

PROFILE OF THE INDUSTRIAL PHD STUDENT IN BRAZIL: MOTIVATIONS, COMPETENCIES AND BENEFITS IN THE DAI PROGRAM

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ABSTRACT

This study aims to identify the profile of the Academic Industrial Doctorate (DAI) student by investigating the pilot program at the Federal University of ABC (UFABC). As the fundamental link between the university and the company, the profile of this doctoral candidate is crucial for the success of the collaboration. Using a qualitative approach with semi-structured interviews, the research found that the main motivation for joining the program is the opportunity to develop applied research for real industry problems. The most desirable personal characteristic for this student is a good interpersonal relationship, which is essential for navigating both environments. Their main role is to conduct the project, acting as the bridge between the academic and corporate worlds. Consequently, the most developed skill is precisely the interpersonal relationship, followed by adaptability. Finally, the greatest benefit obtained by the student is the acquisition of valuable industrial experience, which enhances their career opportunities and networking.

KEYWORDS: *applied research, industrial doctorate. process innovation, university-enterprise relations.*

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1. INTRODUCTION

Universities play an important role in the development of innovation and entrepreneurship ecosystems. They are expected to take a leading role in the development of human capital and the economy, in association with partnerships with the industrial sector and different levels of government (Heaton et al., 2019). Thus, actions developed by universities aimed at substantiating innovations with new companies are relevant given the positive social impact they can provide. Universities, in cooperation with industry, have an essential function to collaborate with society and contribute to regional economic development (Gustavsson et al., 2016). Cooperation between universities and industry can bring benefits to both. Besides developing their research environments, industries can receive knowledge from universities, which in turn can work on real and relevant daily challenges to promote innovation (Lindén & Björkman, 2019). Associations between universities and industries have become recurrent, including in doctoral programs (Assbring & Nuur, 2017). Consequently, the growing demand for collaborative research between universities and industries gives great relevance to doctoral students in the construction and transfer of knowledge between academia and industry (Borrell-Damian et al., 2010; Thune, 2009). Universities are central to knowledge production, while doctoral students, who are pursuing the highest academic degree, can contribute to knowledge production in both academia and industries

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(Yang, 2022). One of the proposals that has been operationalized to promote the association between universities and industries is the industrial doctorate, defined as a doctoral model carried out in collaboration between the university, industry, and the student. This model aims to connect the university to the industrial sector, directing doctoral students towards research focused on solving real-world problems (Sin et al., 2020).

In Brazil, a similar model has been adopted under the name Academic Doctorate for Innovation (DAI). The program originated in 2013 with the name Academic Industrial Doctorate, through a pilot project operationalized in partnership with the Federal University of ABC (UFABC) (UFABC, 2013). Subsequently, the program was expanded to institutions throughout Brazil. It is worth mentioning that the name, Academic Industrial Doctorate, is still maintained by UFABC. In this program, the doctoral student receives a scholarship from the National Council for Scientific and Technological Development (CNPq) through academic doctoral courses to develop innovative projects in partnership with a company/industry (CNPq, 2024). It is relevant to emphasize that the DAI is not an independent doctoral program, but a form of entry into doctoral programs to obtain a CNPq scholarship.

This work focuses on the students participating in industrial doctorates. Besides being the target audience of the program, they also act as the link between the university and the company. Thus, the objective of this work is to identify the profile of the student who undertakes the doctorate through the Academic Industrial Doctorate promoted by the Federal University of ABC. The topic is little explored in literature. A search in the Scopus database in September 2024 revealed a total of 37 works related to the industrial doctorate. In Brazil, a search in the Periódicos Capes database resulted in only one published article on the topic. Furthermore, according to the Analytical Report - DAI/2018 Program, no studies or research on the DAI were found (CNPq, 2024). No work was found regarding the broader benefits acquired by students from industrial doctorates either.

The article presents the introduction in its first section. In the second section, as a theoretical foundation, the article addresses general aspects of the profile of students participating in industrial doctorates. The third section presents the methodological procedures for the elaboration of the article. The fourth section addresses the results obtained from the research. The fifth section presents the discussion of the results. Finally, the sixth section presents the final considerations.

2. THEORETICAL FOUNDATION

This section presents general aspects about the students of industrial doctorate programs.

