. Nowadays, research is much more of an*
3 *everyday tool—and that's what I'd like to promote.*

4 5 **Self-Regulatory Expertise**

6
7 According to the doctoral graduates, the process of completing a PhD was
8 highly self-directed and fostered the development of self-regulatory skills. Writing
9 a dissertation required not only intrinsic motivation and curiosity for the subject but
10 also goal orientation and self-discipline. At times, the research progressed smoothly,
11 while at other times, the frameworks collapsed and had to be reconstructed. A key
12 element of self-regulatory expertise was the constant critical self-evaluation in
13 relation to the demands of scientific work, the perceived meaningfulness of the
14 work, personal endurance, and time management pressures. The doctoral research
15 process highlighted the typical expert-like traits of ownership and developing a
16 personal working style.

17
18 *When there's a lot of information, you quickly learn to find the essentials. These days,*
19 *it's impossible to read everything—it's unfortunate. Sometimes you just skim articles*
20 *and extract what you need to keep things moving. You can't go too deep into all the*
21 *available information.*

22
23 The competitive nature of academia and the doctoral graduates' individual
24 responses to it required strong self-regulatory abilities. For example, externally
25 imposed dissertation deadlines were seen both as motivational and as sources of
26 pressure. Many emphasised the importance of avoiding constant stress and
27 maintaining mental balance. Self-regulatory expertise also included valuing rest and
28 recovery through hobbies and free time.

29
30 *Sometimes I wonder how I'll manage the next 20 years—maybe I work too*
31 *conscientiously. I should reflect on what value this research has: a) for me, and b) for*
32 *anyone else.*

33
34 Gaining employment within academia and advancing to positions of greater
35 responsibility required doctoral graduates to understand the logic of academic
36 systems, and to plan and anticipate their own activities—in other words, to
37 demonstrate self-regulatory expertise. They also had to accept the possibility of
38 failure in a competitive environment. The ability to plan and forecast their career
39 trajectories varied among participants. Self-regulatory expertise also entailed
40 recognising one's own weaknesses in relation to the nature of expert work. The
41 doctoral graduates described the importance of continuous conscious self-
42 assessment.

43
44 *My project management skills are still developing. I've grown as a writer and*
45 *improved my international skills—I can use networks and function as an expert. My*
46 *administrative competence has also grown as I've taken on more responsibility. Now*
47 *I'm supervising doctoral students and involved in completely new things.*
48

1 *My strategy to survive it all is to prioritise. You have to be satisfied with your own*
 2 *decisions—you can't constantly be longing for something else or wondering what you*
 3 *should be doing—that's where stress comes from. Of course, I feel I should become*
 4 *more international, but at the same time, I'm happy where I am now.*

5
 6 A defining feature of their self-regulatory attitude was the understanding that
 7 expertise is never complete. They were characterised by inner curiosity, a desire to
 8 learn, and a readiness to challenge their own thinking—especially within their area
 9 of expertise. Satisfaction and a realistic outlook also reflected their growth process
 10 as experts. Their passion for a research-based way of working and a desire to know
 11 and understand gave depth to the self-regulatory experience of their doctoral studies.
 12 Their sense of growing expertise was strong, and they identified multiple contexts
 13 for its development and application. Long-term academic training, practical
 14 experience, self-monitoring, critical assessment, and social interaction were all key
 15 components of their evolving expertise.

16
 17 *All the things I've been able to do and learn have given me knowledge, skills,*
 18 *competence, and the confidence to know that I can handle this work. And I also know*
 19 *where to go for advice if I don't know something. That gives me a real sense of*
 20 *assurance.*

21 22 **Sociocultural Expertise**

23
 24 Doctoral graduates became integrated into the working culture of their
 25 discipline by actively participating in it. They considered their involvement in
 26 different communities to be meaningful primarily within the academic sphere, but
 27 also in non-academic work environments. Through their dissertation work, they also
 28 connected with disciplinary networks. For some, this meant being part of a
 29 prestigious and successful international research team; for others, it involved
 30 participation in a regularly meeting local doctoral study group. These groups
 31 brought peers together through shared experiences of various phases of the
 32 dissertation process. Practical tips, updates on others' research, and the sense of
 33 belonging created a sociocultural community. Informal peer support was considered
 34 particularly valuable.

