UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Engineering Students' Experiences of Empathy in Entrepreneurial Pre-accelerators: A Hermeneutic Phenomenological Study

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Certificate of Original Authorship

I, Aleksandr Litvinov, declare that this thesis is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise referenced or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

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Signature:

Date: 16 February 2024

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List of Publications Related to This Study

1. Litvinov, A., Gardner, A., Pradhan, S., Childers, J. (2023). The Role and Understanding of Empathy in Entrepreneurial Engineering: A Systematic Literature Review. *The Australasian Journal of Engineering Education*. http://dx.doi.org/10.1080/22054952.2023.2217042

Abstract: This study reviews how empathy and its role are conceptualised in entrepreneurial and engineering literature. Our findings can then be used as a foundation for developing contextual and theoretical models of empathy for entrepreneurial engineering. These models will help create teaching practices and approaches to prepare empathic entrepreneurial engineers. The study deployed a systematic literature review of 40 papers from engineering and entrepreneurship fields, obtained from the Scopus and Web of Science databases. The analysis involved three phases. First, a descriptive analysis of research on empathy in entrepreneurship and engineering was completed, followed by a content analysis focusing on definitions and the role of the empathy phenomenon and a co-citation analysis to identify commonly cited authors. The results of this literature review demonstrate different indicators that reflect the current state of empathy research and study trajectories of this phenomenon in the fields of engineering and entrepreneurship. These indicators include the number of papers related to empathy in engineering and entrepreneurship literature by year of publication, definitions of empathy and keywords used in analysed literature as well as list of authors and their area of interests within empathy research.

2. Litvinov, A., Gardner, A., Pradhan, S., Childers, J. (2022, October). *The role of empathic experiences of entrepreneurial engineers within accelerators: phenomenology study.* [Conference presentation]. Frontiers in Education, Upsala, Sweden. https://doi.org/10.1109/FIE56618.2022.9962500

Abstract: In this full research paper, the empathic experiences of entrepreneurial engineers within accelerators were investigated. Traditionally, engineering research and literature focus more on developing students' technical expertise and knowledge than social skills. However, in recent years, a request for T-shaped engineers with developed social competencies has been formed within the field. One of the essential social competencies in engineering is empathy. Engineering educators have been exploring how to develop this phenomenon using different approaches and interventions such as human-centred design, ethics courses, and service-learning. Another vital component that is being included in the engineering curriculum is an entrepreneurial mindset, where the ability to empathise is also one of the essential competencies. Despite the importance of empathy, existing theories of empathy are ill-suited for entrepreneurial engineering theory. For empathy development among entrepreneurial engineers, it is important to have models of this phenomenon that reflect the contextual features of both entrepreneurship and engineering practices. In this study, the hermeneutic phenomenology is implemented to investigate engineering students' lived empathy experiences and understanding of their interpretations of empathy in an entrepreneurial context. The results of this study can become the foundation for developing contextual models of empathy that reflect the practice of entrepreneurial engineers.

3. Litvinov, A., Gardner, A., & Pradhan, S. (2020, January). *The presence of empathy in entrepreneurial subject outlines for IT and software engineering students*. [Conference presentation]. 31st Annual Conference of the Australasian Association for Engineering Education (AAEE 2020): Disrupting Business as Usual in Engineering Education. Barton, ACT: Engineers Australia. https://search.informit.org/doi/10.3316/informit.725661083811390

Abstract:

CONTEXT: Technology startups are playing an increasingly important role in developed and developing economies. As well as technical expertise, the founders (and other employees) should possess social competencies such as communication, collaboration and empathy. A growing body of literature has identified empathetic behaviours as progressively important for the success of a technology startup. At universities, more entrepreneurial subjects are being introduced increasingly to IT and software engineering students. However, empathy as a phenomenon and its development may not be a common inclusion in engineering and information technology (IT) curricula.

PURPOSE OR GOAL: This paper reports on an investigation of the literature for indicators of an empathetic behaviour or mindset, i.e., how can we know it when we see it? These indicators are then used to examine subject outlines available to engineering and IT students at an Australian university to assess what exposure these students have to the development of empathetic behaviours and mindset.

APPROACH OR METHODOLOGY/METHODS: A systematic literature review was undertaken to identify the key categories or indicators of empathetic behaviours/mindset. Using these indicators, a content analysis of subject outlines was undertaken to identify if and where they exist in the curriculum at UTS.

ACTUAL OR ANTICIPATED OUTCOMES: The key outcomes of this study include that the term empathy itself was almost never encountered, but more than a third of subject outlines have various empathy indicators mentioned. The indicators are mostly related to concepts of empathetic design and problem seeking or ethical behaviour and communication. These concepts relate to the increasing popularity of the design thinking concept or other related frameworks such as human-centred or user-centred design methodologies.

CONCLUSIONS, RECOMMENDATIONS, SUMMARY: This paper offers a framework for evaluating the presence of empathy indicators in entrepreneurial subjects within the engineering curriculum. The main objective is to determine the overall picture of the development of empathy in future technology entrepreneurs. In order to make recommendations for improving the curriculum, it is important to investigate the life experiences of students and academics and to study the effects of specific practices on the development of empathy.

Abstract

This thesis is a hermeneutic phenomenological study of engineering students' lived experiences of empathy within entrepreneurial pre-acceleration programs. The trend towards preparing holistic engineers with developed entrepreneurial and other transferable skills has been formed in recent years. This trend has encouraged educational institutions to introduce various entrepreneurial educational interventions into engineering curricula to foster entrepreneurial skills, mindset, and other professional and transferable capabilities in engineers. Empathy is one of the essential competencies for both engineering and entrepreneurship fields.

On the importance of empathy for engineers and entrepreneurs, it is expected that entrepreneurial educational interventions in the engineering curriculum would also contribute to developing the empathy of future entrepreneurial engineers. These expectations are justified by the widespread use of approaches in which empathic experiences play a key role, such as Design Thinking or human-centred design. It is also justified by the important role that empathy plays in various entrepreneurial phases and processes such as customer validation and problem identification. However, despite the importance of empathy and its wide representation in entrepreneurship and entrepreneurial education, it is not entirely clear how entrepreneurial engineers experience this phenomenon, as well as which experiences and environmental elements may prefigure this phenomenon.

This hermeneutic phenomenology study was conducted to develop a sophisticated understanding of empathy in entrepreneurial engineering. The aim was to focus on how engineering students experience empathy within entrepreneurial programs and illuminate the lived experience of this phenomenon from the engineering students' accounts. At the same time, this study is conducted to shed light on what specific experiences or elements within entrepreneurial programs shape engineering students' empathy. The lived experiences of twenty

engineering students who participated in four different Australian university-based pre-acceleration entrepreneurial programs were examined. Pre-accelerators are chosen as an example of entrepreneurial programs. This type of entrepreneurial program is focused on introducing students to the entrepreneurial process and usually involves both entrepreneurial and educational components, meaning that students in entrepreneurial pre-acceleration programs have the chance to come up with their own products or startups while they have access to various educational activities such as workshops, guest lectures, mentoring.

As a result, a contextual model of empathy has been proposed that demonstrates that empathy is experienced by engineering students in entrepreneurial pre-acceleration programs as a multiphase process that is related to different attributes and orientations. This phenomenon is shaped by four experiences (starting with a broad question, talking with a purpose, being touched through listening to stories, and observing ‘‘clicking” situations). It may be prefigured by four different program elements (design process, the community of practice, diversity of opinions, and market).

Educators, scholars, and other practitioners can use the outcomes of this research for the following reasons. Firstly, it can help them form their own general understanding of empathy in entrepreneurial engineering, which can then serve as a starting point for further research on the facets and role of empathy in various types of engineering. Secondly, the proposed contextual model of empathy can be used when designing and implementing educational activities and programs focused on developing this phenomenon in different types of engineers.