The Profile of Industrial Doctorate Students

A doctorate carried out in collaboration between a university, industry, and a student is designated in the literature as an industrial or collaborative doctorate. These doctoral programs aim to link the university to the industrial sector, helping to direct doctoral students towards industry-oriented research through more interdisciplinary courses, presenting various challenges to students (Sin et al., 2020). This type of doctorate is distinguished from a traditional doctorate by the projects developed by students in industries. This type of postgraduate program combines research components promoted by universities with the enhancement of industry-oriented skills (Evans, 2016).

Industrial doctorates have a contemporary approach of uniting the university and industry to prepare a workforce from postgraduate education (Tavares et al., 2019). Students must be enrolled in a doctoral program and develop a research project based on challenges proposed by or in collaboration with business organizations (Heldal et al., 2021). University supervisors influence the project's design to ensure it is aligned with the program and has scientific quality (Cardoso et al., 2019).

Industrial doctorate students develop projects aimed at solving a practical problem within the industry, and they constantly participate in meetings and presentations where they develop a close relationship with the industry (Lee & Miozzo, 2015). The involvement that students have with various professionals contributes to contact with different values and ways of working (Wardenaar et al., 2014). Doctoral students participating in this program model can assume three roles during the course: producing knowledge, acting in knowledge transfer, and developing network relationships between the university and industry (Thune, 2009). Similarly, the research by Santos et al. (2020) described the role of students in industrial doctorate programs as centered on knowledge transfer between university and industry, knowledge generation, establishing or strengthening the link between university professors and industry, and acting as a research funding channel for university professors.

The link between the university and industry occurs through the doctoral students. For students to perform their functions satisfactorily, some characteristics are desirable: a) flexibility, due to the multiple environments in which research is developed and the need to meet requests from both the university and the industry; b) resilience, an essential characteristic due to the number of challenges the doctoral student must deal with during their research (Tavares et al., 2020). These two characteristics are also relevant for the phase of choosing the topic and planning the research, given the complexity of the negotiation required to balance the interests of students and industries. Proactivity, autonomous learning, and taking advantage of entrepreneurship-related opportunities are also mentioned (Tavares et al., 2020).

The study by Sa'a and Yström (2024) found the importance of the industrial doctorate student in disseminating the knowledge produced within the industry where their project is developed. For this, the student needs to have curiosity and an open mind for absorbing new knowledge, in addition to participating in events and networking for better propagation of their knowledge. The same authors also noted the importance of the student knowing how to transmit their knowledge to different audiences within the industry itself, needing to translate academic language for the industrial environment.

Students who enroll in an industrial doctorate program aim to acquire certain skills and competencies. The acquisition of skills required by the industry is among the reasons students are interested in the industrial doctorate (Cardoso et al., 2019; Tavares et al., 2019). Students are stimulated by the greater employability and career possibilities that the program can generate. They also seek the development and updating of skills through the practical experience acquired and appear to be more optimistic about their careers after completing the course, compared to traditional doctoral students (Roberts, 2018; Thune, 2009).

There is a growing trend of doctoral students who are not specifically interested in research and a university career. Some also show interest in improving practical professional skills to work in other sectors of society, thus giving rise to doctoral programs to meet this demand (Cardoso et al., 2019). Celis and Duque (2016) comment that one of the motivating factors for students to enter industrial doctorates is the possibility that the research carried out will generate innovation in the industrial sphere. The work of Gustavsson et al. (2016) found that several research projects developed by students from Swedish industrial doctoral schools became new or improved products and processes.

The industrial experience acquired by industrial doctorate students can collaborate with the acquisition of competencies and skills. The study promoted by Lee (2008) observed that the experience that doctoral students have with industry contributes to the acquisition of skills related to negotiation, administration, leadership, financial management, initiative, and socialization with other colleagues. Other examples of competencies that can be developed through the industrial doctorate include business knowledge, networking, problem-solving, communication, teamwork, time management, decision-making, and negotiation skills (Tavares et al., 2019). Other important competencies that can be acquired by students were named transferable skills, related to building a

network, communication, negotiation ability, teamwork, flexibility, writing improvement, and independence and entrepreneurship (Tavares et al., 2020).

Many competencies can be acquired during the industrial doctorate; however, it is important that the student starts the course already possessing characteristics that enhance their learning. The competencies acquired by students reported in the literature, in addition to technical skills, are linked to the business area, which are often worked on in specific areas of science. Students will also be able to teach and transmit their knowledge to other students, contributing to the construction of science.

