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INDUSTRIAL PHD EDUCATION – EXPLORING DOCTORAL STUDENTS ACTING IN THE INTERSECTION OF ACADEMIA AND WORK-LIFE

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ABSTRACT

Aim/Purpose	The aim is to explore the benefits and challenges of industrial PhD education through the perspectives of industrial PhD students who are acting in the intersection of academia and work-life by applying a work-integrated learning (WIL) approach to highlight issues that academy and industry need to consider.
Background	Industrial PhD education is a vital part of collaboration between academia and society although still an under-researched field. This paper reveals the perspectives of the industrial PhD students who are at the same time involved in both academia and industry, with the same academic demands as traditionally enrolled academic PhD students combined with demands and expectations from their industrial employers.
Methodology	Qualitative methods were applied and 19 semi-structured interviews with industrial PhD students were conducted. The empirical context is a Swedish university profiling work-integrated learning offering PhD programs for industrial PhD students from both the private and public sectors.
Contribution	This explorative study contributes to advance the current knowledge of third cycle education to deepen the insights into benefits and challenges in industrial PhD education through the perspectives of industrial PhD students acting in the intersection of academia and work-life. By applying a WIL approach on third-cycle education, issues that academy and industry need to consider for successful collaboration within doctoral education are identified.
Findings	Findings indicate that industrial PhD students acting in the intersection of academia and work-life are developing practical and transferable skills requested by employers outside academia, hence increasing societal impact. Findings show

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	that industrial PhD education generates several WIL benefits. Novel challenges identified include unclear financial agreements, conflicts of interest, administrative bureaucracy, work promotion opportunities, and lack of belonging and identity, hence not exploiting the full potential of WIL. This has been further intensified during the COVID-19 pandemic with restricted travel and dependence solely on virtual connections.
Recommendations for Practitioners	It is vital to recognize that challenges do exist and need to be considered to strengthen industrial PhD education as well as collaboration between academia and society. Increased communication and continuous interactions between academia and industry during the entire industrial PhD education are needed.
Recommendations for Researchers	Future studies of WIL in industrial PhD education are encouraged.
Impact of society	This study contributes insights into PhD education transforming along with societal needs based on successful university-society collaboration.
Future Research	Further research is encouraged to deepen and broaden the industry perspective of industrial PhD education.
Keywords	industrial PhD student, industrial PhD education, work-integrated learning, WIL, PhD program, university-society collaboration

INTRODUCTION AND BACKGROUND

Contemporary societal issues often call for the inclusion of many perspectives and competences, hence there is a demand for increased collaboration between academia and society in order to generate learning, new knowledge, and dissemination of research findings (Altbach et al., 2019; Bölling & Eriksson, 2016; Cohen, 2009; Olsson et al., 2021), not least regarding the ongoing digitalization of all sectors of society (Obedait et al., 2019). Academia has to collaborate within a broad spectrum of contexts as many problems are transdisciplinary in nature (Cohen, 2009). Furthermore, universities should act as a provider of trained researchers (Altbach et al., 2019; Hayes, 2021) as well as act as knowledge hubs embedded in society (Lind et al., 2013). Thus, there is a need to continuously scrutinize ways of collaboration with contemporary society as interaction with society and practice are of crucial importance for higher education (Olsson et al., 2021). The importance of doctoral education is recognized in the knowledge society (Bin et al., 2016; Jones, 2018) and there is an emerging interest for collaboration with academia regarding PhD education in third-cycle education (Bernhard & Olsson, 2020; Borrell-Damian et al., 2010; Gill & Mullarkey, 2015; Grimm, 2018; Gustavsson et al., 2016; Roolaht, 2015). Doctoral education has rapidly expanded, encouraged by European higher education policies (Santos & Patricio, 2020) and has been transformed along with societal needs and labor markets for PhDs and the fact that PhD education does not merely aim for academic careers (Malfroy, 2011; Valencia-Forrester, 2019). However, earlier research on doctoral education stresses that universities struggle with low completion rates arguing for the importance of deeper insight into doctoral students' individual as well as structural challenges, e.g., isolation and pressure, need to feel a sense of belonging to the community of research, limited supervision and highly bureaucratic documentation of progress (Littlefield et al., 2015; Roos et al., 2021). Another contemporary challenge for universities all over the world is the crisis due to the COVID-19 pandemic affecting all educational levels causing obstacles and disruptions in doctoral education and dissertation progress, coping with on-line learning, virtual connections, access to external organizations, societal lockdown, restricted travelling, and industry crisis (Andal & Wu, 2021; Donohue et al., 2021; Wang & DeLaquil, 2020).

