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Beyond Five-Legged Sheep: Empirically Grounded Lessons for PhD Candidates and Supervisors to Navigate Challenges in Inter- and Transdisciplinary PhD Trajectories

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Abstract

The complexity and interconnectedness of major societal challenges serve as a key rationale for calls for inter- and transdisciplinary (ITD) approaches to research. These calls are becoming more common, and with it, so does conducting PhD research in ITD contexts. But ITD PhD research is also associated with several challenges, including challenges related to methodological integration, communication across disciplinary boundaries, and institutional structures that remain largely organized around disciplines. In this study we undertook a qualitative, explorative study into the experiences of PhD candidates and supervisors in ITD research, by conducting interviews with PhD candidates and supervisors from two projects on wildlife management and integrated fire management, and surveying supervisors beyond these two project contexts. We found that experiences, challenges and lessons learned from both PhD candidates and supervisors spoke to five main themes: multiplicity of motivation, juggling expectations, navigating a scattered sense of belonging, commitment to learning, and tolerating unpredictability. Overarchingly, we observed that the experiences of PhD candidates and supervisors aligned and mirror each other. Both groups experienced self, co-workers, projects, and system to expect them to be metaphorical unicorns, or 'five-legged sheep'; professionals with competence and performance in everything and more. We distilled and visualized 18 lessons for PhD candidates and supervisors to (1) manage plural motivation; (2) juggle expectations; (3) navigate a scattered sense of belonging; (4) commit to learning; and (5) tolerate unpredictability. We argue that these lessons can serve to nurture a sense of recognition and as concrete action perspective for PhD research and supervision. We emphasize that navigating these challenging dynamics is a shared responsibility for PhD candidates, supervisors, and more systemically departments, policy makers, and funding agencies. We encourage application of these lessons and visuals in other ITD contexts to spark conversation about the support for PhD candidates.

INTRODUCTION

The complexity and interconnectedness of major societal challenges serve as a key rationale for calls for inter- and transdisciplinary (ITD) approaches to research. Wildlife and fire management are examples of such complex societal topics. Ecological, societal and policy perspectives intersect when studying, understanding, and shaping human-wildlife interactions (Dressel et al. 2018). In addition, actors have conflicting interests, trade-offs in which are negotiated in the context of power dynamics and under circumstances of uncertainty and ambiguity (Pereira et al. 2018). Finally, differences are rooted in values and worldviews which cannot be removed to solve conflict (Arts et al. under review). Similarly, fire management is complex as it requires integrated understanding of both the physical environment and human behaviour (Rego et al. 2021). Understanding and shaping fire management thereby requires the bridging of experts across geographies, risks, academia and practice, and social diversity (Stoof and Kettridge 2022), requiring integration of different interests and ways of knowing and doing.

In response to calls to foster a holistic understanding of these kind of complex issues, ITD research is becoming more prevalent (Van Noorden 2015). With the increasing commonness of ITD research

projects, conducting PhD research in ITD contexts has also become more common. PhD research often comprises an essential part of ITD research (Eschen et al. 2025). At the same time, ITD PhD research is also associated with several challenges, including challenges related to methodological integration, communication across disciplinary boundaries, and institutional structures that remain largely organized around disciplinary silos rather than integrative networks (Rana et al. 2025). Achieving effective ITD research requires not only recognizing these challenges, but also actively developing strategies to overcome and navigate them.

Prior research has emphasized the pivotal role of academic institutions in enabling such ITD research (Rana et al. 2025). Within ITD PhD trajectories particularly, supervisors play a crucial role by providing guidance and mentorship, and by supporting PhD candidates in navigating multiple disciplinary perspectives and organizational contexts (Vanstone et al. 2013). Frequently, ITD PhD projects adopt co-supervision models in which multiple disciplinary perspectives are represented. While co-supervision is intended to foster integrative research environments, it also introduces additional complexities, such as power imbalances and diffuse responsibilities among supervisors, which may result in conflicting priorities for both supervisors and PhD candidates (Kálmán et al. 2022; Vanstone et al. 2013). Consequently, PhD candidates in ITD contexts are often required to take on different, potentially conflicting roles (Bulten et al. 2021), which can entail high emotional demands on them (Enright and Facer 2017).

Although these challenges have been flagged repeatedly through reflective self-report by PhD candidates (e.g. Rogga and Zscheischler 2021; Djinlev et al. 2023), there remains a gap in the literature. Specifically, existing studies tend to describe challenges at a general or systemic level, with little insight into the level of individual experiences of PhD candidates and supervisors. As a result, there is a lack of understanding how these challenges manifest in day-to-day PhD research and supervision practice, and which specific measures and structures can be instated to support ITD PhD research and supervision.

In this study we undertook a qualitative, explorative study into the experiences of PhD candidates and supervisors in ITD research programs. By integrating these perspectives, we identified shared experiences, key challenges, and their implications for research and supervision practices. The insights generated in this study are not only reported in conventional academic formats, but are also expressed through a series of visuals. These visuals constitute an integral outcome of the research, translating our empirical insights into concrete lessons, aimed at nurturing understanding and recognition in both PhD candidates and ITD supervisors, and practical tips to directly put into practice.

METHODS

We collected experiences from PhD candidates and PhD supervisors in two projects which represent different stages as well as approaches to ITD research. By combining semi-structured interviews with surveys, the perspectives of PhD candidates and supervisors, and from two different project contexts, we took a methodologically- and data-triangulated approach.

Study context: Two ITD projects

PhD candidate and supervisor interviews were conducted with participants from two projects: PyroLife and WildlifeNL. The access to these research projects was provided by the involvement of first author AH in WildlifeNL and author CRS in PyroLife. In order to guarantee the anonymity of respondents, cultivate safety to share experiences, and minimize socially desirable answers, these authors were not involved in and did not have access to the raw data of the projects they were involved in: for their respective projects, they only engaged with the anonymized and extracted data.

PyroLife

Funded as an Innovative Training Network under the EU Marie-Skłodowska Curie Actions (2019-2024), the PyroLife project trained 15 PhD candidates in integrated fire management (https://pyrolife.lessonsonfire.eu/) based and supervised at 10 organizations across Europe (universities, research institutes, a company, and an NGO).