3. METHODOLOGICAL PROCEDURES

This section reports the methodological path traced for the collection of data that contributed to achieving the objectives of the work. The research has a qualitative approach, also classified as descriptive and exploratory. The research participants were the actors involved in the projects developed within the scope of the Academic Industrial Doctorate promoted by UFABC and actors involved in the promotion of the DAI at the institutional level: a) six alumni; b) six supervising professors; c) seven representatives of the companies involved in the projects; d) the DAI Coordinator at UFABC; and e) a CNPq official involved with the DAI. For the identification of the actors, the Pro-Rectorate of Graduate Studies at UFABC provided information on the students and supervisors, but regarding the company representatives, the report was that they were not authorized to pass on the information.

Regarding the research population, the information provided by the Pro-Rectorate of Graduate Studies at UFABC indicates that the population to be researched would reach a total of approximately 86 actors. Due to the difficulty of accessing all the actors involved, it was decided to use a sample of this population. The type of sample used was non-probabilistic, being stipulated by the researcher's criteria. The sample was also defined by accessibility or convenience, which does not require statistical rigor, without the need for a high level of precision (Gil, 2019).

Three delimitations were defined for the choice of actors to be researched: i) DAI alumni: for having already experienced all the phases of the DAI, thus having a greater possibility of contributing to the research; ii) students' theses available to the public: for the possibility of accessing the theses developed by the students and to mitigate possible problems with the confidentiality of the projects; and iii) projects related to processes: it was observed that the profile of most of the developed projects was related to solving problems related to processes in the involved companies. With the use of these delimitations, the total population was reduced from 86 to 27 actors. Adding the CNPq official, the total reached 28 actors to be interviewed. It is mentioned that the DAI Coordinator also accumulates the function of supervising professor, so it was not necessary to add him to the count. An effort was made to interview the students, supervisors, and company representatives involved in the same project. All 28 actors were invited to participate in the interviews. Information about the company representatives was obtained through the snowball technique, in which students or supervising professors indicated the most suitable representative to provide information about the development in the DAI in their respective companies.

The data collection technique to be employed was the semi-structured interview with the actors involved in the process already presented. All 20 interviews were conducted in the period from 04/12/2024 to 07/04/2024. The duration of the interviews ranged from 23 to 88 minutes. The participants were invited via email, WhatsApp, or the LinkedIn social media platform. Eight invited individuals did not respond to the contact attempts. All participants were free to choose the day and time for their interviews, and all were conducted by videoconference using the Google Meet video communication service. Of the 20 interviews conducted, 19 were recorded. Only one student did not authorize the recording of the interview. Thus, a copy of the interview transcript was sent to the student who later validated it. The transcription of the interviews was done simultaneously through

the Google Scribbl extension. The analysis of the data, obtained through the interviews, was carried out through the content analysis methodology of Bardin (2016). All interviews were transcribed and read. The analysis of the data obtained was supported by the Atlas.ti software, where the interview transcripts were inserted for analysis. In this software, codes were defined and subsequently inserted into their respective categories. After the analysis, the text was prepared.

4. RESULTS

This section presents the results regarding the aspects related to the students who entered their respective doctoral programs through the DAI. The section is composed of five analyzed aspects defined according to the literature: the reasons that led students to enter a doctoral program through the DAI, the desirable characteristics for a DAI student, the role the student plays in the program, the skills developed, and the benefits they enjoy from their participation in the program. All aspects mentioned by the participants will be presented in descending order of the number of citations.

Reasons for Entry

In total, the participating students cited three reasons for entering the DAI. It is noticeable that involvement with industry was a recurring reason mentioned in the interviews. The most cited reason was the 'opportunity to produce applied research'. Some students were attracted by the opportunity to develop an applied research project that was not restricted to the university: "I thought I would fit into the program. Because it was a practical problem from a partner company" (Student 2).

Another reason cited was 'identification with the industrial profile of the DAI'. Due to the DAI developing projects in partnership with an industry, one of the students who already had some industrial experience was attracted by the proposed format: "And you who are there at UFABC, you understand that there is a profile and I was not within that profile. I understand that the DAI had this profile of wanting to bring academia together with industry, the marriage of industry and academia" (Student 5).

The interest in 'entering the job market' was cited by an interviewed student who showed interest in the program for the opportunity to enter the market: "So, I became interested in entering this program because I saw it as an opportunity to get closer to the industry, right? Which could generate a possible job, a professional future, while at the same time I could also get the doctorate that was of interest to me at the time" (Student 1).

The three reasons cited by the students for entering the DAI converge with the existence of a partnership with a company for the development of the project. The identification with the industrial profile, the development of applied research, and the desire to enter the job market demonstrate that the partnership with a company is a relevant attraction for the DAI.