In order to increase industry involvement in research there are issues to consider both for academia and society when establishing a relation as industry research collaboration and its expectations may

differ compared to traditional academic research. It is especially vital to understand the limitations and expectations of partners involved concerning e.g., limitations of research topics, funding, what is beneficial to whom, workforce development, permissions to publication of results, and delay of societal impact (Valentin & Shane, 2014). However, industrial PhD education is emerging as one way of increasing collaboration between academia and work-life *during* the PhD education. Industrial PhD students here refer to students who originate from and are fully employed in industry (industry funded) during their PhD education, i.e., the company is investing in an employee to become a PhD. Accordingly, industrial PhD students are acting in the intersection of academia and work-life, but with the same academic demands as traditionally enrolled academic PhD students. As argued by Bernhard and Olsson (2020), industrial PhD students may be viewed as key stakeholders embodying the informing flows, i.e., interactions between practice and university and between practice and research, offering opportunities for validation and testing of empirical results and models. Earlier research stresses that industrial PhD students act as brokers of knowledge spanning the boundaries between academia and industry (Assbring & Nuur, 2017; Berg & McKelvey, 2020; Gustavsson et al., 2016; Kuntuu et al., 2018; Thune, 2009), while at the same time struggling with dual cultures and expectations (Bernhard & Olsson, 2020; Kihlander et al., 2011; Olsson & Bernhard, 2020). However, research on industrial PhD education is limited and there are calls for more empirical studies (Bernhard & Olsson, 2020; Santos & Patricio, 2020) regarding creating successful collaborative arrangements over time between industrial PhD students and industry (Kihlander et al., 2011). Thus, the benefits and challenges of industrial PhD education need to be further explored (Assbring & Nuur, 2017; Bernhard et al., 2018; Bernhard & Olsson, 2020; Olsson & Bernhard, 2020; Roolaht, 2015; Santos & Patricio, 2020). Earlier research on industrial PhD education has mainly focused on the students´ learning outcomes and educational experiences (Berg & McKelvey, 2020; Thune, 2009). Existing research covers e.g. European industrial PhD programs in informatics and engineering in Sweden (Berg & McKelvey, 2020; Bernhard & Olsson, 2020; Kihlander et al., 2011; Olsson & Bernhard, 2020), engineering and health science in Portugal (Tavares et al., 2020), hybrid trajectories within engineering and technology sciences and social sciences in Portugal (Santos & Patricio, 2020), engineering and automotive manufacturing in Germany (Grimm, 2018), programs as policy tools for university-industry collaboration in Estonia and Denmark (Roolaht, 2015) and in the USA, the interdisciplinary business doctorate program for executives (Gill & Mullarkey, 2015). Valencia-Forrester (2019) states that there is a need to include WIL as industry experience in doctoral education in Australia, the US, and the UK in order to increase the employability of PhDs. McCarthy and Wienk (2019) also point out that the PhD degree covers skills and tools that are essential to all sectors of contemporary society. Still there are issues such as knowledge gaps, labor market hurdles, and international differences to overcome in order to increase PhDs' employability within the academy and/or in "the world outside academia."