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Chapter 1. Introduction

Research Background

This thesis investigates the phenomenon of engineering students' empathy within entrepreneurial pre-acceleration programs. It explores the lived empathy experiences of twenty engineering students who participated in four different university pre-acceleration entrepreneurial programs across Australia. The results of this study are used to form a sophisticated understanding of empathy within the entrepreneurial engineering context and propose a contextual model of empathy that can be used by engineering and entrepreneurship educators and learning designers to foster the phenomenon of empathy in entrepreneurial engineers.

There is increased attention from educators and scholars on adapting engineering education to rapidly changing industry requests and societal needs. Historically, engineering educators mostly focused on developing engineering students' technical knowledge or so-called "hard skills" (Bucciarelli, 2001). However, this situation and focus have changed over recent years. Currently, more professional organisations encourage engineering educators and other stakeholders to pay equal attention to the social and interpersonal professional capabilities of engineering graduates as well as their technical skills and knowledge (e.g., Crosthwaite, 2019). A similar trend of increased attention on transferable and interpersonal competencies can also be observed in the engineering education research sector, as researchers emphasise the need to prepare socially-competent engineering professionals who put more effort into addressing social issues (e.g., Korte et al., 2008; Anderson et al., 2009; Henriksen et al., 2017). According to Rovida and Zafferri (2022), modern engineering education should

pay close attention to developing soft skills, interpersonal and social professional capabilities in future engineers, considering the trends and demands of Engineering 4.0. Therefore, it is worth noting that the tradition of prioritising the development of technical knowledge and skills among engineering students over so-called "soft skills" is changing.

Empathy as an essential competency

The ability to empathise with others is considered an essential social competency. The important role of empathy has been noted in various fields such as social work (Gerdes & Segal, 2011), design (Kouprie & Visser, 2009), entrepreneurship (Humphrey, 2013), medicine (Bellet & Maloney, 1991; Halpern, 2001; Decety, 2020), leadership (Rahman & Castelli, 2013), teaching (McAllister & Irvine, 2002; Wynn et al., 2023), marketing (Pedersen, 2021), sales (Anaza et al., 2018; Delpechitre et al., 2019) and engineering (Penzenstadler et al., 2009). Within the engineering field, empathy can bring a variety of benefits in different engineering-related processes, including but not limited to problem-solving or designing human experience (e.g., Kouprie & Visser, 2009; Schmitt et al., 2016). Battarbee et al. (2014) state that empathy in design activities can promote the development of innovations. Furthermore, a range of studies reveal that the developed empathic abilities positively affect the formation of outcomes such as effective team management (Köppen & Meinel, 2015), effective collaboration and communication (Walther et al., 2012), creativity (Young, 2015), and ethical decision-making, for example, around privacy requirements (Levy & Hadar, 2018). These studies clearly show why empathy is considered one of the core competencies of a modern specialist because it benefits engineering and other fields.

As it is believed that empathy can be fostered through various educational interventions (e.g., Davis, 1990; Walther et al., 2017), researchers and educators suggest different types of interventions, approaches and environments to foster empathy in engineering students (Cooper, 2011). For example, Hess and Fila (2016b) list the following concepts and techniques that may be used to promote empathy development and growth among engineering students: Design-Thinking, Service-Learning, Communication, Collaboration and Ethics Education. Lunn et al. (2022) outline pedagogical approaches to promote empathy among STEM students: narrative and creative arts techniques; communication training; problem-based learning; interactions with different stakeholders; and experiential immersion. Also, empathetic experiences can be generated using certain tools or artefacts, such as personas and journey maps (Fila et al., 2022).

In addition to the growing interest towards the development of engineers' social competencies, researchers and professional associations pay particular attention to the introduction of entrepreneurship into engineering as engineers with developed entrepreneurial competencies can "develop new ideas, generating new technology-based opportunities for creating economic and social value" (Elia et al., 2017, p. 29). For example, the Engineering Futures 2035 scoping study prepared by the Australian Council of Engineering Deans (ACED) states that entrepreneurship and innovation capabilities will be essential for future engineering professionals (Crosthwaite, 2019). The importance of entrepreneurial and innovation competencies is also highlighted by various professional associations such as the American Society for Engineering Education (ASEE) (ASEE, 2012) and The National Academy of Engineering (NAE, 2013). Additionally, many researchers and educators state that it is necessary to pay special attention to developing these competencies among engineers due to the many

benefits they can bring into engineering practice. These benefits may include an increase in students' engagement, strong leadership and human-centred innovation competencies, customer orientation, and a higher employment rate due to the creation of more technology organisations (e.g., Creed et al., 2002; Nichols & Armstrong, 2003; Vodă & Florea, 2019; Huang-Saad et al., 2020).

Entrepreneurial skills

The importance of entrepreneurial skills and understanding of entrepreneurial processes for engineers is also driven by industry trends. According to the Crossroads 2020 report, seven of the ten biggest companies (market cap) are technology firms (McCauley & Gruszka, 2020). Simultaneously, technology startups need STEM specialists who can run small and medium technology enterprises. Educational programs must be tailored according to market demand and focus on the entrepreneurial skills of engineers and other technical professionals (McCauley & Gruszka, 2020). A modern engineer should, therefore, have well-developed social and technical professional capabilities and an entrepreneurial mindset.

Considering the importance of entrepreneurship for engineers, various educational institutions, academic conference divisions (e.g., Entrepreneurship Division of ASEE), and educational networks (e.g., Kern Entrepreneurship Engineering Network (KEEN) have begun to actively propose the integration of various entrepreneurial activities into engineering curricula. Currently, many different entrepreneurial interventions and activities are aimed at developing entrepreneurial competencies among engineering students from various entrepreneurship-focused subjects or entrepreneurial modules through full-fledged programs such as entrepreneurial accelerators, pre-accelerators, pitch competitions, or incubators. However, despite the

diversity and variability of educational approaches, entrepreneurial engineering education should be more focused on integrating different business models and innovation competencies in STEM courses. They should do this by offering educational interventions and events that promote opportunity validation, communication, team and group work, product development, and creativity (e.g., Duval-Couetil et al., 2016; Gilmartin et al., 2016). Therefore, entrepreneurial interventions in engineering education should immerse engineering students in the entrepreneurial process by enabling them to experience the entrepreneurial processes and practices.

Some entrepreneurial programs for engineering students may be quite complex and involve various experiences and formats. One such program is the pre-acceleration entrepreneurial program. According to Merguei and Costa (2022, p. 8), ‘‘pre-accelerators introduce participants to the entrepreneurial process and allow them to gain knowledge about their ability”, focusing on supporting early-stage founders. These programs include educational activities and other experiences, such as collaborations with peers, customers, or mentors, pitching, and design. It should be noted that engineering students participating in these programs have the opportunity to immerse themselves in the process of entrepreneurship and develop basic entrepreneurial competencies. Therefore, in this context, students can analyse and evaluate the role of specific models or skills through the prism of entrepreneurship and engineering since they also study engineering subjects and approaches. Thus, entrepreneurial pre-accelerators are an important source of entrepreneurial and other experiences that can encourage engineering students to develop their entrepreneurial and other interpersonal and transferable capabilities.

Entrepreneurship in engineering education (similar to the other approaches mentioned above) can also encourage engineering students to empathise with others and develop their empathic abilities as it involves a variety of empathy-related experiences. Neck et al. (2019), believe that entrepreneurship education may provide some opportunities for students to practise and use their empathy in various activities, meaning that students (including engineering students) not only have a chance to experience it but also understand its role. For example, according to Litvinov et al. (2020), entrepreneurial subjects designed for engineering students may have various indicators of empathy both as part of educational modules (content) or intended learning outcomes. This, in turn, means that when designing entrepreneurial subjects for engineers, educators and learning designers consider the need to develop this phenomenon in future engineers. Moreover, some learning activities commonly used in entrepreneurial subjects, such as the simulation of customer experiences, can contribute to developing empathy in engineering students (Bell-Huff & Morano, 2017). At the same time, intensive entrepreneurial programs that include collaborations with different stakeholders, especially customers, are another approach that can encourage the development of engineering students' empathy (Pellicane & Blaho, 2015). These approaches or specific elements of entrepreneurial education are thus an important source of different experiences that can encourage engineering students to empathise with others.