35
 36 *It feels really important and is a central space to check in on how things are going.*
 37 *Everyone had very different types of projects, but there were also overlaps, and that*
 38 *was genuinely helpful. We had common ground in terms of methods, findings, and*
 39 *theoretical background—not to mention opportunities to share experiences of the*
 40 *process itself.*

41
 42 *I've done several short research visits abroad in different labs. That's how I've built*
 43 *new networks and gained new expertise.*

44
 45 The research group was described as the core of research work. Collaborating
 46 with others led to continual learning and the development of new research
 47 perspectives and topics. Working together, sharing, and being an active member of
 48 a community expanded the doctoral graduates' practical and social expertise. It

1 provided opportunities to explore the latest research in their field and to develop
 2 sociocultural knowledge. The different dimensions of expertise were deeply
 3 interwoven and strongly shaped through social relationships.

4
 5 *I've been in the right place at the right time. There are people who look out for me—*
 6 *people who are aware of my employment situation and advocate for me. The support*
 7 *around me has been strong, the work varied, and I've had many chances to develop*
 8 *myself in different areas. That builds confidence—I know I've given the impression in*
 9 *these networks that I'm a good employee, someone worth hiring.*

10
 11 *I've joined networks through conferences and try to stay in touch with certain people.*
 12 *Now I pitch them ideas and article topics so we can write together.*

13
 14 Doctoral graduates valued collaboration with colleagues. Engaging in hands-
 15 on work, articulating scientific ideas, and collaboratively developing research was
 16 highly rewarding. Participation in international research groups also brought insight
 17 into theoretical and methodological issues, as well as the collective achievements
 18 possible within the scientific community. Some had expanded their collaboration
 19 networks and sociocultural expertise beyond academia by working outside the
 20 academic community. However, integration into academic communities was
 21 sometimes hindered by competitiveness and the uncertainty of employment.
 22 Working in academia was not solely a matter of personal ambition or expertise—
 23 external factors such as the competitive funding environment set constraints.
 24 Opportunities outside academia were appealing, offering more stable and practical
 25 job roles. Even short-term positions in non-academic contexts provided chances to
 26 network and demonstrate competence.

27 Engagement in academic communities deepened doctoral graduates'
 28 understanding of how academia operates and helped them develop a wide range of
 29 skills such as collaboration and tacit knowledge. The career paths of other experts
 30 were seen as examples of different opportunities.

31
 32 *The whole doctoral process is an important journey of growth and*
 33 *development. You learn and grow into expertise during that time. I'd*
 34 *recommend it to anyone who wants to engage in research—even if they don't*
 35 *plan to stay in academia afterward, doctoral studies offer a lot. Some might*
 36 *think it's a narrow specialisation, and yes, you do go deep into one topic. But*
 37 *that doesn't mean your expertise is narrow. You learn to search for*
 38 *information, to filter it quickly, to grasp the big picture—these are skills that*
 39 *are undoubtedly useful in all kinds of jobs.*

40 41 42 **Discussion**

43
 44 This study explored the types of expertise developed during doctoral education,
 45 as experienced by doctoral graduates. The research identified that doctoral expertise
 46 aligns with the four dimensions outlined by Ericsson et al. (2006): theoretical,

1 practical, self-regulatory, and sociocultural. In addition, doctoral expertise also
2 emerged as integrative and networked (see also Hakkarainen et al., 2002).

3 According to the participants, theoretical expertise forms the self-evident core
4 of doctoral-level expertise. It is rooted in the content of the dissertation but also
5 extends into broader interdisciplinary themes. Its development is a long, rewarding,
6 and at times challenging process. Practical expertise is tightly connected to
7 theoretical knowledge and is reflected in general academic competencies. It is
8 particularly developed through involvement in the various phases of the dissertation
9 process, such as information processing and publishing activities. Practical skills
10 also include the ability to apply for project funding, which connects doctoral
11 graduates to opportunities beyond the university. Additionally, readiness for
12 continuous learning and language proficiency enable international engagement and
13 adaptation to new contexts.

14 Self-regulatory expertise develops through the self-directed nature of the
15 doctoral journey, including goal-setting, time management, and efficiency.
16 Understanding research logics and academic competition further strengthens self-
17 regulation. The doctoral process is continuous, and promoting well-being and the
18 ability to detach from research supports sustainability within doctoral education.
19 Sociocultural expertise, on the other hand, grows through participation in
20 disciplinary cultures, networks, and academic and non-academic communities.
21 Research groups and close colleagues form the sociocultural community for the
22 doctoral expert. Social relationships within research contexts facilitate the
23 development of all dimensions of expertise.