Desirable Characteristics

In total, ten characteristics that would be desirable for a student entering a doctoral program through the DAI were mentioned. 'Good interpersonal relationship' was the most cited characteristic by the interviewees. The importance of communication within the company was emphasized, due to the fact that the student is the project leader and constantly needs to request help, materials, and equipment from employees. In addition to developing relationships with professionals and companies with whom they have contact: "Communication skills are fantastic, they are fundamental. Not fantastic, fundamental! Yes, you need to know how to communicate, because here no one is going to be able to hover over him, pampering him. He will have to talk to one, talk to another. When things are not working out, he will have to seek, to search" (Company 2).

The characteristic 'having industrial experience' is understood as a positive factor that favors the conduct of the project by the student who already has knowledge and experience in an industrial

environment: "Because I have been repeating here that the DAI also has this purpose or this opportunity to show the student how life in industry works, right? And maybe the student who has already had this comes to the DAI with a little more experience and can absorb it better. So, another factor that is important for us is that the student has previous professional experience" (DAI Coordinator).

The characteristic 'possessing technical and theoretical knowledge' highlights the importance of the student having a good background for the development of their project through the DAI. This characteristic can be considered elementary for doctoral students: "Well, knowledge, super important! We are not interested in teaching the student what to do. They have to have the knowledge to come up with a very good literature review. From the information they get from us, they have to develop. The DAI is different from an internship, right? We are not here to teach the student how to make a part that is developed, but rather, we want the student to understand from the information they will have what we have to do, we have to learn from the student" (Company 7).

Regarding 'autonomy', the reports were that, at times, the student will not receive support from either their supervisor or the team that assists them in the company. Therefore, it is important that the student has the attitude to be able to conduct their project with reduced assistance: "The company, it has its company problems, right? So, they are not going to hold your hand, they are not going to help you with what you need, they are not going to say: 'Look, you need this material'. You have to know what you need, you have to know when you need it. You have to run after it to demand it. It's no use waiting for the supervisor to demand it, it's no use waiting for someone to bring it to you. So, mainly autonomy, much more than technical capacity [...]" (Student 1).

Regarding 'self-motivation for problem-solving', the interviewees reported that students are expected to have a good ability to solve problems that arise during the development of their project. It is important to note that some interviewees emphasized not only the ability but also the will to solve the problems: "So, we expect the student to be a student who has a problem-solving capacity and that they can deal quite independently" (Supervisor 3).

The interviewees reported the importance of the student having 'initiative' to deal with situations in the partner company arising from the project development: "[...] but I think it's like this, you have to have a little, not a little, I think you have to have a lot of initiative because the corporate world is totally different from the academic world. So, it has to be a person who has initiative to understand that the speed of industry is different from the speed of academia" (Student 6).

In the same way that industrial experience was highlighted earlier, some interviewees also stressed the need for the student to 'have research experience'. One of the examples cited of how a student can acquire this type of experience is through participation in scientific initiation projects during their undergraduate studies. 'Persistence' proves to be a relevant characteristic for a doctoral student who must remain constant in the face of problems that need to be solved in the development of projects. 'Knowledge of the company's business' contributes to the project's development, to problem-solving, and to a better relationship with the company. Knowledge about the business can complement the technical knowledge that the student possesses. The 'desire to innovate' is relevant, as one of the objectives of the DAI is the promotion of innovation. Therefore, it is important that there is a convergence between the objectives of the DAI and the student's desire to increase the chances of achieving the program's objectives and for the student to make the most of the experience.

The interviewees cited a significant number of desirable characteristics for a DAI student. However, it is important to understand that most of them are not mandatory characteristics. Among the characteristics presented, good interpersonal relationship stands out, without which the project development is very difficult, given the need to communicate with professionals close to the project being developed. Other characteristics that deserve mention are persistence, autonomy, and self-motivation for problem-solving, which are also necessary for traditional doctorates.

The Student's Role

Five roles played by the student in the DAI program were cited. The most cited role by the participants was 'to conduct the project'. This role emphasizes that the student is the executor and responsible for the project, which, in most cases, is proposed by the company. Regardless of having a supervisor and the company's assistance, the student is the main person responsible for the operationalization of the developed project. The student also depends on the project's success to be able to finish their thesis: "So, his role is to perform the activities as proposed, right? The CNPq provides the scholarship resources so that he has the possibility to perform these activities well. So, there we have the role and the personal engagement of the student for the project to be executed in the best way, right? And, without that, the result will not be as expected, right? But we know that there is a percentage of unsuccessful cases that always happen in any action. But the greater the student's engagement, the better and greater the chance that the project will be successful" (CNPq). The role of 'link between university and company' highlights the fact that the student performs the function of being the link between the university and the company. The student is considered the center of this partnership, being the main person responsible for its success: "[...] I believe that the student is the bridge between the university and the industry, because the DAI project itself does not guarantee anything. The one who will guarantee that this partnership is made is the student. If the student is not there, does not make a conscious effort to stay close to the industry, at the same time as academia, the DAI ends up becoming just a doctorate. A doctorate for which some industry gave the samples for development, you know [...]" (Student 1).