Empathy and Entrepreneurship

However, despite the diversity and variability of approaches, at the moment, there are some challenges when integrating empathy into engineering and other courses. A significant challenge is the diversity of empathy definitions. This means it is not entirely clear which domains and facets of this phenomenon should be involved and

covered during educational activities. Historically, the term ‘‘empathy” was presented by Titchener, who used the word "Einfühlung" (German), which is translated as “in-feeling” or “feeling into”. Over the last century the understanding of this concept has evolved (e.g., Wispé, 1986; De Vignemont & Singer, 2006; Barnett & Mann, 2013) so that currently, most academics emphasise its complexity and multifaceted characteristics (Davis, 1983; Walther et al., 2017). Scholars also highlight its socio-cognitive nature by noting its cognitive and affective elements (Davis, 1996), and its processual characteristics of simulating “another person’s situated psychological states” (Coplan, 2011, p. 44). Many also outline the various empathy-related concepts or facets such as perspective-taking (e.g., Hoffman, 2000; Prandelli et al., 2016), empathic accuracy (Ickes, 1993), and empathic concern (Zahn-Waxler & Radke-Yarrow, 1990). Considering the variability in understanding the phenomenon of empathy, some scholars call for the formation of cohesive models of empathy. For example, Walther et al. (2016) state that to teach empathy, it is essential to develop a conceptually cohesive understanding of this phenomenon and language for incorporating empathy into the engineering practice and educational programs. The call for the development of a "coherent framework" of empathy has also been made by Strobel et al. (2013). As a result of this variety of conceptualisations, definitions and concepts of empathy, it is important to form a holistic understanding of this phenomenon for entrepreneurial engineering practice.

Another challenge for integrating empathy into engineering and other types of courses is the lack of empirical models of empathy that reflect the contextual features of practice. According to Walther et al. (2020, p.12), the challenge of incorporating empathy into the curriculum is caused by "a scarcity of conceptual models and empirical bases". Therefore, it is necessary to consider situational and contextual

features when incorporating empathy into educational models. Also, at the moment, there is a lack of cohesive and contextual models of empathy, which in turn create difficulties in creating educational activities aimed at developing empathy among engineers.

Statement of the Problem and Research Aims

This research sheds light on the phenomenon of engineering students' empathy in the context of entrepreneurial pre-acceleration programs. Entrepreneurial programs such as pre-accelerators may contain activities or elements that encourage engineering students to empathise with others. Therefore, it is essential to understand how empathy is experienced by engineering students during participation in entrepreneurial programs and what processes, tools, or pedagogical approaches within entrepreneurial education interventions encourage engineering students to empathise. In addition, there is a request within the entrepreneurial engineering field to form cohesive and contextual empathy models that would enable teaching empathy.

At the same time, it is important not only to have a clear understanding of how empathy is experienced in a specific context but also to have an idea of the connection between existing approaches or experiences and this phenomenon.

Also, it should be noted that studies on empathy have emerged recently in the field of engineering education, and over the past several years, interest in its development among engineers has grown (e.g., Hess, 2015; Bairaktarova et al., 2016; Hess & Fila, 2016a, 2016b; Hess et al., 2016a, 2016b; Walther et al., 2017; Walther et al., 2020). However, at the moment, there is a need to investigate it from a qualitative perspective since these approaches can help to understand not only the relationship

between specific activities and empathy but also to explore its role within a field and how it is experienced in various contexts (Yeaman, 2020). At the same time, the qualitative approach is valuable when the research goal is to investigate poorly understood constructs such as empathy (MacFarlane et al., 2017).

To summarise, to create a conceptual model of empathy for entrepreneurial engineering educational approaches that can encourage future entrepreneurial engineers to use empathy and develop their empathic skills, it is essential to initially understand how empathy is experienced in the context of entrepreneurial engineering. Moreover, researchers and educators need to understand the processes and practices where empathy is ‘‘woven into” and investigate the existing elements of entrepreneurial programs that may contribute to its formation and shaping.

The first aim of this study is to illuminate the lived experiences of engineering students’ empathy who participated in entrepreneurial pre-acceleration programs by obtaining detailed descriptions of participants’ empathic experiences (e.g., stories, entrepreneurial philosophy), their understanding of potential outcomes that empathy can bring, and strategies and techniques that they used to empathise with different stakeholders.

Aim 1: to illuminate the engineering students’ lived experience of empathy in entrepreneurial pre-acceleration programs.

The second aim of this study is to investigate and interpret how specific experiences of the entrepreneurial journeys of engineering students shape their empathy. This will allow the author to understand and interpret the existing elements and experiences in entrepreneurial interventions that shape engineering students’ empathy.

Aim 2: to understand what specific experiences of entrepreneurial processes shape engineering students' empathy.

Taking into account the statement of the problem, existing requests for future research and research aims, the following research questions have been formulated for this study:

RQ 1. How is empathy experienced by engineering students in pre-acceleration entrepreneurial programs?

RQ 2. What are the experiences that shape empathy in pre-acceleration programs?

As the first research aim is to illuminate the lived experience of empathy, the focus will be on ways to extract the students' descriptions of their experience of empathy. A focus on this will provide the chance to not only understand how students make sense of empathy, but also to consider the role of the context and the purpose of this experience. It is also important to mention that the purpose of this study is not to define the phenomenon of empathy, as there are already many academic studies on empathy in different fields, such as psychology, education, and sociology. The aim is to attempt to form a comprehensive and holistic understanding of this phenomenon within this specific context and reveal any undiscovered aspects of the experience of empathy. The second research question is concerned with the experiences that may shape empathy, to understand what experiences shape it and interpret the lived experience in identified instances. Combined, the two research questions should help to obtain a much more detailed understanding of empathy than is currently available. As this research focused on developing a sophisticated understanding of the complex empathy, constructed through illuminating the lived experience and investigating experiences that

shape engineering students' empathy within the specific context, the qualitative perspective is considered to be a rational approach.

Methodology and Research Design

This research implements a qualitative hermeneutic phenomenological approach to answer the proposed research questions. According to Yorks & Kasl (2002), phenomenology is an approach that can be adopted to explore subjective experiences, taking into consideration cultural, personal, and even emotional characteristics. Moreover, phenomenological lenses allow researchers to understand the research phenomenon through participants' interpretations of their lived experiences. According to Heidegger (1962), humans' subjective experiences are "inextricably" linked with social, historical or cultural context, and individuals cannot easily separate themselves from their lifeworld. They always refer to their "background understandings" when experiencing a phenomenon (Neubauer et al., 2019). That is why, through investigating lived experience, a researcher can understand more profound layers of a phenomenon considering the world's influence.

The research design is qualitative, as it focuses on individuals' subjective empathic experiences and their interpretations of these experiences. Phenomenology has been selected for this research as it helps to "explore, describe and analyse the meaning of individual lived experience" (Marshall & Rossman, 2014, p. 19). This methodology is typically applied in various fields, including social work (e.g., Wilcke, 2002), health (e.g., Rodriguez & Smith, 2018), and education (e.g., Dall'Alba, 2009). Within the context of empathy development in engineering education, phenomenology has been used to understand the role of empathy in engineering formations (Walther et al., 2020) and explore the empathic experiences of undergraduate engineering students in service-

learning programs (Yeaman, 2020). This study investigated engineering students' descriptions and accounts of their lived experiences of empathy while participating in pre-acceleration entrepreneurial programs. Data collected from the participants have been used to understand their lived experience of empathy and the experiences that shape this phenomenon.