The project focused on four axes of diversity: interdisciplinarity, intersectorality, geography, and gender PhD candidates' primary task was the conduct of research. The majority of PhD research projects and supervision vision teams were predominantly disciplinary, ranging from the social sciences to natural sciences and engineering; a small number was strongly interdisciplinary. Each individual research project included two 4-month secondments that provided intersectoral and intra-climate exposure, allowing candidates based in academia to embed their research in practice (e.g. land management, fire suppression, small enterprises, NGOs, etc), and vice versa

Cross-disciplinary exchange and learning for most PhD candidates occurred predominantly in network-wide training and workshops (15 ECTS), including interdisciplinary and intersectoral events, workshops and online risk communication training). Recruitment was done by each host organization locally, but aligned across the project using standardized advertisement texts and a dedicated rubric (Stoof et al. 2020). All PhD projects were due to start at 1 April 2020, the onset of the COVID-19 pandemic two weeks earlier delayed their start for several months in some cases.

WildlifeNL

WildlifeNL is an ITD research project running for eight years (2023-2030) funded through the Dutch NWA-ORC funding scheme executed by the Dutch Research Council (NWO). The project investigates how humans and large mammals can coexist in the Netherlands and aims to contribute to a transition towards more constructive co-existence. The WildlifeNL consortium consists of academics from ecology, governance science, philosophy, communication sciences, and computer sciences from four higher education institutes in the Netherlands, with non-academic partners including national and provincial governments, representatives of the agricultural sector, a hunters association, terrain managers, and nature conservation organizations.

WildlifeNL includes eight PhD candidates, six of whom started simultaneously in March 2025 after an integrated, team-oriented hiring procedure (Horn et al. under review). They started two years after the start of the project, as the first two years of WildlifeNL were dedicated to transdisciplinary agenda-setting with the consortium which informed the PhD research (Arts et al. 2026). The remaining two PhD candidates started earlier and worked on the project parttime. The WildlifeNL PhD candidates are based at two different Dutch universities. All WildlifeNL PhD candidates are team-supervised by three or four academics with different disciplinary backgrounds and affiliation, with overlap in supervision teams between PhD candidates. All WildlifeNL PhD candidates were part of an Early Career Researcher group with weekly, facilitated meetings which were part of the project design.

Interviews

We conducted 20 interviews in total, with 13 PhD candidates and seven supervisors. At the time of conducting the interviews, the PyroLife program had ended and most PhD candidates had completed their PhD research. Most PhD candidates and their supervisors of WildlifeNL had just started.

Interviews were semi-structured, based on a topic list on the following these themes: (1) background; (2) motivation; (3) selection and hiring; (4) team; (5) competencies and roles; (6) training and supervision; (7) outputs and recognition; and (8) career beyond PhD. The topic lists were adapted to fit the project contexts and roles of PhD candidate and PhD supervisor. Considering the different stages the projects were in at the time of conducting this study, the interviews with the PyroLife PhD candidates focused on their experiences throughout the PhD research, while for the PhD candidates on the WildlifeNL project a greater focus was on their motivation and expectations.

The interviews were conducted from April to June 2025 and lasted approximately one hour. They were held in-person or online, depending on practical possibilities and respondent preferences. They were conducted in Dutch if this was the mother tongue of the respondent, and otherwise in English. The interviews were recorded using a recorder for the in-person interviews and Microsoft Teams for the online interviews, transcribed verbatim assisted by the AmberScript software, and pseudonymized.

Survey

In order to reach more supervisors of ITD PhD candidates than only those involved in PyroLife and WildlifeNL, we complemented the interviews with an online survey. The survey gauged background information about respondents (e.g. time since completion of their own PhD, years of experience supervising PhD candidates, and number of PhD candidates they (co-)supervised) and posed broad open questions with probes on six themes: (1) academicprofile; (2) experiences with ITD PhD supervision; (3) motivation for ITD PhD supervision; (4) selection and hiring of ITD PhD candidates; (5) ITD and team supervision; and (6) competencies and training for ITD PhD supervision.

We disseminated the English language survey, designed in Qualtrics, in our own network and through several relevant newsletters. We targeted people with experience supervising at least one ITD PhD, which

we defined as a PhD candidate conducting ITD research or doing their PhD in the context of an ITD project. We defined ITD as bringing perspectives from two or more disciplines together and/or collaborating with academic and/or non-academics from different backgrounds. We asked participants to assess themselves against these inclusion criteria before participating. Participation in the survey was voluntary and anonymous. We accumulated the answers to the open questions per respondent in a text file that we added to the Atlas.ti database with interview transcripts as to be analyzed through the same coding scheme.

The survey was completed by 16 supervisors, who held positions as assistant, associate, or full professors and represent a wide range of experience in terms of the years of experience supervising PhDs (ranging from 3 to more than 20) and the number of PhDs they supervise(d). Of them, 10 had experience as main and daily supervisor, and six as daily supervisor only.

Data Analysis

The qualitative data from the interviews and survey were analyzed in two subsequent steps using the constant comparative technique (Rihoux and Ragin 2009). Data was first extracted by coding for the main categories from the interview topic list. Authors AH and JO jointly composed a coding book with the following topics: (1) motivation; (2) interdisciplinarity; (3) competencies; (4) belonging; (5) roles; (6) activities/responsibilities; (7) supervision; (8) training; (9) outputs, and corresponding sub-codes. Codes and subcodes were predefined based on the topic list and literature, and open codes and subcodes were added to capture topics that came up but were not yet covered in the coding book. For final analysis, authors AH, JO and PB and a visual designer extensively and iteratively discussed all codes and the associated quotes to interpret the data and identify emerging patterns. During these discussions, concrete practical lessons were identified which, through multiple iterations, led to the creation of the presented visuals. We primarily address findings that apply across both contexts, but explicitly refer to findings about relevant differences between the PhD candidates and their supervisors or in the context of PyroLife or WildLife. The findings are illustrated by quotations from PhD candidates (“PhD”) and supervisors (“Supervisor(interview)” / “Supervisor (survey)”).