One transdisciplinary approach to increase collaboration between academia and society is work-integrated learning (WIL) as an umbrella term for a range of university initiatives and forms to integrate theoretical knowledge with practice work bridging research, higher education and practice for mutual learning outcomes and preparing students for the transition into work-life (Bates, 2008; Bernhard et al., 2018; Billett, 2009; 2014; Bowen & Drysdale, 2017; Gellerstedt et al., 2018; Lundin et al., 2008; Olsson et al., 2021; Patrick et al., 2008; Rampersad, 2015). WIL is here applied as theory and a model for academia-society collaboration aiming at knowledge exchange and research together with industry. Thus, the aim of this study is to explore the benefits and challenges of industrial PhD education through the perspectives of industrial PhD students, who are acting in the intersection of academia and work-life, by applying a WIL approach to highlight issues that academy and industry need to consider.

RQ1: What are the benefits and challenges of being an industrial PhD student active in the intersection of academia and work-life?

RQ2: How may academy and industry respond to identified benefits and challenges?

The empirical setting for this study is University West in Sweden which has a profile area in work-integrated learning (WIL) to address issues on integrating theory and practice in all levels of higher education (University West, 2022).

THEORETICAL FRAMEWORK – WORK-INTEGRATED LEARNING

Work-integrated learning (WIL) is often defined as an educational strategy in which students combine conventional academic learning with some periods of time at workplaces (industry) of relevance to a program of study and careers (Coll et al., 2008). Billett (2014) argues that adults continue to learn and develop through their occupational practice (i.e., work) and hence the industry settings need to be "legitimized, understood more fully and on their own terms as environments in which individuals come to participate and learn" (p. 690). In higher education WIL may be categorized as: (i) co-op, the traditional cooperative education model (Barbeau, 1973; Betts et al., 2009; Franks & Blomqvist, 2004; Groenewald, 2004), often referred to as sandwich education (Ward & Jefferies, 2004) or internships (Sovilla & Varty, 2004; (ii) case, using practice as inspiration; (iii) imprint, bringing practice to class; (iv) tools, using professional tools; (v) field, bringing class to practice (Gellerstedt et al., 2015); and (vi) industrial PhD education (Bernhard & Olsson, 2020). All categories of WIL are based on the fundamental idea of a tripartite collaboration between academia, students, and industry (Coll, 1996) integrating knowledge and skills from academia and work-life.

The WIL concept in higher education has developed over time and is today an umbrella term covering education, collaboration, and research (Bernhard & Olsson, 2020; Olsson et al., 2020; Gellerstedt et al., 2015). WIL has the potential to provide direct benefits not only for work life and academia, but also for a wider community as well as creating synergy between theory and practice (Arvemo et al., 2018; Gellerstedt et al., 2015). WIL is mainly applied in undergraduate degrees and supported by industry and governments (Valencia-Forrester, 2019). WIL students are often more psychologically prepared for work-life (Purdie et al., 2013), with a stronger professional identity (Jackson, 2013) and have career benefits regarding early career job advancement and higher salary (Gellerstedt et al., 2015). Academic supervisors in doctoral education stress that WIL brings forth students with greater maturity and improved research skills (Garza & Jones, 2017), while employers benefit by accessing work-ready students (PhillipsKPA, 2014). Apart from the pedagogical learning benefits, WIL also forms the basis for collaboration and interactions between higher education and practice (Olsson et al., 2019; Olsson & Bernhard, 2020). Thus, the WIL approach needs to adjust to the development of contemporary society and there are calls for more innovative applications of WIL as well as including broader, sector-wide research incorporating the perspectives of students, universities, industry, and global perspectives on the future (Bowen & Drysdale, 2017; Bernhard & Olsson, 2020; Valencia-Forrester, 2019; Zegwaard & Rowe, 2019). The role of WIL in doctoral education or third-cycle education is less explored compared to undergraduate education (Bernhard & Olsson, 2020; Valencia-Forrester, 2019). Thus, there is a need for more research on collaboration between university and industry with focus on industrial PhD students as they are active in the university-industry intersection (Bernhard & Olsson, 2020; Olsson & Bernhard, 2020). Furthermore, previous research stresses that there is a dual knowledge gap as industry employers have limited insight into the value of engaging a PhD graduate, while PhD graduates are often uninformed of employment opportunities outside of academia (McCarthy & Wienk, 2019), which strengthens the need for further studies in this research field.