Semi-structured interviews were adopted for this purpose as it is a common phenomenological data collection method that allows researchers to record the lived experiences of people (e.g., Marshall & Rossman, 2014; Zeivots, 2015; Jartell, 2017; Qutoshi, 2018; Claflin, 2020). This method also allows a researcher to capture the emerging reactions and responses of the interviewees. Additionally, adopting semi-structured interviews facilitates the collection of individuals' descriptions in their own words, as well as the detailed uniqueness of each interviewees' experiences. The semi-structured interview guide used in this method is based on the insights gained from the literature review and helps in facilitating the discussion when required. This helps, for example, if a participant struggles in articulating some of their experiences, answering a question, or providing an example from their experience. Further, semi-structured interviews have been successfully applied in previous studies on the social skills of engineers and entrepreneurs (e.g., Hess et al., 2016a, 2016b; Walther et al., 2017; Packard & Burnham, 2021).

Research data are analysed using the six stages data analysis method proposed by Ajjawi and Higgs (2007). This is built on previous methodological research utilising hermeneutic phenomenological perspectives (e.g., Titchen & McIntyre, 1993; Lincoln & Guba, 2000; Titchen, 2000; Edwards & Titchen, 2003).

Significance of the Study

The outcomes of this study can be used for various purposes. Firstly, it sheds light on how empathy is experienced in entrepreneurial programs (specifically, pre-accelerators) and what elements of the entrepreneurial pre-acceleration programs shape engineering students' empathy. Since empathy is a phenomenon that has received increasing attention in recent years, educators and practitioners who wish to incorporate empathy into their engineering education programs can use the results of this study to understand what role certain activities and environments play in experiencing it and evaluate their own programs/activities in terms of its absence or presence.

Secondly, this study attempts to fulfil the need to conceptualise empathy within the entrepreneurial engineering field. It is expected that this type of engineer will not only be able to perform the functions and duties of an engineer, but also create and manage technological enterprises. However, because the concept of an "entrepreneurial engineer" has just recently emerged, academics, researchers and industry experts continue to engage in dialogue regarding the specific practices and competencies that form entrepreneurial engineering activity and profiles. In this regard, this study's results can clarify the nature of the phenomenon of entrepreneurial engineering empathy.

Thirdly, this study demonstrates the way the hermeneutic phenomenology approach can be used to make sense of a complex phenomenon such as empathy. That is why future researchers can use the proposed research design when researching some other complex phenomena in the field of engineering education, such as creativity and innovation.

Summary of COVID-19 Impact

This study was conducted between 2020 and 2023. During this period, the researcher and the study participants were affected by the COVID-19 virus and pandemic-related restrictions. Therefore, it has been important to acknowledge the impact of COVID-19 and discuss COVID-19-related limitations throughout the thesis. These limitations include the following: firstly, the interviews were conducted via Zoom; secondly, some pre-acceleration programs were conducted in a hybrid format, and, as a result, for some students, it could have been challenging to tolerate restrictions on an emotional level.

Glossary of Abbreviations and Key Terms

Abbreviations

AAEES: the American Academy of Environmental Engineers

ABET: Accreditation Board for Engineering and Technology

ACED: Australian Council for Engineering Deans

ASCE: American Society of Civil Engineers

ASEE: American Society for Engineering Education

ASME: American Society of Mechanical Engineers

BS: Business School

EC: Engineering Council

EQ: emotional intelligence

FEIT: Faculty of Engineering and Information Technology

FIE: Frontiers in Education Conference

FTDI: Faculty of Transdisciplinary Innovation

ICT: Information Communications Technology

IEA: International Engineering Alliance

KEEN: Kern Entrepreneurship Engineering Network

MSI: Management System International

MVP: Minimum Viable Product

NAE: National Academy of Engineering

NSF: National Science Foundation

OECD: Organisation for Economic Co-operation and Development

PFC: Peter Farrell Cup

RDMP: Research Data Management Plan

STEM: Science, Technology, Engineering and Math

UNSW: University of New South Wales

UQ: University of Queensland

UTS: University of Technology Sydney

Terms

Accelerator: "fixed-term, cohort-based program, including mentorship and educational components, that culminates in a public pitch event or demo-day" (Cohen & Hochberg, 2014, p. 4).

Attributes: a quality or characteristic of someone who is "exerting a directive or a dynamic influence upon the individual's response to all objects and situations to which it is related" (Kapur, 2018, p. 3).

Attunement: ''an immersion in the present moment and a sensory awareness of ourselves, others, and the space we inhabit" Kossak (2021, xi).

Bracketing: "a component of our attitude in which we consciously identify our values and biases that influence our assumptions about patient care" (Greenfield & Jensen, 2010, p. 1189).

Community of Practice: "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2011, p. 1).

Design process: the process of developing a product or solution to fulfil specific requirements (Taura & Nagai, 2013).

Entrepreneurial engineer: an engineer with well-developed entrepreneurial skills and knowledge, the ability to identify and exploit technology-related opportunities, and an understanding of how to transfer technology into products or services (Fraser et al., 2017).

Hermeneutic circle: an iterative way of interpreting and understanding the phenomenon through continuous iterations between data and context/knowledge (Bontekoe, 1996).

Hermeneutic phenomenology: a research approach that focuses on human lived experiences and the meaning-making (sense-making) process of these experiences (Neubauer et al., 2019).

Holistic engineer: a new engineer who "will be not only a truly comprehensive problem solver, but a problem definer, leading multidisciplinary teams of professionals in setting agendas and fostering innovation" (Grasso & Burkins, 2010, p. 14).

Incubator: "business-incubating organizations that support the establishment and growth of new businesses with tangible (e.g. space, shared equipment and

administrative services) and intangible (e.g. knowledge, network access) resources during a flexible period and are funded by a sponsor (e.g. government or corporation) and/or fund themselves taking rent (or less frequently equity) from incubatees (Hausberg & Korreck, 2021, p. 163).

Lived experience: "personal knowledge of the world gained through direct participation and involvement in the event or phenomenon" (Sibeoni et al., 2020, p. 3).

Market: the interaction of buyers and sellers defined within the bounds of broad product categories (Goodwin et al., 2019).

Nvivo: software that allows to analyse qualitative data sets individually and collaboratively with other researchers. Produced by Lumivero.

Open-mindedness: "an open and unprejudiced attitude toward out-group members and different cultural norms and values" Van der Zee and Van Oudenhoven (2001, p. 279).

Orientation: the state of being oriented toward achieving specific outcomes such as growing and learning as well as helping yourself and helping others (Walther et al., 2016).

Phenomenology: "the systematic exploration of the field of conscious subjectivity" (Gallagher, 2022, p. 1).

Pre-acceleration program: entrepreneurial programs that "introduce participants to the entrepreneurial process and allow them to gain knowledge about their ability" (Merguei & Costa, 2022, p. 8).

Reflection: "the process of actively and consciously engaging with experiences in order to learn from them. (…). Reflection enables new experiences to be integrated into existing frameworks of knowledge" (Pee et al., 2000, p. 755).

Stakeholder: "any groups or individuals who can significantly affect or be affected by an organisation's activities" (Driscoll & Starik, 2004, p. 56).

The Organisation of the Thesis

This thesis consists of six chapters. Chapter One gives a brief overview of this research and its background. It outlines the research problem aims, presents the chosen methodology and covers the significance of the study to the readers. It also provides a summary of the impact of COVID-19.

Chapter Two provides an overview of existing research and literature on the research topic. It discusses the current knowledge related to empathy research in engineering and entrepreneurship contexts and extends the focus further to describe cross-disciplinary research on these topics. The literature review explains in detail the research rationale and leads the reader to the research problems and questions.

Chapter Three introduces the qualitative, hermeneutic phenomenology methodology of this study and justifies the chosen research strategy. It covers the proposed research methods, data collection and data analysis strategies. This chapter also discusses the research context and reflects on this researcher's perspectives and experiences during the research phases of this thesis.