Ethics

The research protocol and data management plan for this study have been approved by the Humanities’ Faculty Ethics Assessment Committee of Utrecht University (The Netherlands) under reference number 24-170-04. The approval was granted on 24 March 2025, prior to the start of the study. All research was performed in accordance with the Declaration of Helsinki and the Netherlands Code of Conduct for Research Integrity. All participants participated voluntarily and provided verbal consent for recordings. This research was explicitly independent from the WildlifeNL and Pyrolife projects, with separate funding and ethical approval.

FINDINGS

We present the findings organized into five themes that we identified in the analysis: (1) motivation; (2) juggling expectations; (3) scattered belonging; (4) commitment to learning; and (5) tolerate unpredictability. We end the findings section with a subsection about intersections and overarching patterns between themes.

1. Motivation

Our findings reveal several aspects that shaped PhD candidates' motivation to apply for ITD PhD positions and their motivation while conducting their PhD research. Most prominently, participants indicated that they experienced an ITD PhD, and therefore their motivation for it, to be fundamentally different from a disciplinary PhD.

Although some motivational factors were not specific for ITD PhDs – such as pragmatic considerations (e.g., job security, salary and location), intention to pursue an academic career, and a theoretic interest in the specific research topic - of particular interest here are the motivational aspects that were closely linked to the ITD nature of the project. The specific combination of topics and perspectives offered by the ITD research aligned closely with the PhD candidates' interests and thus contributed to their motivation. These candidates were explicitly seeking a holistic approach to a research topic that itself was inherently inter- or transdisciplinary. The ITD nature of the project, therefore, provided the breadth they were looking for.

A second motivational aspect was related to (opportunities for) collaboration. The possibility of working closely with other PhD candidates, academic partners, and non-academic partners was an important incentive to apply, as one PhD candidate mentioned:

I think the possibility to also connect. Yeah. With stakeholders beyond academia definitely sounded interesting to me, as well as the possibility to collaborate with other ECRs – PhD

PhD candidates mentioned that these collaborations often resulted in the development of extensive professional networks, an additional benefit of doing an ITD PhD.

A key aspect of the motivation of most PhD candidates concerned the societal relevance and practical implications of their research. Many PhD candidates emphasized that the project's grounding in real-world problems and societal needs was essential for their decision to apply. Participants mentioned that they would not have applied for a PhD at all, if the project had not been explicitly connected to societal challenges and creating direct impact in society:

It kind of combined my joy of working scientifically with this need I would see to make an actual difference in the real world. Because it was not just science, but it had connections to different companies and organizations – PhD

Furthermore, several participants mentioned that they did not perceive academic publications as most the meaningful outcomes of their PhD work. Instead, the value of the PhD was often associated with

broader forms of impact and engagement beyond academia (e.g., stakeholder engagement, workshops, policy contributions, outreach activities), and that was a crucial aspect for their motivation.

Taken together, these findings indicate that ITD PhD candidates are driven by a combination of motivational aspects that extend beyond traditional academic aspects. Their motivation can be characterized as 'triple': an interest in the research topic, commitment to collaboration, and desire to contribute to real-world impact. Several PhD candidates expressed that their PhD projects fulfilling (certain of) these triple motivations were essential for them to start and/or continue the PhD project altogether.

Supervisors also emphasized that several motivations are important for ITD (PhD) projects. The importance they assign to motivation is also reflected in their priorities in hiring processes: rather than focusing primarily on disciplinary background, or methodological and theoretical knowledge or experience, supervisors mentioned the importance of candidates' intrinsic motivation for ITD:

So I find background as such is less important, beyond someone having a feel for research and analysis, and more about drive, interest in the topic of research in a broad sense, and bringing something else to the table than I do (that is complementary though) – Supervisor (survey)

However, the activities and outcomes that PhD candidates expressed to be motivated by were often not the same that they also perceived to be expected of them or rewarded and valued by their supervisors and in academic structures. In particular, while societal engagement and non-academic outputs are major motivating factors for the PhD candidates themselves, they also experienced that these were not always (formally) recognized as important within PhD requirements, which typically emphasize academic publications.

To prevent frustration and subsequent drops in motivation because of these potential tensions between societal engagement and formal academic expectations, supervisors identified a crucial role for themselves :

The second point is that they enjoy their PhD trajectory. And I think it's important for that to happen that they're able to really find their own way through that PhD trajectory. So we need to actively facilitate that. – Supervisor (interview)

Supervisors mentioned that they could play a crucial role in determining the amount of time and energy allocated to academic output on the one hand, and non-academic outputs on the other.

2. **Juggling expectations**

A recurrent theme in the data was the expectations experienced by PhD candidates, which translate into different activities they perform, roles they assume and the competencies required to do so. PhD candidates reflected that these expectations stem from diverse internal and external pressures, including their own expectations and standards, explicitly allocated tasks from the project or supervision

team, formal requirements on the quality, amount and timing of outputs, and perceived pressure from the academic system to perform.

Aside from general, 'disciplinary' activities and associated skills (e.g., applying (disciplinary) research methods and theories, academic writing skills, writing a thesis, following courses and attending conferences), participants mentioned many different and widely varying expectations specific for ITD PhD candidates or accentuated by doing research in an ITD context, in which additional project activities need to be undertaken and different disciplinary expectations can compete.

Emerging in our data was the importance of 'social skills', which include the ability to collaborate, communicate and network in diverse groups in terms of disciplines, professions and knowledge, and to participate in corresponding activities (e.g., attending numerous meetings and working groups with different people and different tasks), which required adaptability and being open-minded. This need for social skills is illustrated by how a PhD candidate described it:

I guess you need to be able to talk to people and relate to them, and having that ability to network with people in a genuine way and sort of naturally bring people together – PhD

While supervisors mentioned that PhD candidates should not be held responsible for the integration of (all) different perspectives in ITD research, PhD candidates stated the opposite: in practice they were often concerned with the integration of several perspectives. They experienced having to adapt to different perspectives, know how to translate these into a 'shared language' and know how to represent and integrate them in their research.