24 Examining doctoral expertise through these dimensions highlights its breadth
25 and, when mirrored against existing research, demonstrates that doctoral graduates
26 possess widely discussed transferrable skills (see Hasgall & Paneoasu, 2022;
27 Hasgall et al., 2019). Expertise evolves into differentiated forms through the process
28 (Sarrico, 2022). Career trajectories vary across disciplines (see also Piironen et al.,
29 2025; Bardner & Doore, 2020; Jaksztat & Gross, 2024; Skakni et al., 2021), and this
30 variation should be acknowledged from the outset of doctoral training. Expertise
31 continues to grow after the doctorate (Cappelli, 2015), which is intrinsic to the
32 nature of expertise (e.g. Ericsson et al., 2006). As doctoral careers progress and
33 contexts change, expertise continuously takes on new dimensions (Waijjer et al.,
34 2017). Mentoring also supports doctoral graduates in terms of career sustainability
35 and lifelong learning (Maunula et al., 2024).

36 The participants in this study represented a range of disciplines, which reflects
37 the diverse contexts of doctoral education. This diversity in background has also
38 been recognised in previous research, and individual differences cannot be
39 standardised. Doctoral education should embrace and accommodate individual
40 variation as part of career development. While research has identified key influences
41 on career paths, these influences are not always sufficiently integrated into doctoral
42 education practices (e.g. Piironen et al., 2025). Although evidence-informed
43 development and leadership should be standard in academia, in practice it often
44 challenges already time-pressed academic staff.

45 Expanding doctoral training to include information on the development of
46 expertise, disciplinary career paths, and employment opportunities would

1 strengthen doctoral candidates' self-regulation, agency, and awareness of potential
2 career paths. Rethinking and clarifying supervisors' roles and profiles—possibly
3 extending beyond academic subject expertise—would also support development. A
4 single professor cannot be expected to master every aspect of the doctoral training
5 process alone.

6 Wider employment of doctoral graduates across sectors requires both academia
7 and external stakeholders to recognise the breadth of doctoral expertise. As
8 highlighted by the doctoral graduates in this study, they are frustrated by
9 misperceptions of PhDs as overly theoretical and disconnected from practice.
10 Doctoral expertise takes different forms in different contexts. The increasing
11 number of doctoral graduates and their employment outside universities presents a
12 significant challenge to the content and practices of doctoral education (reference
13 missing). While doctoral education cannot be expected to fully equip graduates with
14 all transferrable skills, career guidance should help identify broader career
15 pathways. The responsibility for defining expertise and finding career options
16 should not fall solely on the doctoral researcher. An effective doctoral education
17 system supports graduates in finding roles that benefit society. At the same time,
18 employers must also commit to ongoing learning, offering professional
19 development in collaboration with universities.

20 This study shows that doctoral education cultivates differentiated forms of
21 expertise that are not yet fully recognised, but which could be valuable across
22 sectors if their development were more consciously guided. Doctoral expertise is
23 shaped and refined at the intersections of different contexts. Raising meta-awareness
24 of the dimensions and processes of expertise, and engaging in dialogue across fields,
25 supports doctoral graduates in developing and applying their expertise more
26 effectively. Public discussion around the nature of expertise may also help clarify
27 expectations of experts across sectors.

28 The implementation value of this research lies in recognising the importance of
29 doctoral graduates' experiences in shaping the development of doctoral education.
30 The diversification of career paths can be seen as an opportunity to reform training
31 in response to these realities (Coates et al., 2020). However, we stress the need for
32 multifaceted development: specialized supervision, comprehensive guidance for
33 students, and enhanced agency through increased awareness. As a future research
34 avenue, it would be valuable to gather descriptions of doctoral education contexts
35 and best practices across Europe to further inform development. In addition, more
36 research is needed on specialized supervisory practices and the evolving dimensions
37 of supervisors' expertise.

38 **Conclusion**

39
40 This chapter highlights how doctoral education fosters a broad, multifaceted
41 form of expertise that evolves through theoretical, practical, self-regulatory, and
42 sociocultural dimensions. Recognising and supporting this complex development
43 can strengthen doctoral graduates' career adaptability both within and beyond
44 academia.

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