Chapter Four presents the research results and explains what led to the insights that are presented. It introduces the readers to the themes emerging from data and

addresses the research questions; it then discusses how these results align with the existing knowledge. These insights are supported with participants' verbatim quotes.

Chapter Five discusses research findings and links them to existing literature, providing implications for researchers and practitioners and also recommendations for future research. Research limitations are also included in this chapter.

Finally, Chapter Six concludes with the significance of the research findings and theoretical contributions to the research of empathy as well as methodological contributions.

Chapter 2. Literature Review

Introduction

In this chapter, the research background as well as the context for this research are provided. It starts with an overview of academic and industry-related materials, demonstrating the increasing need for holistic engineers with transdisciplinary knowledge and well-developed social skills. It covers the materials that emphasise empathy as an essential competence for holistic engineers and provides existing definitions and models of empathy used in the field of engineering and engineering education. This demonstrates the existing training and pedagogical practices used to foster empathy in students and outlines the challenges of teaching and conceptualising this phenomenon.

This chapter also provides an overview of the role of entrepreneurship in engineering practice, followed by a discussion of the existing approaches of entrepreneurial education used to develop an entrepreneurial mindset and competencies (e.g., pre-accelerators) in different types of students, including engineering. Finally, the link between entrepreneurship education (or specific elements of entrepreneurial education) and empathy is scrutinised to demonstrate that entrepreneurship education interventions can foster empathy in engineering students.

Request for Holistic Engineers and Response From Various Stakeholders

Emerging Engineering Challenges Form a Profile and Practice of Future Engineers

The world of the 21st century represents a complex multipolar system with many rapid technological, economic, environmental, and social changes that engender

various opportunities and form different challenges in various industries, including engineering. The National Academy of Engineering (2018) formulated fourteen major challenges for engineers in the 21st century, such as advancing personalised learning, providing clean access to water, making solar energy economical, enhancing virtual reality, reverse-engineering the brain, engineering better medicine, advancing health informatics, restoring and improving urban infrastructure, securing cyberspace, providing access to clean water, providing energy from fusion, preventing nuclear terror, managing the nitrogen cycle, developing carbon sequestration methods, engineering the tools of scientific discovery. Many of these challenges go beyond solving purely technical tasks and include consideration of social aspects, which have impacted engineering practices, specialist profiles, and skill set requirements.

Holistic engineers as Specialists who Can Address Emerging Engineering Challenges

Over the past decades, a range of principles has been incorporated into engineering practice and principles to address the above-mentioned challenges (e.g., iterative, or human-oriented principles). Within the engineering field, these new approaches include frequent interaction between engineers and other stakeholders to help them achieve project objectives, for example, decreasing production costs or ensuring faster time to market and creating more socially oriented solutions. It is important to note that these principles require engineering practitioners to have well-developed social-professional capabilities, as their lack may affect the outcomes of interactions and the overall quality of projects and results (Alzoubi & Gill, 2014). Therefore, taking into account established practice, modern engineers, in addition to technical expertise and knowledge, must possess well-developed interpersonal competencies that enable them to manage various processes that are based on

communication, such as teamwork or networking (Creed et al., 2002; Täks et al., 2014). In this regard, to address the industry's emerging challenges and align with the changing practice of engineering activity, engineers must have well-developed technical competencies and a range of social and interpersonal capabilities.

In addition to interpersonal capabilities, the current engineering context encourages engineers to have other well-developed professional capabilities. For example, engineering specialists should be able to identify opportunities within their practice, act ethically and manage uncertain scenarios (Nichols & Armstrong, 2003; Oswald, 2015). Human Resources (HR) specialists currently expect applicants for engineering positions to have the following skills: technical, communication, interpersonal, and problem-solving skills, as well as enthusiasm, commitment, and motivation (e.g., Brown, 2016; Bosman et al., 2018). Thus, the nature of engineering challenges and problems encourages engineers to possess a wide spectrum of developed professional capabilities.

In addition to a range of developed professional capabilities, modern and future engineers should also have contextual knowledge in various disciplines and not only be limited to engineering knowledge. According to Huang-Saad et al. (2020), it is no longer sufficient for modern engineers to possess only technical expertise to succeed. Engineers must be prepared to lead different types of projects considering the business context and people's motivations, beliefs, opinions, and behaviours. Grasso and Burkins (2010, p. 1) state that the future of engineering practice "is beyond technological labels", where engineers will not be limited to specific narrow expertise or a position (e.g., being a mechanical or electrical engineer). However, they will be required to become *holistic engineers* who can work in complex and multidisciplinary systems and

teams embracing and connecting technologies, sustainability, public policy, industry, and government. Such an approach will require modern engineers to possess various new skills and professional attributes. A holistic engineer must possess a range of skills, including technical (e.g., knowledge within the field of physics, engineering, maths, and others), professional (ethics, professional responsibility, understanding of the broad impact of engineering practice on society, sustainability), as well as other non-technical skills such as multidisciplinary teamwork (Canney & Bielefeldt, 2015; Birzer & Hamilton, 2019). In the near future, industry will need many engineers who can collaborate effectively, think holistically and work across different disciplines (Lucas et al., 2014). As Grasso et al. (2010, p. 164-165) point out:

> *"The future of leadership and excellence in our profession is one in which we invest in and create engineering practitioners who crave broad knowledge across disciplines and command a diversity of both technical and professional acumen throughout their career, be it for high-tech engineering or the management of a global IT corporation. These engineers are holistic in view, adaptive in the face of challenges, and able to provide continuous, cost-effective value to employers or clients – in rapidly changing markets. They are creative and innovative and will inspire the next generation of engineers to invest in our practice and profession".*

Request for Holistic Engineers and Response From Engineering Professional Associations Around the World

Different professional organisations and associations worldwide have already begun responding to this request for holistic engineers. To address it, they have already included interpersonal competencies and a range of other professional attributes (for example, ethics and the ability to consider social impact) in professional standards and

requirements for competencies of modern engineers. For example, according to the Engineers Australia's Competency Standard (2017), professional engineers, apart from technical knowledge and engineering application ability, should also possess professional and personal attributes such as ethical conduct and professional accountability, practical oral and written communication skills, creativity, management skills, and team-managing skills.

The importance of interpersonal capabilities is also highlighted in the American Society of Civil Engineers (ASCE) report "Civil Engineering Body of Knowledge: Preparing the Future Civil Engineer" (2019). The report stated that professional civil engineers must communicate effectively, lead teams, and consider ethical responsibilities in addition to having strong engineering fundamentals, technical knowledge, and competencies. According to the American Society of Civil Engineers (ASCE) and the American Academy of Environmental Engineers (AAEES), engineers' bodies of knowledge should include an understanding of the social impact of their professional decisions and technical solutions, and an understanding of the role of ethical responsibility in their practice (ASCE, 2008; AAEES, 2009).

The American Society of Mechanical Engineers (2019) also declares that engineers should focus on developing diverse social skills to advance their careers. These skills include communication, presentation, self-confidence, humility, resilience, empathy, and brand identity. IEEE (Institute of Electrical and Electronics Engineers) Computer Society published the Software Engineering Competency Model (SWECOM) which outlines communication, technical leadership and team participation as essential behavioural attributes and skills for software engineers developing and altering software systems (IEEE Computer Society, 2014). According to Engineers Canada (2018),

engineering professionals should have well-developed communication and team management skills and knowledge in social, economic, environmental, and sustainability, as well as technical competence and professional accountability. The importance of the holistic development of modern engineers is also reflected in the Code of Ethics of various professional organisations. According to the Engineers Australia's Code of Ethics and Guidelines on Professional Conduct, engineering practice requires engineers to demonstrate integrity, practise competently, exercise leadership, and promote sustainability (Engineers Australia, 2019). In this regard, it can be noted that various professional associations highlight interpersonal competencies and professional attributes related to ethics and social impact as critical parts of a modern engineer's profile. The list of professional associations mentioned in this section and associated materials on the topic of engineering education produced by these associations is presented in Table 1.