The role of 'choosing the company' refers to one of the first challenges of the student when entering the doctorate through the DAI. The choice process occurs in the pre-doctoral phase, in which the student, together with their supervisor, defines in which company the project will be developed. The role of 'adapting to the company's reality' presents one of the challenges faced by the student during the development of their project. The student needs to be aware that they will find a different reality in the company from that found in the university. Previous professional experience helps to minimize the challenge. Finally, the role of 'professional responsibility' points to an elementary function for any professional in a work environment. The student acquires the experience that not honoring the commitments made can lead to consequences and damages to the development of their project and, consequently, to the company that welcomed them.

It was possible to see that the student plays a fundamental role in the operationalization of the DAI. It is they who will choose the partner company to conduct the agreed project. In addition, it depends on the student for the link between the university and the company to be fruitful.

Skills Developed

Three skills that were developed by the students during the realization of the DAI were reported. The skill 'interpersonal relationship' refers to the communication ability necessary for interaction with different types of actors in the business and academic environment: "[...] because you have to learn to talk to the industry people in a way that is not an annoying way of demanding, that you end up being disliked and the people drag their feet to meet your needs [...]" (Student 1).

Regarding 'adaptability', the students report having acquired the ability to adapt to both the academic and industrial environments, which have different languages, objectives, and demands: "[...] you have to be able to reconcile with the academic demands that are much more rigid and demanding than the industrial ones. For example, I had to do a presentation for the DAI, to present to the industrial supervisor and the factory director, which had to have a much more technical, much more succinct language and with data that are more quantitative, related to production, related to application. Whereas for everything that had to do with the doctorate itself, which was presented at UFABC, it had to be much more scientific with a much heavier focus on the literature, right? Having to explain the related scientific concepts in a much more elaborate way. So, you have to have this adaptability to these two worlds as well [...]" (Student 1).

Regarding 'technical competencies', one student mentioned having acquired new technical knowledge during the project: "One, learning a new programming language, totally suited to modeling, something I didn't have before. Deepening in statistical methods, because all the algorithms I used are of an advanced mathematical level" (Student 2).

The skills developed converge with the desirable characteristics mentioned earlier, although in smaller numbers. It is observed that, if the student does not have the characteristics when starting the DAI, they will possibly acquire them during the doctorate.

Benefits to the Student

In total, ten benefits to the student from undertaking the doctorate through the DAI program were cited by the participants. The benefit of 'industrial experience' received the highest number of citations. The interviewees consider that a doctorate carried out through the DAI provides the student with a differential experience in the industry, through applied research, that they would hardly obtain in a traditional doctorate carried out only within the university: "Because look, the student who completes the DAI comes out with the same academic training as the student who does the traditional academic one, the same competencies, but the DAI student has opportunities beyond the traditional doctoral student, which is the interaction with the company, which is to visit, get to know the environment, understand how the dynamics work and really prepare to work with applied research, development, and innovation" (DAI Coordinator).

Regarding 'opportunities abroad', the participants reported opportunities to work and supplement their studies abroad due to the influence of the DAI. It is mentioned that the companies where the projects were developed contributed to some of the students being able to take advantage of opportunities abroad: "[...] so I got this position here in Australia as a researcher thanks to my doctorate and this opportunity I had to go to England, so, without a doubt, the doctorate enabled me to find, to get this researcher position when I came here to Australia. So, I went to Brazil, defended my thesis, after, I don't know, four weeks that I defended my thesis I moved to Australia as a researcher, and then I worked for five years as a researcher and now, I'm in the industry, I went back to the industry here in Australia" (Student 3).

Regarding the 'possibility of employment', the participants understand that the DAI increases the possibilities for the student to enter the job market. The reports were that the experience obtained in the companies contributes to the students being absorbed either by the company itself where the project was developed or by other companies in the same segment. It is mentioned that none of the six interviewed students remained in the company where the research was carried out. Only one student reported having been invited to stay at the company but declined the invitation: "So, I wouldn't say the majority, but still a good part of the students end up being hired by the company itself, so he has the opportunity to get a job, right? Not just the training, but a professional occupation, right? This is an eventual gain that the student can obtain in addition to the degree" (CNPq).