The WIL approach is here combined with the Informing flow framework, originating from Gill et al. (2016) in order to illustrate and analyze university-society collaboration with the perspective of industrial PhD students. The Informing flow framework is closely related to the WIL approach as it stresses transdisciplinary work and exchange of knowledge among actors to break down boundaries that hinder interactions and flows of knowledge e.g., by using information technology as discussed by Cohen (2009). The Informing flow model is a strategic tool to identify and assess interactions related to informing channels and forms based on the premises of growing complexity of society and

growing participant diversity of the stakeholders. Key stakeholders are categorized as students, research community, community of practice (industry) and academia (Gill et al., 2016).
In this study as illustrated in Figure 1, industrial PhD students are placed in the center of the framework overlapping all key stakeholders, thus embodying the informing flows between practice and academia, and between practice and research. Furthermore, they are part of informing flows within practice, research, and student communities (Bernhard & Olsson, 2020). Here, the collaboration is viewed as a cross-fertilization not only of disciplines but also of academia and industry, theory and practice related to industrial PhD third-cycle education.

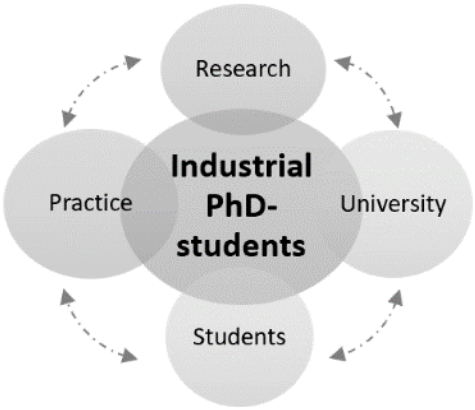

Figure 1. A WIL-based model for informing flows of industrial PhD education (Bernhard & Olsson, 2020).

METHODOLOGY

This research is conducted as an explorative qualitative study focusing on industrial PhD students' perspectives across three disciplines at a Swedish university profiling in work-integrated learning. An initial study of a small sample of industrial PhD students and their organizations was conducted in 2019-2020 (Bernhard & Olsson, 2020). This study is a subsequent study in order to broaden and deepen the research problem by covering industrial PhD students in various educational phases, adding more disciplines as well as more industrial contexts.

RESEARCH CONTEXT

This study is contextually drawn from higher education in Sweden. Across all Swedish universities 17,100 PhD students were enrolled in 2020 (Swedish Higher Education Authority, 2021). In 2020 approximately 5% of all PhD students were industrial PhD students (Swedish Higher Education Authority, 2021). The empirical research context is University West in Sweden, which is one of 31 public Swedish higher education institutions (Swedish Higher Education Authority, 2021). University West has a WIL profile as the only Swedish university. In 2001 the university was commissioned by the Swedish government to further develop WIL as a pedagogical strategy. Doctoral degrees with specialization in WIL in the fields of informatics and pedagogy have been offered since 2011. In 2020 an additional doctoral degree in WIL was launched. A Swedish PhD program corresponds to four years of full-time study comprising 240 ECTS credits (Swedish Higher Education Authority, 2021).

DATA COLLECTION AND ANALYSIS

This study explores the benefits and challenges of an industrial PhD education through the lens of the doctoral students who are acting in the intersection of academia and work-life.

During this period University West had in total 21 enrolled industrial PhD students within the three disciplines of Informatics with a specialization in WIL, Production Technology, and Work-integrated Learning. Qualitative methods were applied including interviews and document studies. All 21 industrial PhD students were invited, i.e., a total survey, and 19 of them participated in this study.