The common thread that emerged in the data is that both PhD candidates and supervisors have concerns about the combination of expectations, tasks and competencies that are demanded of PhD candidates and the struggle to navigate between all of these. Supervisors mentioned their responsibility to help PhD candidates prioritizing expectations and tasks:

What you're starting to hear now is that it's all a little overwhelming, that there's a lot for them to deal with. And that they sometimes find it difficult to ensure that this doesn't lead to too much stress. To put it simply. Yes, and that's where supervision plays an important role: in managing that effectively. – Supervisor (interview)

One particular concern supervisors raised is that PhD candidates have to spend too much time on networking and integration and that consequently too little time remains for their research. It was mentioned that in particular in disciplines that employ research methods requiring prolonged periods of concentrated work, these network- and integration activities were perceived to distract from the specialized research within the project.

3. **Scattered Sense of Belonging**

The professional sense of belonging of the PhD candidates we interviewed comprised combinations of relations to several groups and places, including: PhD candidates in their project, PhD candidates in their departments, disciplinary communities, academic and non-academic project partners, supervisors, and others with whom they shared physical (office) space.

This scattered sense of belonging posed challenges as well as opportunities. Some PhD candidates expressed that they felt lost, lonely or overwhelmed, either mainly at the beginning of their PhD or throughout it. Moreover, some PhD candidates expressed a tension between feeling at home in the ITD context and feeling at home in a specific discipline:

Sometimes I slightly miss that I also feel at home in my own discipline. Then I'm maybe swallowed by the group. […] I don't really feel like I'm currently working in my own discipline, especially because I'm in so many gatherings, and meeting people. […] So it feels a bit out of balance now – PhD

On the other hand, there were also PhD candidates who mainly experienced the opportunity to belong in different places as rewarding and who emphasized the potential for building a rich network. This is in line with the earlier observation that we presented in the subsection on motivation that networks and collaboration motivated doing an ITD PhD.

The PhD candidates in WildlifeNL expressed consistently that they felt the strongest belonging with the PhD cohort within the project. Multiple aspects came together: they shared their interest in human-animal interactions, collaborated with many of the same people, were synchronized in career stage and PhD trajectory, and shared ITD experiences and challenges. The PhD candidates also employed at the same institution expressed to feel additional closeness.

The PyroLife PhD candidates reported a more diffuse sense of belonging and expressed struggling with this. They experienced a less strong sense of belonging in the PhD cohort within the project, which they linked to being geographically dispersed, having little direct practical collaboration in the PhD cohort, and additional challenges of the Covid-19 pandemic and corresponding lockdown measures. Instead, they seemed to find different kinds of belonging with different people: social belonging through proximity, e.g. colleagues at local organizations, value belonging through shared dedication to wildfire in the project and in local contexts, and epistemic belonging through shared disciplinary views with their supervisors. They expressed that relationship building with the other PyroLife PhD candidates took a leap when lock-down measures lifted and in-person meetings and trainings became possible again.

This suggests that seeking out and creating relationships in which different dimensions of similarity coincide may contribute to reducing diffuseness of belonging and thereby strengthening it. Furthermore, physical proximity was experienced to be a key factor in cultivating a sense of belonging. The potency of physical space-sharing is illustrated by how a PhD candidate described their experience of a fieldwork trip with other PhDs from the project:

We went on a week-long fieldwork trip. That means that you are spending a full week in a cabin with those people. You really live on top of each other for a week. But that immediately gave us a strong connection. And what I really appreciate is that this was really an investment from the project in us. I was really impressed by that […] both content-wise and socially a lot of time is invested in us, that is really meaningful – PhD

This example demonstrates that project design choices and supervisors can play a role in building a sense of belonging by organizing immersive and in-person activities such as training programs and joint fieldwork.

At the same time, both PhD candidates and supervisors also expressed that a sense of belonging cannot be coerced. They mentioned that personal 'click' also plays an important role. A project or supervisor can create opportunities for connections and relationship building and can invite PhD candidates to different communities and networks, but in the end it is up to PhD candidates themselves to find the people with whom they level and build relationships. A supervisor reflected on this interplay a follows:

I would never force a PhD candidate to attend a certain meeting. I don't believe that to be effective. But I do try to show them the advantages and to give some encouragement like: this may be an interesting group to be part of […] then I write an email to this colleague or that colleague and write that I would enjoy it if they joined too. Because I find that important. But I would never say 'you HAVE to come', because I find that nonsense. Some are simply more involved than others, but I do try to involve them with social events. – Supervisor (interview)

4. **Commitment to Learning**

From the perspective of PhD candidates and supervisors, it became clear that doing an ITD PhD is a continuous learning process for all involved. For PhD candidates this included further developing their competence in dealing with diverse actor needs, building confidence to speak up when bringing deviating perspectives, and the acquisition of topic-specific knowledge and methods. Specific learning needs were situational, depending on the PhD candidate's prior experience and specific topics and challenges of the project.

Multiple PhD candidates indicated that most of their interdisciplinary learning took place in interaction with their supervision teams. The PhD candidates who participated in this study were supervised by a team with a various degrees of disciplinary diversity. Disciplinary diversity seemed to be a double-edged sword: on the one hand it could be one of the most potent learning opportunities, on the other, if it resulted in unresolved tension and disagreement, it could be one of the most pressing sources of stress for PhD candidates. One PhD candidate described these dual implications as follows:

I think it may be too much to expect all of the qualities [needed for an ITD PhD] from one person. But then sometimes when you have several supervisors, they also contradict themselves. And it can also be stressful. – PhD

Possible sources of tension that PhDs candidates and supervisors flagged were differences in expectations, disciplinary publishing practices, epistemic values, and contradicting feedback. If these differences and tensions were left to PhD candidates to resolve, this was reported to be stressful and labor-intensive. One PhD candidate described as follows how they experienced their responsibility of managing differences in their supervision team:

We were encouraged from the very beginning of the project, um, that our role is to manage our supervisors and not the other way around […] I think for a lot of people that was a huge challenge, especially people who are not used to, um, you know, confronting strong opinions or planting themselves as the, you know, protagonist of their project. And that was a big challenge for me, too. – PhD

If these differences were instead resolved among supervisors, PhD candidates could be shielded from this additional labor, and observing or participating in such constructive conversation could actually be inspiring. One PhD candidate described their experiences as follows:

It was not like I had to buffer any [tension]. There was no tension between the supervisors. It was very constructive because they were very humble, both of them, in which was not their field of expertise. And they were very respectful of each other's disciplines. And I think this only happened because they felt like safe in each other's presence. And it was not the first time they collaborated, on my PhD supervision. No, they were like colleagues – PhD

Both PhD candidates and supervisors indicated that realizing the potential of this disciplinary diversity required a humble, learning mindset from supervisors to be open to different perspectives brought in by their co-supervisors and the PhD candidate. Supervisors indicated that previous experience with ITD contributed to feeling equipped to supervise ITD PhD candidates. And also PhDs mentioned ITD experience of their supervisors as a success factor for their supervision. Supervisors also emphasized the importance of learning from colleagues to be equipped for ITD PhD supervision. Such learning could for instance take place through co-supervision, (structured) peer intervision, and advice from role models.