The benefit of 'network' refers to the network of relationships that the student can build during the development of their project. The interviewees reported that a network involving professionals in the area and companies can enhance the student's possibilities of obtaining professional and academic opportunities, including outside the country: "So, I think it opens the doors of networking, like, right? The *** was responsible for connecting me with other companies and these other companies, one of them financed me to go abroad. So it was via the company also this networking, like, that has a very important role for-me as a doctoral student at the time" (Student 3).

The participants consider that the 'development of applied research' is a benefit to the students, thanks to the opportunity to see in practice the results of their research in an industrial context: "So, what she studied she sees, she is studying something that is applied in practice. So, I think that is a cool feeling, right? She can even show it, right? She showed it in the presentation. She showed, for example, this aspect of chassis weight reduction, the more you increase the resistance of the chassis

materials, which was the proposal of her work, to use materials, side rails and frames with higher resistance, you end up reducing the vehicle's weight, you have an environmental impact, you gain, right?" (Company 5).

Regarding 'using the company's resources', the participating students consider the opportunity to have contact with the equipment and materials available in the industry—which would probably not be possible to have only at the university—a benefit from the DAI. Access to resources from the company even made the research possible: "Benefits, is the access to the company, right? I had total access to the company" (Student 5).

The 'broadening of horizons' refers to the opportunity for the student to develop their project in partnership with a company, but with the focus of being able to amplify their vision in relation to their professional area, beyond the boundaries of the university: "The benefit is that he leaves that bubble called the university, which talks a lot about theory, but often forgets that theory exists to support the resolution of real-world problems, problems that have some kind of economic or social motivation, but mainly economic" (Company 1).

The 'receipt of the DAI scholarship' reflects perhaps the most direct benefit. Receiving the scholarship allows students to have a full commitment to the program. 'Maturity in research' refers to the research experience acquired by the student with the conduct of a developed project that has the differential of being in partnership with a company. Finally, the code 'obtaining a post-doc scholarship' reflects an experience of one of the students who reported that the DAI had great relevance in obtaining their post-doc scholarship.

The number of benefits obtained by the student through the DAI, cited by the interviewees, reveals a positive aspect related to the program. The interaction that the student has with the company where the project is developed is highlighted again. This interaction allows access to the company's resources that make the project's realization viable, the opportunity to obtain employment, the creation of a network of relationships with professionals and companies, and the broadening of the student's vision about their area beyond the university.

5. DISCUSSION

The results section identified data on five aspects related to the profile of students who completed their doctorate through the DAI. Regarding the reasons for entering the DAI, three reasons were mentioned by the alumni. The first reason pointed out was the opportunity to produce applied research. The applied research produced by the DAI was mentioned on several occasions during the interviews, which shows its relevance to the program. The second reason was the identification with the industrial profile of the DAI, and the third reason is the opportunity to enter the job market. The three reasons pointed out by the alumni are interconnected by the fact that the research is developed, as a rule, in an industrial environment, attracting a specific profile of candidates.

There is a growing trend of doctoral students who are not specifically interested in research and a university career. Some also show interest in improving practical professional skills, valid for working in other sectors of society, thus giving rise to doctoral programs to meet this demand (Cardoso et al., 2019). Students are encouraged to enter an industrial doctorate program due to the greater employability and career possibilities that the program can generate, in addition to seeking the development and updating of skills through the practical experience acquired in the development of activities in the industry. Students appear to be more optimistic about their careers after completing the course in the DAI model than students from traditional doctorates (Cardoso et al., 2019; Roberts, 2018; Tavares et al., 2019; Thune, 2009). One of the motivating factors for students' entry mentioned by Celis and Duque (2016) is the possibility that the research carried out will generate innovation in the industrial sphere.

In total, ten desirable characteristics for a DAI student were cited by the participants. According to the testimonies, it was observed that the characteristics were divided into personal and technical.