The industrial PhD students were in different stages of their PhD education: 14 in the beginning, three in a middle phase and two at the end as illustrated in Table 1. Four of the industrial PhD students were studying corresponding to half-time studies while the others were enrolled in 80-100% studies. The distribution among disciplines were: Five from Informatics with a specialization in WIL, six from Production Technology, and eight from Work-integrated Learning. Different kinds of organizations (i.e., employers) in society were represented as eleven of the industrial students were employed in the public sector and eight in the private sector. The respondents included nine women and ten men ranging in age from 27 to 55. The percentage of their PhD enrollment at the university varied from 50% to 100%.

Table 1: Overview of respondents

Respondents	Data collected	Sector	Phase of PhD Education
R1	Nov 2019	Private	Beginning
R2	Nov 2019	Public	Beginning
R3	Nov 2019	Public	Middle
R4	Dec 2019	Private	Beginning
R5	Nov 2019	Public	End
R6	June 2021	Private	End
R7	June 2021	Private	Beginning
R8	Oct 2021	Private	Beginning
R9	Oct 2021	Private	Middle
R10	Jan 2022	Private	Beginning
R11	Oct 2021	Private	Beginning
R12	Oct 2021	Public	Beginning
R13	Oct 2021	Public	Beginning
R14	Nov 2021	Public	Beginning
R15	Nov 2021	Public	Beginning
R16	Nov 2021	Public	Beginning
R17	Nov 2021	Public	Beginning
R18	Nov 2021	Public	Middle
R19	Nov 2021	Public	Beginning

The interview guide for the industrial PhD students covered topics about the benefits and the challenges of being an industrial PhD student to identify issues that academy and industry need to consider strengthening the collaboration for the industrial PhD education. Furthermore, the interview guide included questions about if and how the COVID-19 pandemic had impact on their PhD-education.

In total 19 semi-structured interviews were conducted during 16 months from October 2019 until January 2022. Due to the respondents studying and/or working in different contexts and due to the ongoing COVID-19 pandemic, the data collection was performed as a mix of face-to-face interviews, focus groups, digital (telephone, Zoom) semi-structured interviews and e-mails to give voice to the respondents. All interviews were conducted by the two authors together and ranged from 20–40 minutes, and were recorded with informed consent, transcribed, and coded.

In this qualitative, explorative study, we strove for research rigor by semi-structured and coded interviews and awareness of how to reduce research bias as recommended by Gill and Gill (2020). Furthermore, a detailed documentation of all steps in the research process was conducted in order to enhance transparency and replicability. Following research ethics and striving for research rigor, the authors have not had any supervisory relationships with the industrial PhD students and their organizations and have not served on their thesis committees although the authors of this paper are employed at the same university. Anonymity have been applied to make the industrial PhD students feel independence and openly describe benefits and challenges. This entails not presenting details about the PhD project topics nor the industrial PhD students' disciplinary affiliations. All collected data was analyzed by the two authors of this paper to identify patterns and themes following the analyzing method described by Alvesson and Kärreman (2007). Identified themes related to benefits and challenges were analyzed as interactions between academy and industry according to Figure 1. An initial coding of all the data was done individually by each author using color markings and analytic memos to capture the researchers' ongoing reflections, inspired by Linneberg and Korsgaard (2019), followed by iterative steps of analysis conducted together by the two authors.

FINDINGS AND DISCUSSION

This section presents and analyzes the benefits and challenges of an industrial PhD education through the lens of the doctoral students who are acting in the intersection of academia and worklife.