5. Tolerate unpredictability

PhD candidates and supervisors emphasized the unpredictable nature of ITD PhD trajectories. Supervisors indicated that PhD trajectories are unpredictable in general, as the research is usually shaped throughout the process, and is adapted based on the outcomes and PhD candidate's preferences and qualities. But they highlighted the *additional* unpredictability of ITD research, in which changing needs from societal actors and disciplinary cross-fertilization may direct research down unexpected paths. One supervisor described the additional unpredictability and disorientation they experience in ITD research as follows:

It's a different set-up than if you would do a PhD that is clean within one discipline, because then also I would say the literature and what you need to connect to and familiarize yourself with is better defined. But

we basically open so many doors at the same time, and it's a lot about navigating and also seeing. – Supervisor (interview)

Finally, the additional complexity of university politics when supervising PhD candidates across departments and institutes were experienced to further add to unpredictability and uncertainty.

Both PhD candidates and supervisors indicated that the unpredictability of ITD PhD is partially inherent to ITD PhD projects. Dealing with this unavoidable unpredictability was at the root of their needs for **flexible** and **personal** PhD supervision.

Flexible supervision approaches were deemed important to also for shaping, reconsidering, and revising the process throughout in response to changing learning needs. PhD supervisors indicated that supervision needs vary strongly from one PhD candidate to the other, depending on their tasks, ambitions, strengths, prior experience, and personality. Moreover, these needs are likely to change throughout the PhD trajectory, as tasks and activities change and competencies develop.

Both PhD candidates and supervisors, however, emphasized that flexibility should be met with structure. Structured support such as pre-defined (mandatory) trainings and periodic meetings were implemented with the aim of training competencies that were considered essential for all PhD candidates in their projects, to proactively put things on the agenda also before they may have surfaced or that would otherwise have remained hidden, and providing support beyond the expertise represented in the supervision team. One PhD candidate described as follows how they experienced the combination of structured training and personal supervision:

[there were] plenty of trainings and courses and webinars, and so there was so much opportunities to really get a lot of knowledge, not just from your main supervisor. But still, like writing the PhD thesis is something that you need support, and this didn't come from webinars. This comes from a direct person working with you. – PhD

Both PhD candidates and supervisors expressed that higher intensity of predefined or mandatory trainings better fit the early stages of the PhD trajectory, with the focus gradually shifting to more responsive, tailored approaches.

Lastly, several PhD candidates expressed that personal connections and safety with their supervisors were key success factors in dealing with uncertainty and corresponding discomfort. Supervisors indicated that they find the personal aspect of PhD supervision important. One supervisor said the following about it: *Supervision ultimately means dealing with and supporting another human being* (supervisor, survey).

Respondents indicated that personal investment in supervision helped to (1) build psychological safety and thereby lower the threshold to share struggles and ask for help, (2) contribute towards personal and professional transformation, (3) share visions, ambitions, and passion, and (4) support PhD candidates towards their post-PhD career paths.

6. **Intersections: PhD Candidates and Supervisors as Five-legged Sheep**

The five themes laid out in the previous subsections demonstrate a wide range of experiences and expectations of ITD PhD candidates that are often at tension with each other. In this section we integrate these diverse experiences and expectations to provide the overarching picture that emerges. The challenges of dealing with diverse activities, situations, communities and roles suggest a picture of unrealistically high expectations, demanding ITD PhD candidates to be the metaphorical 'unicorn', or 'five-legged sheep', people who are good at everything and still more: PhD candidates indicated that they experience to be expected to engage in a wide range of activities and tasks. They need attitudinal aspects such as triple motivation, the willingness to navigate between different group, expectation to deal with a scattered sense of belonging, as well as the willingness to invest time and energy in tasks that do not always seem to be directly to *conventional* academic outputs. Unpredictability, which is inherently linked to ITD research, in addition requires adaptability and flexibility. One PhD supervisor described the high demands for ITD PhD candidates as follows:

Well, if you're just working on a specific [disciplinary] research project on your own, you simply need good research skills. But if you're part of a team that works in a transdisciplinary way, you also need skills such as the ability to communicate with people. You need to be respectful towards different stakeholders who have different backgrounds or different interests and concerns. You need to be interested in collaborating with others, interested in moving beyond your own discipline, and enjoy that integration. And on top of that, you also need to be good at research. – Supervisor (interview)

However, these expectations also apply to supervisors. We saw that they also experienced a scattered sense of belonging, struggled with diverse expectations, felt a mismatch between what drove them and is rewarded, have to deal with unpredictability and need to engage in interdisciplinary collaboration to supervise ITD PhD research. We therefore argue that the experiences of PhD candidates and supervisors mirror one another, they are *both* required to be five-legged sheep. One of the PhD candidates described this parallel between PhD candidates and supervisors as follows:

So I am quite aware that with the project I had, or with the nature of the program [name project], there were different qualities that are needed both in us as the candidates but also in the supervisors. And so it's much more than working scientifically, for sure. It's not just theory and reading and writing, it's also networks and it's also curiosity and lots of things. – PhD

DISCUSSION

In this exploratory study of PhD candidates' and supervisors' experiences in ITD research, we identified five overarching themes capturing key experiences and challenges: motivation, expectations, belonging, learning and unpredictability. These interrelated themes converge in a broader insight: engaging in ITD PhD research requires both PhD candidates and supervisors to embody the metaphorical 'five-legged sheep'. This entails not only motivation, willingness, and the capacity for the research itself, but also for managing the diverse tasks and responsibilities across academic and non-academic contexts,

navigating multiple perspectives in both research and supervision, and coping with unpredictability inherent to these projects.