The most cited characteristic was good interpersonal relationship, indicating that the ability to communicate well with the professionals of the partner company is valued by the participants. The student is the one who conducts the project and, at times, they will have to request materials and resources, in addition to having to participate in meetings or events to present the results obtained so far. Other four characteristics cited were autonomy, self-motivation for problem-solving, persistence, and initiative. It is understood that the personal characteristics cited are desirable for any doctoral program, but the need to possess them is accentuated in a doctorate carried out through the DAI. Doctoral students cannot always count on the support of the company's professionals, or their supervisor, for assistance in the project's development and for solving problems arising from it. In addition, the technical problems that students may face may not be solved in an elementary way, requiring initiative and persistence for the obstacles to be overcome. It was also mentioned as relevant that the student has the desire to innovate, a characteristic in line with the objectives of the DAI. The student having an aptitude and desire to design new things increases the chances of the program's success.

Flexibility and resilience are two desirable characteristics for a student of an industrial doctorate. Flexibility is desirable due to the multiple environments in which the research is developed and to meeting the requests from both the university and the industry. Resilience is due to the number of challenges the doctoral student must deal with during the realization of their research. Proactivity, autonomous learning, and taking advantage of opportunities related to entrepreneurship are also desirable characteristics for the student (Tavares et al., 2020). According to Sa'a and Yström (2024), the student needs to have curiosity and an open mind for the absorption of new knowledge. In addition, the student must participate in events and networking for better propagation of their knowledge, which also relates to a good interpersonal relationship. The same authors also found the importance of the student knowing how to transmit their knowledge to different audiences within the industry itself, needing to translate the academic language for the industrial context.

The characteristics: having industrial experience, having research experience, and having technical and theoretical knowledge highlight that a student who already has a technical background and knowledge in the area of operation may face a smoother path in the development of their project, which does not mean that the experience is essential, but desirable. It is emphasized that half of the interviewed students claimed to have previous industrial experience. The last characteristic to be mentioned is having knowledge about the business of the company where the project will be developed. This knowledge is capable of increasing the student's credibility in relation to the company's professionals, in addition to forming a base of previous and specific knowledge so that the project is in line with the company's objectives.

Regarding the student's role in the DAI, conducting the project was what received the highest number of citations. This is due to the fact that the function is elementary to any doctoral student who, in fact, is directly responsible for the development of the defined project. The student also performs the function of linking the university to the company, due to the transit they have between the two organizations. The student shows themselves as the actor capable of facilitating communication and forwarding possible demands of the involved organizations. A function prior to what was reported is the choice of the company by the student, together with the supervisor. The dialogue between the parties is essential for all ideas to be in agreement and for all obstacles to be informed, mainly by the company, so that the student is not surprised during the project's progress. In relation to the company, the student still needs to adapt to its reality and act with professional responsibility. The adaptation can be difficult if the student does not have industrial experience, due to the different language used and the profile of the professionals with whom they will have to coexist. A fact that contributes to a harmonious and fruitful coexistence is the responsibility that the student must have to comply with the deadlines and agreements established by the company—which may differ from what the academic environment requires.

According to Thune (2009), industrial doctorate students produce and act in the transfer of knowledge and develop network relationships between the university and industry. In this perspective, Santos et al. (2020) complement that the role of students is centered on knowledge transfer between university and industry, knowledge generation, establishing or strengthening the link between university professors, and acting as a research funding channel for university professors. Industrial doctorate students develop projects that aim to solve a practical problem within the industry, participate in meetings and presentations where they develop a close relationship with the industry (Lee & Miozzo, 2015). The involvement that students have with different professionals contributes to contact with diverse values and ways of working (Wardenaar et al., 2014).

Regarding the skills developed, the work sought to identify which skills were acquired by the students during the doctorate carried out through the DAI. Although the literature lists a considerable number of skills that can be acquired during an industrial doctorate, the interviewed students cited a restricted number. Interpersonal relationship was the most cited skill by the participants. This characteristic, also cited as desirable for the student, shows how relevant it is, because if the student does not possess it upon entry, they will consequently acquire it due to the need for interactions with various professionals during the program. Adaptability refers to the ability to transition between the university and company environments, being able to adapt to the language and particular demands of each organization. Finally, the technical competencies cited as acquired skills are according to the particularities of each program and each developed project.

The work developed by Lee (2008) presents some skills acquired by students of industrial doctorates, among them, skills related to interpersonal relations: negotiation, administration, leadership, financial management, initiative, and socialization with other colleagues. Similarly, Tavares et al. (2019) and Tavares et al. (2020) present skills acquired by students that include skills related to interpersonal relationship: business knowledge, networking, problem-solving, communication, teamwork, time management, decision-making, negotiation skills, flexibility, writing improvement, independence, and entrepreneurship.