THE BENEFITS OF BEING AN INDUSTRIAL PHD STUDENT

According to the respondents, there were several benefits from being an industrial PhD student, such as inclusion in academia as well as in industry, being in the intersection and part of a research context as well as an industrial context spanning boundaries between university and industry with mutual benefits. As pointed out in earlier research (Assbring & Nuur, 2017; Berg & McKelvey, 2020; Gustavsson et al., 2016; Kunttu et al., 2018; Thune, 2009) the industrial PhD students benefit from access to networks, projects and synergy effects related to empirical data and recent research which are illustrated in the following quotes:

> It is very good to have one foot in the organization [industry] as you keep your friends and workmates and continue to work in your work context.… I also try to look at myself as an "inspirer" being part of the research and the scientific way of thinking bringing it into work life. (R2)

> I am close to my research area; I have a lot of empirical knowledge and experience. … I am really passionate about the area. I see the anchoring in the research area as a great advantage. (R16)

> The major advantage is the proximity to the empirical data, the accessibility to exciting projects and interesting people. (R5)

> When you are employed by the company you may access confidential information much more easily. (R9)

Another benefit is the experience from work-life that the PhD students have compared to other PhD students. This led to having contextual understanding, tacit knowledge, and mutual learning for both university and industry.

> I have a number of years in the industry, and there is a lot of silence in organizations that is not that easy to discover. If you come into a company and conduct a study, interviewing and observing then you do not notice the tacit processes,

> what is not so explicit but what just happens in some way, the contacts between people, synergies that are only there. (R6)

> I am not starting from scratch; I am *not* newly graduated from university and have a little clue of how the world around works in a way. Nobody really needs to explain to me the industrial context. (R8)

> …. benefits I felt is to get a large of exposure from people on various levels of work, people with different experience of working. (R7)

Furthermore, the respondents are highlighting the work-integrated learning perspective when generating learning and new knowledge in industry during the PhD program that is in line with earlier research (Bernhard & Olsson, 2020; Bernhard et al., 2018; Olsson et al., 2020; Valencia-Forrester, 2019). The duality in work-integrated learning is emphasized:

> It is the masterpiece of work-integrated learning in both directions …. really a win-win if you provide the conditions [at the workplace] for it. (R17)

Also, the COVID-19 pandemic is viewed as a benefit advancing on-line PhD education, allowing taking all courses regardless of geographical location and keeping up the completion rate of the PhD education.

> The greatest advantage on a personal level is that it has been possible for me to complete a doctoral program [at a distance]. (R14)

> The pandemic came just at the same time as I was admitted. Nothing has been the same as normal. In that way, it has been positive for me that everything was switched to digital. That is why it has not affected me so much not to be able to be in place either. (R15)

The fact that the PhD education also offers opportunities and tools to critically reflect and review the industrial workplace is a benefit which is illustrated in the quote below:

> The greatest advantage I experience is that I get the opportunity to see my organization in a completely different way. I have rediscovered my own organization. … I actually had to critically review myself as much as I critically examined my own organization. (R18).

The Challenges of Being an Industrial PhD Student

The industrial PhD students stress the mutual benefits of being in the interface of academia and work-life. As stated in previous research, there are also challenges being an industrial PhD student such as difficulties of balancing and prioritizing among tasks related to studies or work, dual and changing roles, and heavy workload (Assbring & Nuur, 2017; Bernhard & Olsson, 2020; Gustavsson et al., 2016; Kunttu et al., 2018; Littlefield et al., 2015; Thune, 2009). Results of this study add challenges, by far the most articulated is the employers' limited understanding of the industrial PhD students' *entire* work situation, work schedule, expectations to always prioritize work tasks before PhD studies, and also drawbacks related to the COVID-19 pandemic.

> If you are employed by a company you have to work much more, you have many more things to get done than just your research and your PhD. … it is much more difficult to finish the PhD on time due to other responsibilities. Usually, the company does not prioritize the research that much since things change extremely fast in industry. (R9)

> My employer has a hard time understanding that it is so labor-intensive taking courses and submission of assignments. (R1)

> 50% work and 50% studies become a challenge. It is a little tough. It is very much on and off! (R16)

> As a part-time student, 50% plus 50% easily becomes more than full-time especially if the PhD program is designed for full-time studies with expected participation in meetings, activities, and seminars. You must prioritize and opt out which was difficult, especially in the beginning. (R5)