Previous research shows that disciplinary PhD trajectories already involve a broad range of responsibilities extending beyond core research activities, including teaching, project management and collaboration (Woolston 2019), alongside persistent ambiguity in expectations and roles which both PhD candidates and supervisors must continuously navigate (Polkinghorne et al. 2023; Palmer et al. 2023). Our findings align with this literature, but suggest that these dynamics are intensified in ITD contexts. ITD research is reported to require activities, tasks, and responsibilities that are often experienced as not being valued as the 'core business' of academic research and can therefore be perceived as mere 'extras'. This can further accentuate the experience of ITD stretching ITD PhD candidates thin.

In our findings, we found that ITD PhD candidates are expected to navigate multiple expectations and perspectives. This aligns with previous studies, which showed that ITD PhD candidates must navigate heterogeneous disciplinary norms and values, multiple institutional actors, and diverse epistemic cultures, which often results in divergent expectations and communication challenges (Vanstone et al. 2013; ITD Alliance Early Career Researchers Working Group 2025; YAG Interdisciplinary Working Group 2023; Rana et al. 2025). In addition, PhD candidates need to balance scholarly rigor with stakeholder expectations (Rogga and Zscheischler 2021; ITD Alliance Early Career Researchers Working Group 2025).

We found that ITD PhD candidates consequently take on substantial responsibilities in coordinating and facilitating ITD processes in addition to core academic work, supporting the findings in previous studies (Rogga and Zscheischler 2021). Existing literature increasingly acknowledges these additional tasks (Rogga and Zscheischler 2021; Rana et al. 2025). Furthermore, PhD candidates themselves repeatedly warned for the pressure and additional workload of these activities that compete with core research activities (Rogga and Zscheischler 2021; Djinlev et al. 2023). Finally, PhD candidates – in our study and in the literature (e.g. Bridle et al. 2013; Djinlev et al. 2023) – express that they often feel insufficiently equipped for the activities and responsibilities that ITD research demand among others because they were not (sufficiently) trained in these activities and corresponding competencies in their academic education leading up to their PhD. This suggests that further uptake of ITD higher education can contribute to addressing this challenge.

In line with our findings, the literature indicates that supervisors play a crucial role in supporting interdisciplinary research (Rana et al. 2025; Dericks et al. 2019). Although our results suggest that there could be advantages to having an interdisciplinary supervisor team, such supervision entails challenges, including divergent views on research quality and doctoral guidance, inconsistent expectations (Rana et al. 2025), and even power imbalances and conflicting priorities (Kálmán et al. 2022). Our findings further confirm that it is important for supervisors to be willing to learn themselves, which was also reported by Polkinghorne et al. (2023) and support the findings of Vanstone (2013), suggesting that supervisors

need to remain open to discussions about disciplinary interests and the concepts of interdisciplinary work.

However, it is also clear that in practice some of the challenges in ITD research are hard to prevent, due to the asymmetrical time availability and content engagement between PhD candidates and senior researchers on projects, often further accentuated by funding structures (Horn and Krabbenborg, 2025). Supervisor frameworks that provide support for supervisors in ITD trajectories are still lacking, so the question remains how the additional activities and responsibilities can be designed, organized, and distributed in ITD project in such a way that project goals are pursued, while PhD candidates' sovereignty and wellbeing are also guarded.

Practical implications: lessons for doing and supervising ITD PhD

Based on our findings, we formulated lessons for PhD candidates conducting ITD research and supervisors of such PhD trajectories. With these lessons, we aim to surface common challenges in ITD PhD research and provide concrete pointers on how to navigate them. A designer translated the lessons into playful visuals (see Figure 1 and Supplementary Materials A for high resolution versions), with the aim of supporting their uptake beyond scholars studying ITD, to foster recognition and stimulate reflection and dialogue in practice. The visuals feature PhD and supervisor 'sheep' that mirror one another, reflecting our finding that both ITD PhD candidates and supervisors may feel or be expected to embody the ideal of a 'five-legged sheep'. The PhD and supervisor sheep each have their own, yet related, lessons.

We invite others to use these lessons and visuals in their ITD training and supervision contexts, for PhD candidates, but at least as importantly, for supervisors. We argue that PhD research and supervision are a joint effort and mutual responsibility, and stress that framing ITD PhD research as something that PhD candidates and supervisors do jointly can prevent burdening PhD candidates with additional expectations.

The lessons follow from the findings and are organized into the same five categories. The following subsections describe the lessons for PhD candidates and supervisors per topic; their numbering corresponds with the numbering in Figure 1.

1. *Manage plural motivation*

As PhD candidates' motivation was very powerful when it combined motivation for topic, *and* collaboration, *and* societal relevance, we recommend that PhD candidates **nurture triple motivation (PhD-lesson#1)** by seeking out positions and activities where these align. Supervisors confirmed this importance of motivation which prompts them to **prioritize motivation (SV-lesson#1)** over skills or theoretical knowledge in selection procedures. The (apparent) absence of progress and misalignment between what PhD candidates personally value and what is being rewarded, could harm motivation. Therefore, we advise PhD candidates to **make invisible progress visible (PhD-lesson#2)** by not fixating

on completed outputs, but also explicating the progress in the research process. We advise supervisors to **create what you value and value what you create (SV-lesson#2)**. This means making explicit what they find important, and creating the possibility to generate outputs that are in line with these values, not as a mere add-on, but as a legitimate academic activities.

2. Juggle expectations

We saw that PhD candidates in ITD research contexts implicitly and explicitly carry different tasks and responsibilities. To not be swallowed by other activities and stall in their research, they need to **find focus for PhD research (PhD-lesson#3)**. They can, however, not do this by themselves. This demands that supervisors **help prioritize (SV-lesson#3)** and that supervisors **do not make PhD candidates (solely) responsible for ITD (SV-lesson#4)** thereby shielding PhD candidates from being over-asked on communication, stakeholder management activities, and integration activities. They can for instance do this by explicitly allocating these responsibilities and tasks elsewhere.