Table 1

Engineering professional associations and materials

Professional associations	Materials
Engineers Australia	Competency standard for Professional Engineer
	Engineers Australia's Code of Ethics and Guidelines on Professional Conduct
American Society of Civil Engineers (ASCE)	Civil Engineering Body of Knowledge: Preparing the Future Civil Engineer report
American Academy of Environmental Engineers (AAEES)	Environmental engineering body of knowledge
American Society of Mechanical Engineers	7 Soft Skills to Advance Your Engineering Career.
IEEE Computer Society	Software Engineering Competency Model (SWECOM)
Engineers Canada	A closer look at the Competency-Based Assessment project

Interpersonal and Professional Capabilities in the Existing Accreditation Criteria for Engineering Educational Programs

The existing criteria for the accreditation of educational engineering programs in different countries have also included interpersonal competencies as a requirement for the formation of modern engineering professionals. A range of accreditation bodies extended their requirements for accreditations of engineering courses and state that the development of social competencies should be a compulsory component of graduate attributes and learning outcomes (Anwar & Richards, 2018; Bachnak et al., 2019). The International Engineering Alliance (IEA), in its revision of the Graduate Attributes and Professional Competencies international benchmark, states that engineers should possess knowledge of public safety and sustainability, and "ethics as well as inclusive behaviour and conduct". They state that engineering graduates should also be aware of “relevant social science” and “the role of engineering in society” (IEA, 2021, p. 11-12). The proposed graduate attribute profiles include various social characteristics related to communication, interaction with others, ethics, and other social competencies (IEA, 2021).

Furthermore, the holistic profile of a modern engineer with well-developed interpersonal competencies is also a requirement of national accreditation agencies. For example, the requirements to teach social competencies to engineers are reflected in the Criteria for Accrediting Engineering Programs developed by the Accreditation Board for Engineering and Technology (ABET EAC, 2020) and The Australian Engineering Accreditation Centre. According to ABET EAC (2020; p. 5), engineering educational programs, in addition to effective communication and team-managing competencies, should also focus on developing engineering students’ abilities to recognise ethical and

professional responsibilities in engineering'. The Engineering Council (EC) in the UK, which licences other engineering bodies to undertake accreditations of engineering programs, is driven by similar guidelines (EC, 2020). As a result, it is expected that programs' areas of learning should be focused on the broad context (including legal, social, ethical, environmental, and economic aspects) and teaching "additional general skills" apart from technical knowledge (Qadir et al., 2020; EC, 2020). Therefore, an increasing number of accrediting organisations are highlighting social and interdisciplinary competencies as essential for engineering graduates.

Educational Institution Initiatives and Scholars' Recommendations to Prepare Holistic Engineers with Well-developed Professional Capabilities

To address industry requests and meet the requirements of accreditation bodies and professional associations, various educational institutions have taken a series of actions to adapt their own educational products, documents, and requirements to prepare holistic engineering specialists. Firstly, universities and other educational institutions have integrated into engineering programs and educational standards, strategic and other policy documents the necessity to develop social and interpersonal and transferable competencies such as communication, ethics, and lifelong learning in most engineering educational programs (e.g., University of Sydney, 2013; University of Technology Sydney, n.d.; University of Queensland, n.d.; Purdue University, 2020).

Secondly, educational institutions have begun reviewing their pedagogical and educational approaches to form holistic engineering graduates, considering the results of existing research and best practices. According to Litzinger et al. (2011), educational programs and courses should involve authentic and practical activities aimed at developing social orientations and competencies in future engineers, taking into account

contextual characteristics. At the same time, it is necessary to use appropriate pedagogical, including experiment-based and research-based strategies, as well as active learning (Grodotzki et al., 2018). Also, when preparing future engineers and aiming to develop holistic engineering thinking, it is essential to combine various engineering disciplines (e.g., electrical, mechanical and systems engineering) and offer a large number of non-technical subjects such as ethics, emotional intelligence (EQ), and subjects related to creativity and even arts. According to Canney and Bielefeldt (2015), professional attributes are formed in engineering students throughout their lives, not just in the classroom.

Therefore, when designing programs and activities to develop professional attributes for holistic engineers, it is important to use long-term approaches considering the impact of both social and environmental aspects. It is also worth noting that educational institutions and the academic community have already begun to follow the requests from the engineering industry, professional associations, and accreditation organisations to prepare engineering graduates possessing a large number of developed competencies to help them learn and work effectively in the new and future reality. At the same time, the engineering education industry needs effective educational models and frameworks that take into consideration various contextual characteristics of engineering practice.

Another vital component for preparing holistic engineers is the qualifications and skills of engineering educators. The Australian Council for Engineering Deans (ACED) published the Engineering Futures 2035 report, stating that engineering educators and future technicians should be equipped with sufficiently developed generic skills; they should understand the importance of trust and social licence (Crosthwaite,

2019). Also, engineering educators should pursue an understanding of the contextual characteristics and knowledge in their discipline and other areas such as ethics, sustainability, and policymaking. That is why one of the recommendations for a further detailed investigation that was made as a result of this ACED report is to: *"Establish the existing engineering educator workforce profiles and desired profile for the engineering educator workforce that can deliver on the required knowledge, skills and attributes"* (Crosthwaite, 2019, p. 5). It is suggested to involve practitioners from various non-technical backgrounds who possess strong facilitation skills and professional experience (Crosthwaite, 2021). According to the European Commission report on curriculum guidelines for Key Enabling Technologies and Advanced Manufacturing Technologies (2019), engineering professors should continuously be trained to develop professional and non-technical skills that can create an atmosphere in the classroom for knowledge exchange. Therefore, as part of the preparation of holistic engineers, educational organisations should pay special attention to creating innovative and holistic programs, and training engineering educators.

These modern challenges, as well as changes in engineering practice associated with these challenges, have thus encouraged various professional associations and educational institutions to pay special attention to the training or education of holistic engineers who are able to work on multidisciplinary projects, as well as possess both social and technical competencies. At the same time, to prepare holistic engineers, these professional associations and educational institutions need to create educational programs that include modules and elements to develop a wide range of skills and knowledge among future engineers.

Empathy: An Important Competency in a Holistic Engineer

Empathy has been identified as one of the important competencies that underlie the mindset and practice of a holistic engineer (Hess et al., 2014). As a result, more and more academics, researchers and educators are calling for it to be incorporated into engineering education programs (Strobel et al., 2013; Walther et al., 2016; Hess et al., 2016a, 2016b). The following sections will discuss the definitions of empathy from various fields, and the different training activities in different fields which aim to foster this phenomenon. The benefits of empathy for engineering practice and the teaching tradition of empathy in engineering education will then be presented.

Empathy Definitions and Benefits: Insights from Different Areas

As mentioned above, one of the essential social competencies is empathy. The term "empathy" was introduced more than a century ago by Titchener as a translation of the German word "Einfühlung", which means "in-feeling" or "feeling into". However, over the past 100 years, this term has been defined and conceptualised in various ways in different fields (e.g., Wispé, 1986; Decety & Jackson, 2004; De Vignemont & Singer, 2006; Barnett & Mann, 2013).

Cuff et al. (2016) identify 43 distinct summaries and definitions of empathy used in different fields. In their review, the authors emphasised the variability of understanding and complexity of this phenomenon and highlighted the different topics crucial to an understanding of its characteristics. First, it is essential to distinguish this phenomenon from other concepts as it is commonly confused with other social competencies, for example, sympathy or compassion. Second, most definitions of empathy emphasise that it includes both affective and cognitive components, and that there are other dichotomies inherent to its nature, such as congruent or incongruent, and

self or other-oriented. Third, there are various discussions related to empathy, such as whether it is a result of state or trait influences, whether empathy is automatic or can be controlled, and whether or not it is related to behavioural outcomes. In addition to these discussions and dichotomies, other studies have also highlighted that empathy can be multidimensional (Davis, 1983) and multifaceted (Walther et al., 2017). Clearly, the assorted definitions and models of empathy, as well as the various discussions around it, create difficulties in studying and implementing empathy in educational programs.