> It is all about balancing and switching between different roles and often opposite perspectives and goals such as what is in the interest of research or company management. (R5)

> You cannot isolate yourself at work, as you can at the university, since you also have to take care of a lot of other things that happen at work. (R6)

> It was not easy, it was difficult to make time and *get away* from work to follow out my doctoral courses. My department did not understand at all the time and concentration required. It was phones that rang and emails, and it was my boss who wanted to get in touch and… I was not given the conditions to carry out my PhD studies. I had many different roles; sometimes operational, sometimes responsible for skills development and sometimes development work. Now and then I had to replace my boss and be department manager when my boss was not in place…there was an attitude that: 'please stop that [PhD studies] and come here and work for real instead. You are needed on the floor.' (R17)

> There are many people you are responsible to and work towards … It can be a bit fragmented since everyone wants you to be involved … but I struggle to stay focused even though I would like to be part of more. (R2)

> As an industry PhD student you may have to spend time traveling far to the university, yet on-line education [during COVID-19] is a challenge since the courses are not originally planned as on-line courses. (R1)

Most industrial PhD students accentuate feeling alone during PhD education as recognized in earlier studies (Andal & Wu, 2021; Donohue et al., 2020; Wang & DeLaquil, 2020). Some of the respondents of this study also view themselves as an outsider not really belonging anywhere. This is especially prominent among those industrial PhD students who are in the beginning phase. Hence the benefit of belonging to both university and industry mentioned above, is also experienced as a disadvantage, which has been further intensified during COVID-19 with restricted travel and only virtual connections.

> I am very, very alone in my work, right now I feel it very much, as I do not have the proximity to other PhD students, no one to discuss with, no natural contact. It may also be caused by the fact that so far, I had to take all courses on-line due to the COVID-19. (R16)

> My relationship with the university is a challenge and I am mainly thinking of the COVID-19. Now I am halfway through my PhD education, but I have still not visited the university. My feeling of belonging suffers, and the university feels extremely far away. … (R13)

> Every time I come; I feel as if the discussions with the other PhD students have moved on since I last saw them. I only come in here and there. I would have

> liked to be part of those discussions and exchanges of ideas in the student group. (R2)
>
> You are alone — that is the main challenge! It is incredibly lonely to be an industrial PhD student. (R18)

Furthermore, the respondents highlight the challenges related to collaboration agreements of their PhD education that sometimes include multiple actors (e.g., due to financing within research projects) as these constellations often generate conflicts of interest, administrative bureaucracy and lack of industry understanding of or interest in the design of the PhD education:

> You are in the middle — in my case, I am in the middle of three organizations: all the old contact networks that you had are still there, but the relationships become completely different as you step away. (R18)
>
> In my case it has been very confusing initially due to conflicts of interest among the collaborating partners. (R12)
>
> The drawbacks that I have to live with is the fact that in my opinion there are a lot of conflicts of interest.… I have not had as much freedom as I would have liked. (R8)
>
> There was repeatedly a lot of trouble with the arrangement of my financing [salary-payments]. (R17)
>
> As an industrial PhD student, you end up a little outside the digital infrastructure. Every year my profile page is deleted on the university website and every year I have to argue with the IT department about it …. and I do not get access to the Wi-Fi for employees. (R4)
>
> My employer is not happy in the least that I am an industrial PhD student and not interested in my PhD education. (R19)

Additionally, respondents experience ethical dilemma being an "insider" related to data access and publication:

> There are challenges for me as internal data is not accessed freely anyway although I have had more opportunity to negotiate more data for myself. There is a greater trust in me, but at the same time it is a greater responsibility for me to make sure not to publish what is sensitive. I have a responsibility to my company, and I am probably scrutinized more harshly than an external person. (R6)

How May Academy and Industry Respond to Identified Benefits and Challenges?