3. Navigate a scatted sense of belonging

Partially belonging to multiple communities and places could be challenging for PhD candidates in ITD contexts. We recommend that supervisors **provide a house that can be turned into a home (SV-lesson#5)** and that PhD candidates **furnish their own home (PhD-lesson#4)**. By this we mean that supervisors offer diverse options of belonging to PhD candidates, for instance by actively inviting them to events, introducing them to people, an establishing structures for regular in-person meetings. Only the PhD candidates themselves, however, can then in turn familiarize themselves with these contexts, selectively relate to them and make one or several contexts their own. The other thing PhD candidates themselves can do is **seek out other (ITD) PhD candidates (PhD-lesson#5)** as these are relationships that can cultivate recognition and understanding in shared lived experiences of doing (ITD) PhD research.

4. Commit to learning

An ITD PhD trajectory is a learning process for all involved. The supervision team can be one of the most fruitful learning environments for PhD candidates, if the diverse supervision team is committed to ITD and engages in interdisciplinary collaboration constructively themselves. As such, it requires that supervisors are aware that **interdisciplinary supervision is interdisciplinary teamwork (SV-lesson#6)**. For PhD candidates this means: **don't become the supervisor of your supervisors (PhD-lesson#6)** which means not becoming responsible for negotiating the differences and disagreements between the supervisors on their behalf. ITD supervision requires that supervisors **act as co-learners (SV-lesson#7)**, assuming a humble stance about towards their own partial expertise and being open to learning from and with their co-supervisors and PhD candidate. Finally, learning needs for PhD candidates vary, depending on their interests, prior experiences and knowledge, career goals, and tasks. This demands of them that they **shape their own unique learning process (PhD-lesson#7)** in which they (learn to) formulate their wants and needs and ask for help to realize these.

5. Tolerate unpredictability

ITD PhD projects are inherently unpredictable, which makes it impossible to eliminate uncertainty. Therefore, we recommend that PhD candidates should **embrace disorientation (PhD-lesson#8)**, especially in the beginning of their PhD trajectory. This unpredictability can also cause stress, where supervisors can play a role when they **recognize the human in the PhD candidate (SV-lesson#8)** to create a good personal relationship and safe learning environment. Another way in which supervisors can deal with and help PhD candidates deal with unpredictability is to **continuously monitor and evaluate process (SV-lesson#9)** to identify new learning and supervision needs and adjust course accordingly. Another source of unpredictability is that PhD candidates are often (unavoidable) subject to university politics due to financial, personnel and promotion policies. We therefore advice PhD candidates: **realize that you're an academic resource (PhD-lesson#9)**, which will not resolve this challenging reality, but may help PhD candidates deal with and open up conversation about those dynamics and its impact on their PhD experiences.

Research Implications

In this study, we conducted explorative research focused on the perceptions and experiences of PhD candidates and supervisors. This broad approach means that it serves to generate follow-up questions and hypotheses for further studies. Experimental research could provide insight into whether strategies suggested by PhD candidates and supervisors are indeed effective in generating desired results. For instance, follow-up research could examine whether motivation is indeed a more powerful predictor of ITD PhD success than prior knowledge, skills, or experience. Moreover, next steps could examine how experience with and commitment to ITD in supervision teams affects the ITD success of the PhD candidate they supervise. Additionally, further research could potentially assess the relationship between the required integrative capacity and the disciplinary diversity in interdisciplinary PhD supervision teams, which requires further examination.

Besides effectivity-oriented experimental design, another way to study ITD PhD research and supervision, relying less on self-report of experiences, would be to take an ethnographic approach to observe and study the actual collaboration, interaction, and communication among PhD candidates and others involved in ITD projects. Auto-ethnographic and collective auto-ethnographic approaches could provide a way to study one's own experiences while engaging in ITD PhD research and supervision (Lapadat 2017), and cognitive ethnography (Nersessian 2019) could provide a methodological lens to study collaborative structures as an outsider.

Methodological Considerations

In this study, we took a multi-method approach to study the experiences of PhD candidates and supervisors involved in two ITD research projects: PyroLife and WildlifeNL. This enabled triangulation across projects and contexts, perspectives (PhD candidates and supervisors), and data sources (survey and interview). Including two different projects allowed us to reflect on both commonalities and

differences. Both projects took different approaches to ITD research, training and supervision, and were in different stages of execution. This allowed higher resolution on the hiring and selection process which at the moment we collected the data had recently taken place in WildlifeNL, while PyroLife, in its final stages, enabled reflection on the entire project and as such provided higher resolution on collaboration, supervision and training experiences. Moreover, the difference in approaches allowed us to foreground the experiences with more structured training and geographically spread-out collaboration in PyroLife and more tightly knit supervision teams and more extensive co-location in WildlifeNL.

At the same time, it should be noted that we included only two projects, and thus only two approaches to ITD, while ITD research practices are highly heterogeneous (Vienni-Baptista et al. 2022). By opening up the survey to a wider audience beyond these two projects, we diversified our respondents and thus the contexts from which we collected experiences. However, future research could benefit from including a larger number of projects and approaches to ITD PhD supervision. Moreover, our study design was not tailored for studying the differences between disciplinary and ITD PhD research. While some supervisors reflected on these differences based on prior experiences, and interviews touched on which challenges were ITD specific versus those that more generally applied to PhD research, these insights remain limited to self-reported within-subject experiences. A comparative design could make stronger claims on which challenges or strategies are unique, or differ within, ITD contexts compared to disciplinary ones. Possibly such research could benefit from taking degrees or forms of (inter)disciplinarity as an independent or control variable.

In spite of collecting the data in just two research projects, we reached data saturation. Patterns of recurring observations emerged, and the number of novel open codes reduced drastically towards the end of the analysis. Nevertheless, our findings are highly contextual and should be interpreted as such. Therefore, we were transparent about research contexts, as to equip readers to appraise transferability to their own contexts (Korstjens and Moser 2018).

CONCLUSION

Our findings show that triple motivation, navigating multiple expectations, coping with a scattered sense of belonging, and dealing with unpredictability are central challenges of ITD PhD trajectories, all unfolding within a continuous learning process for everyone involved. Importantly, our results indicate that these expectations also apply to supervisors. The broad range of competencies, activities, and responsibilities expected from both ITD PhD candidates and supervisors extends beyond those traditionally associated with disciplinary PhD trajectories.