Finally, the work sought to know what benefits were obtained by the students participating in the program by carrying out the doctorate through the DAI. The ten benefits cited by the participants denote a positive aspect of the program. Some of the benefits cited were: the industrial experience acquired during the program, the possibility of employment, and the development of applied research. The opportunities abroad occurred according to the experience of students who managed to carry out a sandwich doctorate and even got professional opportunities in other countries. The students attribute these opportunities to the DAI. One of the reported opportunities is due to the network formed with the professionals of the companies where the student coexisted during the research development and even with other companies in the same field. The development of a network is relevant both for the development of the research and for getting opportunities during and after the end of the doctorate. The network is also related to the interpersonal relationship that the student develops during the doctorate. Building a network is pointed out as one of the competencies acquired by a student in an industrial doctorate (Tavares et al., 2020).

Using the company's resources was also a cited benefit that is linked to the industrial experience acquired. The company's resources are linked to the use of materials, equipment, and laboratories that were relevant both for the student to acquire experience and for the development of the research. The broadening of horizons refers to the fact that the student acquires a vision beyond the university's borders and perceives other professional possibilities that companies can bring. Receiving the DAI scholarship through the CNPq, although a common benefit for the program's students, is still a relevant benefit that allows students to dedicate themselves to research full-time. Maturity in research can be understood as a consequence of all the study developed during the doctorate, but with the particularity of being an applied research that differs from a traditional research within the university. The obtainment of a post-doc scholarship refers to the report of a

student who attributes to the DAI the fact of having obtained a post-doctoral scholarship granted by the CNPq. No works were found that seek to identify the benefits acquired by students of industrial doctorates in a broader sense. It is possible to understand that the acquired skills are also benefits to the students; however, it is observed that the benefits go beyond the development of skills.

6. FINAL CONSIDERATIONS

This section presents the final considerations of the research, which aimed to identify the profile of the student who undertakes the doctorate through the Academic Industrial Doctorate promoted by the Federal University of ABC. To achieve the objective, five aspects were defined whose information was obtained through interviews with the actors involved with the program. Three reasons that led students to enter a doctoral program through the DAI were identified: the opportunity to produce applied research; identification with the industrial profile of the program; and the possibility of entering the job market.

Regarding the desirable characteristics for the student, ten were mentioned by the participants: good interpersonal relationship; having industrial experience; possessing technical and theoretical knowledge; autonomy; self-motivation for problem-solving; initiative; having research experience; persistence; knowledge about the business of the company where the project will be developed; and the desire to innovate.

Regarding the student's role in the program, the following were identified: conducting the project; being the link between the university and the company where the project is developed; choosing in which company the project will be developed; adapting to the company's reality; and having professional responsibility.

The benefits provided to the students were also identified: industrial experience for the student and supervisor; career opportunities; possibility of employment in the company where the research was conducted; network with professionals in the area; development of applied research; use of the company's resources for carrying out the study; broadening of professional and personal horizons; receipt of a DAI scholarship that provides the necessary subsidy for the development of the study; maturity in academic and applied research; and visibility for obtaining a post-doctoral scholarship.

It is concluded that the DAI program has the potential to obtain satisfactory results in the collaboration between university and company, in addition to providing a differentiated experience to the student due to the development of applied research. The work contributes with a study of a national model of industrial doctorate in Brazil, whose literature is still scarce. The research also contributes to identifying the reasons that may lead a student to become interested in the program and the benefits obtained from its completion.

The research had as limitations the fact that it was carried out in only one locus, although it is the one that hosts the oldest DAI program in Brazil. This locus still promotes the Academic Industrial Doctorate, which has some differences in relation to the current model, the Academic Doctorate for Innovation, not specifically addressed in this work. The research also encountered difficulties in obtaining collaboration from students for granting interviews. Some of them did not respond to the requested contact. The students are relevant actors for the research as they are the target audience of the DAI, for experiencing practically all stages of the program, and for maintaining relationships with the university and the company during the doctoral period.

The experiences of the interviewed students were very plural, with not many similarities between their experiences. On the one hand, the variety of experiences is positive for the greater knowledge of the possibilities that can be experienced; however, this variety also makes it difficult to identify patterns and generalize them to the program. Another limitation is the fact that some of the interviewed actors participated in the DAI a considerable time ago and, during the interviews, stated that they could not accurately recall some relevant details of their experiences. In the case of the students, their entry into the program occurred between 2013 and 2018.

For future research, an amplification of the research locus is suggested so that the experience of other ICTs that participate in the Academic Doctorate for Innovation can be studied. It is also suggested to conduct research regarding the intellectual property of the projects developed by the DAI students.

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