This section discusses how academy and industry may respond to identified benefits and challenges. Findings show that this kind of university-society collaboration (i.e., industrial PhD education) generates several WIL benefits for academy and industry such as access to networks, projects and synergy effects related to empirical data and recent research and mutual learning. Respondents clearly recognize benefits from being active in the intersection of collaboration between academia and work-life. They have contextual understanding and tacit knowledge which promote the overall PhD education. The industrial PhD students are spanning organizational boundaries, thus strengthening the informing flows (interactions) between practice and academia, and between practice and research (see Figure 1). Both academy and industry have to have detailed insights into the industrial PhD education in

order to recognize and fully exploit these benefits while building mutual relationships sustaining informing flows over time.

As stated in the findings, there are challenges related to both academy and industry such as the industrial PhD students' *entire* workload and work conditions, understanding of industrial PhD education, industrial PhD students' need of belonging and identity, financial agreements, conflicts of interest, administrative bureaucracy, and work promotion opportunities for the industrial PhD students. Both academy and industry have to invest time and energy in the relationship to reach and understanding of each other's expectations and limitations regarding e.g., research topics, funding, data access, dissemination of research findings and societal impacts. Thus, there is a need for increased communication and continuous interactions (informing flows) between academia and industry during the entire industrial PhD education. Notable in this study is that financial agreements including more than two organizations have negative impact on the industrial PhD education generating conflicts of interest, administrative bureaucracy, and lack of belonging and identity.

A university-society collaboration should be prepared to deal with unexpected societal circumstances in order to keep and sustain the relation and its benefits. In this study this has been exemplifies by the COVID-19 pandemic that restricted travel and hence intensified the collaborating partners' and industrial PhD students' dependence solely on virtual connections. User friendly virtual platforms are thus important for complex interactions such as university-society interactions in order to build and sustain relations around industrial PhD-education. Further, there are important lessons learned regarding communication from the pandemic that may strengthen future academy and industry interactions.

Despite traditionally enrolled academic PhD students struggling to find employment in academy or industry after graduation, industrial PhD students are employed. Yet, industry needs to have a long-term perspective on the work promotion opportunities of the industrial PhD education in order to keep and engage the graduated industrial PhD student in relevant work tasks to retain knowledge and skills. On the other hand, it may be beneficial for the academy to keep the relation with the industrial PhD student after graduation by part time involving them in education and/or research projects i.e., extending work integrated learning for academy and industry beyond graduation.

CONCLUSION

This explorative study contributes to advance the current knowledge of doctoral education to deepen insights of benefits and challenges of industrial PhD education through the perspectives of industrial PhD students who are acting in the intersection of academia and work-life. Further, how academy and industry may respond to identified benefits and challenges are discussed. Findings partly correspond to previous research on benefits and challenges. Yet, this study adds novel challenges for industrial PhD students such as: financial agreements, conflicts of interest, administrative bureaucracy, work promotion opportunities and lack of industry understanding of or interest in the design of the PhD education that academy and industry need to consider. Financial agreements including more than two organizations have negative impacts especially on the industrial PhD students' sense of belonging and identity, hence may counteract identified benefits.

Implications for successful collaboration within industrial PhD education are highlighted. Both academy and industry have to invest time and energy in the relationship to reach and understanding of each other's expectations and limitations regarding e.g., research topics, funding, data access, dissemination of research findings and societal impacts. Thus, there is a need for increased communication and continuous interactions (informing flows) between academia and industry during the entire industrial PhD education. Especially in order to facilitate unexpected societal circumstances such as the COVID-19 pandemic that might affect the collaboration.

This study contributes a WIL approach on third-cycle education and application of Informing Flows framework to illustrate the collaborative interactions and mutual learning opportunities between

academy and industry. Results indicate that industrial PhD students acting in the intersection of academia and work-life are developing practical and transferable skills requested by employers outside academia, hence increasing societal impact.

Limitations and Future Studies

There are limitations of this explorative study due to the single case covering one university and three disciplines. The study was conducted during the COVID-19 pandemic which may have affected the results. Further research to deepen and broaden the industry perspective of industrial PhD education is encouraged.

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