Empathy is considered an essential competency in many different contexts and fields, such as healthcare (Tavakol et al., 2012; Sulzer et al., 2016), nursing (Zarzycka et al., 2016; McKinnon, 2018), counselling (Bowman & Reeves, 1987), and social work (Gerdes et al., 2011). Empathy is important in these industries because of the extensive benefits that it can bring to professional practice and relationships. These include encouraging positive therapeutic interventions (Watson, 2002), reducing adolescents' aggression and potential crime rate (Weisner & Silbereisen, 2003), and helping to promote healthy personal growth (Hoffman, 2001). Furthermore, Forrester et al. (2008) claim that a practitioner's level of empathy is related to positive client experience, less resistance and better communication, a claim that is supported by Jensen et al. (2005), who conclude that empathy is essential for effective outcomes when conducting psychotherapy treatment for children. As a result, much attention is paid to empathy assessment and measurement from social, behavioural, and physiological perspectives (Ferri et al., 2019; Fragkos et al., 2019).

How Empathy is Taught in Different Areas

Considering the benefits of empathy and the assumption that empathy can be facilitated (Davis, 1990) or taught (Thangarasu et al., 2021), various professional

associations and educational institutions have begun calling for incorporating empathy in educational courses and programs and recommending different activities that may foster it in students. For example, empathy is indicated in the Council on Social Work Education's Educational Policy and Accreditation Standards (2015) as one of the core elements of a social worker's practice; therefore, these standards recommend incorporating the teaching of this competency in the social work curriculum. Different teaching techniques, such as watching videotapes, writing narratives from the other person's perspective, and role-play games assist healthcare and social work educators in encouraging students to be more empathetic and responsive towards their clients (e.g., Gerdes et al., 2011; Dodson et al., 2017).

Lam et al. (2011) analyse different studies focused on training methods of empathy in different human service and social science fields such as medicine and nursing, social work, and education. Their narrative review identifies seven common types of training methods focused on empathy development which are (1) experiential training, (2) a didactic and experiential training approach that involves theoretical (e.g. lecture) and experiential components, (3) a skill development approach (where empathy is considered as a skill), (4) didactic and skill training, (5) mindfulness training (mindful awareness), (6) writing training that encourages learners to write from or interpret something from their perspective, and (7) video stimulus.

Over recent years, a tradition of empathy training has also been formed in social sciences and human service disciplines. Taking into consideration its advantages has led to a growing range of educational approaches and models aimed at fostering it among different types of students and graduate engineers, educators, academics, and researchers. Along with the influence of this tradition of conceptualisation and teaching

of empathy in these disciplines, engineering academics also see the need to emphasise the importance of considering the contextual features of engineering practice when designing educational models and activities focused on teaching empathy to future engineers. The following section will review the papers that define empathy in the engineering field and outline the various educational approaches used in engineering programs aimed at developing it in engineering students.

Empathy in Engineering

More and more academics and researchers believe that empathy can be considered an essential competency for holistic engineers and the engineering world (Penzenstadler et al., 2009). The research finds that empathy can help engineering professionals to connect crucial inter and intrapersonal skills, especially if they work in a multidisciplinary environment and need to communicate with various clients and stakeholders (e.g., Pink, 2006; Rieckmann, 2017; Walther & Sochacka, 2017). The important role of empathy is also noted in specific processes that form parts of engineering practice, such as managing a team (Köppen & Meinel, 2015), collaboration and communication (Walther et al., 2012), and ethical decision-making and managing privacy requirements (Levy & Hadar, 2018). At the same time, empathy plays a vital role in problem-solving and designing human experience (Kouprie & Visser, 2009; Schmitt et al., 2016). Empathy, therefore, plays an important role in forming socially oriented holistic engineers and is also considered one of the essential competencies in engineering practice.

The recognition of the importance of empathy in engineering practice has led in recent years to a growing number of studies and academic materials on this topic. The conference materials about empathy provided by the ASEE are cited five times more

frequently in 2018 than in 2010 (Hess & Fila, 2016a). More recently, Litvinov et al. (2023) identified 22 papers from the Scopus and Web of Science databases that directly focus on the phenomenon of empathy in the field of engineering. These papers are summarised in Table 2.

Table 2

Empathy research in engineering (Litvinov et al., 2023).

Year	Authors	Title	Journal	Approach
2012	Rasoal, C., Danielsson, H., & Jungert, T.	Empathy among students in engineering programmes	European Journal of Engineering Education	Qualitative
2013	Strobel, J., Hess, J., Pan, R., & Wachter Morris, C. A.	Empathy and care within engineering: Qualitative perspectives from engineering faculty and practicing engineers	Engineering Studies	Mixed method
2015	Akgün, A. E., Keskin, H., Cebecioglu, A. Y., & Dogan, D.	Antecedents and consequences of collective empathy in software development project teams	Information & Management	Quantitative
2016	Hess, J. L., & Fila, N. D.	The manifestation of empathy within design: findings from a service-learning course	CoDesign	Qualitative
2016	Hess, J. L., Strobel, J., & Pan, R.	Voices from the workplace: practitioners' perspectives on the role of empathy and care within engineering	Engineering Studies	Qualitative
2016	Fila, N. D., Hess, J. L., Dringenberg, E., & Purzer, S.	Engineering students' utilization of empathy during a non-immersive conceptual design task	The International Journal of Engineering Education	Mixed method
2016	Hess, J. L., Fila, N. D., & Purzer, S	The relationship between empathic and innovative tendencies among engineering students	The International Journal of Engineering Education	Quantitative

2017	Hess, J. L., Strobel, J., Pan, R., & Wachter Morris, C. A.	Insights from industry: a quantitative analysis of engineers' perceptions of empathy and care within their practice	European Journal of Engineering Education	Quantitative
2017	Walther, J., Miller, S. E., & Sochacka, N. W.	A model of empathy in engineering as a core skill, practice orientation, and professional way of being	Journal of Engineering Education	Conceptual paper
2017	Hess, J. L., Strobel, J., & Brightman, A. O.	The development of empathic perspective-taking in an engineering ethics course	Journal of Engineering Education	Qualitative
2019	Haag, M., & Marsden, N.	Exploring personas as a method to foster empathy in student IT design teams	International Journal of Technology and Design Education	Qualitative
2019	Hess, J. L., Beever, J., Zoltowski, C. B., Kisselburgh, L., & Brightman, A. O.	Enhancing engineering students' ethical reasoning: Situating reflexive principlism within the SIRA framework	Journal of Engineering Education	Quantitative
2020	Shah, C., Elison, Z., & Kokini, K.	Inclusive Circles of Conversation: Implementing AN Innovative Diversity Program among Engineering Faculty and Staff	Journal of Women and Minorities in Science and Engineering	Qualitative
2020	Sochacka, N. W., Youngblood, K. M., Walther, J., & Miller, S. E.	A qualitative study of how mental models impact engineering students' engagement with empathic communication exercises	Australasian Journal of Engineering Education	Qualitative
2020	Walther, J., Brewer, M. A., Sochacka, N. W., & Miller, S. E.	Empathy and engineering formation	Journal of Engineering Education	Qualitative
2020	Hess, J. L., Miller, S., Higbee, S., Fore, G. A., & Wallace, J.	Empathy and ethical becoming in biomedical engineering education: a mixed methods study of an animal tissue harvesting laboratory	Australasian Journal of Engineering Education	Mixed method
2021	Hess, J. L., Fila, N. D., Kim, E., & Purzer, S.	Measuring Empathy for Users in Engineering Design	International Journal of Engineering Education	Quantitative
2021	Guanes, G., Wang, L.,	Empathic approaches in engineering capstone design	European Journal of Engineering Education	Qualitative