This illustrates that both PhD candidates and supervisors experience the expectation (from self and others) to meet exceptionally high—arguably unrealistic—standards, and that they are required to embody the metaphorical ‘five-legged sheep’. The lessons formulated for both PhD candidates and supervisors in ITD PhD trajectories provide practical guidance for navigating these challenges in everyday practice, while fostering recognition, reflection, and dialogue. Moreover, these lessons,

captured in visuals, can be used as concrete tools in the training of both PhD candidates and supervisors within ITD PhD programs. In doing so, they may help transform challenges into opportunities, ultimately contributing to the realization of the full potential of ITD research.

Declarations

Competing interests

The authors declare no potential competing interests

Data availability

The data collection instruments – topic lists and survey questions – are available in the supplementary materials for this publication. Anonymized data and detailed are stored in the YoDa repository. To ensure confidentiality and the use of the data only for specific purposes, the data will be available upon reasonable request, based on a Data Transfer Agreement, only with permission of the principle investigator of this research (AH).

Ethical approval

The research protocol for this study has been approved by the Humanities' Faculty Ethics Assessment Committee of Utrecht University (The Netherlands) under reference number 24-170-04. The approval was granted on 24 March 2025, prior to the start of the study. All research was performed in accordance with the Declaration of Helsinki and the Netherlands Code of Conduct for Research Integrity. All participants participated voluntarily. All research data is anonymized.

Informed consent

Informed consent was sought and obtained from all study participants before their participation. The research was conducted on the legal basis of public interest. For the interviews, oral informed consent was obtained at the start of the conversation, after participants had received and read the information letter. For the surveys, participants arrived on a landing page that provided information about the study before informed consent was sought. Participants were informed about the purpose of the study, the voluntary nature of participation, and the right to withdraw from the study at any time.

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Figures

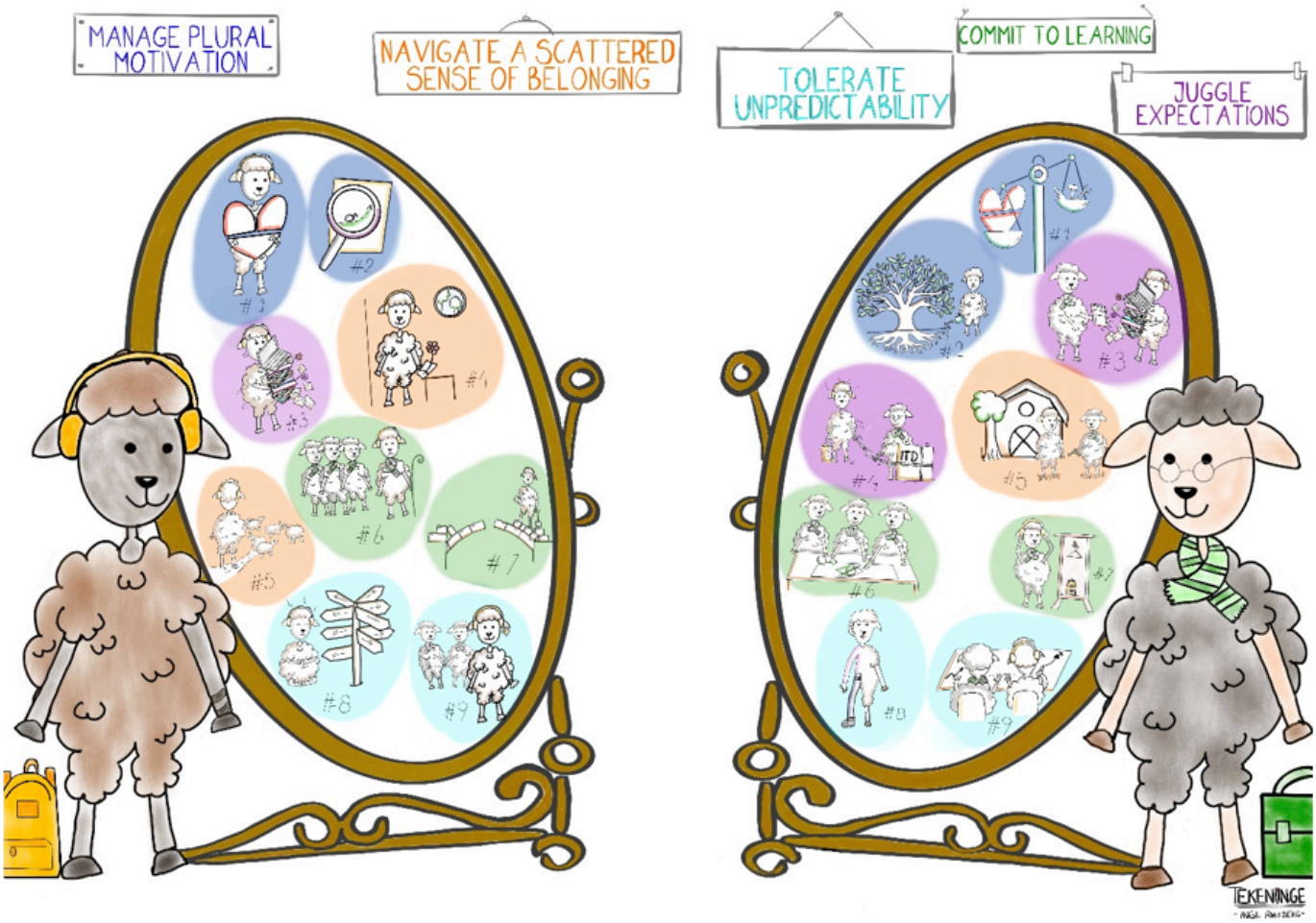


Figure 1

Visual representation of lessons for PhD candidates conducting ITD research (left) and supervisors of ITD PhD candidates (right). They are organized into the following categories: (1) managing plural motivation (dark blue); (2) juggling expectations (purple); (3) navigating a scattered sense of belonging (orange); (4) commitment to learning (green); and (5) tolerating unpredictability (cyan).