	Delaine, D. A., & Dringenberg, E.	projects: student beliefs and reported behaviour		
2021	Wallisch, A., Briede-Westermeyer, J. C., & Luzardo-Briceno, M.	Fostering User-Empathy Skills of Engineering Students by Collaborative Teaching	International Journal of Engineering Education	Qualitative
2021	Huerta, M. V., Carberry, A. R., Pipe, T., & McKenna, A. F.	Inner engineering: Evaluating the utility of mindfulness training to cultivate intrapersonal and interpersonal competencies among first-year engineering students	Journal of Engineering Education	Qualitative
2021	Sochacka, N. W., Delaine, D. A., Shepard, T. G., & Walther, J.	Empathy Instruction through the Propagation Paradigm: A synthesis of developer and adopter accounts	Advances in Engineering Education	Conceptual paper
2021	Alzayed, M. A., McComb, C., Menold, J., Huff, J., & Miller, S. R.	Are you feeling me? An exploration of empathy development in engineering design education	Journal of Mechanical Design	Mixed method

This review listing 22 papers from the Scopus and Web of Science databases shows that despite the increase in interest in empathy and the diversity of studies at the methodological and contextual levels, researchers investigating empathy in engineering and engineering education face the same problems as researchers from other disciplines.

There is a lack of consensus on the definition of empathy in the engineering field as the definition (word) of empathy is not commonly used in engineering practice. For example, according to Strobel et al. (2013), empathy is not explicitly represented in the academic literature as a distinct phenomenon in engineering practice and engineering education. Strobel et al. (2013) also state that in the early stages of empathy research, empathy was commonly associated with other phenomena such as compassion, care, or user needs. While engineering practitioners state that the term empathy is not commonly

used in engineering practice, it is challenging to define this phenomenon clearly. Also, engineers do not see the utilitarian value of empathy in their practice.

Another problem when researching the phenomenon of empathy in engineering is its complexity and the lack of any holistic models. Litvinov et al. (2023) conclude that academics have mostly relied on research from psychology at the early stage of studying empathy in engineering. As a result, they conceptualise empathy as a phenomenon that includes both affective and cognitive components (Davis, 1980, 1983; Batson, 2009). However, in later research, engineering researchers have begun conceptualising empathy as a more holistic phenomenon and an important skill or practice in engineering that should be incorporated into the engineering way of thinking (Walther et al., 2017). The various authors declare that in the engineering context, there is a trend toward creating holistic models and understanding of empathy, considering cognitive and affective dimensions (multidimensional) and the contextual characteristics of engineering activity and practice (Litvinov et al., 2023). Further, despite the increasing attention to empathy from researchers in engineering and engineering education, there is still a lack of a coherent and universally recognised framework that conceptualises it in engineering.

Empathy in Engineering Education

Despite the lack of consensus on conceptualising the phenomenon of empathy, researchers and educators, relying on definitions from other disciplines (or using measuring tools from other disciplines), study the role of specific educational approaches, contexts or tools in the fostering or formation of empathy in future engineers.

Multiple studies investigate the role of the various educational contexts in the formation of empathy in engineering students. These contexts include design and service learning-based engineering courses (e.g., Cummings et al., 2014; Bairaktarova et al., 2016; Hess & Fila, 2016b), ethics education (Hess et al., 2017a), transdisciplinary communication and learning (e.g., Walther et al., 2012; Levy, 2018), and entrepreneurship education (Litvinov et al., 2020; 2021). Lunn et al. (2022) identify the application of the following pedagogical approaches to foster empathic abilities within STEM courses: different creative arts or narrative modules, modules and programs focused on developing communication abilities, problem-based approaches, collaborations with different stakeholders at different levels, and experiential immersion. The latter approach, experiential immersion, is where specific tools are used to encourage engineering students to immerse themselves in the experiences of others, such as via personas and customer journey maps (Wertz et al., 2020; Fila et al., 2022). Thus, in recognition of the potential benefits of empathy in engineering practice, academics and educators have begun to pay more serious attention to developing and studying empathy in engineers.

Despite this growing recognition of the vital role of empathy in contemporary engineering formation and activities, the extant academic literature needs to provide more detailed guidance on how to foster empathy within engineering programs. Many engineering educators however state that empathy is vaguely defined and is thus excluded from pedagogical approaches and practice (Strobel et al., 2013; Fila & Hess, 2015). Hess and Fila (2016b) state that it is essential to investigate the nature of empathic development to determine effective educational practices and approaches. However, it is also important to understand the role of specific tools and experiences influencing empathy and engineering students' interpretations of empathy. Walther et

al. (2017) add that it is essential to consider the role of learning arrangements and disciplinary cultures in forming empathic tendencies in engineering students. When studying empathy development, Hess et al. (2019) recommend considering situational and individual variables such as personal characteristics, and formal and informal (co-curricular) experiences. On this point, the problem of the lack of cohesive models that conceptualise the phenomenon of empathy also has an impact on educational methods.

The literature shows that empathy is considered an essential competency for holistic engineers. Despite the lack of cohesive frameworks that conceptualise this phenomenon in engineering, educators and researchers explore and propose various educational interventions to foster empathy in engineering students. Entrepreneurship and entrepreneurial programs can potentially be examples of contexts that foster empathy in engineering students, as various researchers state that some elements of entrepreneurship or entrepreneurial education can positively impact empathy. In the next section, the ecosystem of entrepreneurship education in Australia and its challenges will be discussed. Examples of entrepreneurial education interventions will be analysed, followed by examples of entrepreneurial programs and approaches that are used to prepare entrepreneurial engineers. Finally, the relevant academic literature will be discussed, demonstrating the relationship between certain elements of entrepreneurship and empathy.

Entrepreneurship and Entrepreneurial Education in Engineering

Entrepreneurship Education in Australia

Entrepreneurship education is an essential component of the Australian economy and educational system. Since introducing the first entrepreneurship course at the

Swinburne University of Technology in 1989, Australia's entrepreneurial educational opportunities have been increasing constantly (Maritz, 2017; Nabi et al., 2017). Over the past ten years, incubators and accelerators have increased by nearly 40% per year, demonstrating that Australia is experiencing a steady entrepreneurial education boom (Maritz et al., 2019).

Most Australian universities run various entrepreneurial programs such as accelerators (Bliemel et al., 2016); many organise incubators and provide co-working spaces for nascent entrepreneurs (Smart, 2002), delivering undergraduate and postgraduate courses with specialisations in entrepreneurship as well as subjects on this topic (Maritz et al., 2015). At the same time, tertiary education providers are not the only contributors to the Australian entrepreneurial ecosystem and growth of the startup community, as there are also government authorities of different levels, the tech community, industry and business partnerships, training centres, hackathon organisers, policymakers, angel organisations, and innovation networks (e.g., Renando, 2018; Maritz et al., 2019).

Although no formal national body oversees entrepreneurs, each Australian state has a range of support agencies that develop a startup ecosystem by providing entrepreneurs and founders with advice, education, funding and more. The State Government can support them as, for example, LaunchVic in Victoria, Sydney Startup Hub in New South Wales, StartupWA in Western Australia, an entrepreneurial hub at the innovation precinct, Lot Fourteen in South Australia, and Enterprise in Tasmania. In addition to government-funded agencies, there are various independent, philanthropic, and corporate programs (Bliemel et al., 2016; Renando, 2018).

The academic community also plays an important role in developing entrepreneurship in Australia. Topics of entrepreneurial education, entrepreneurship ecosystems, enhancement of entrepreneurship structures and entrepreneurial mindset are intensely investigated, resulting in many different teaching and development approaches (e.g., Miles et al., 2017; Kuratko & Morris, 2018). There are, therefore, many diverse actors and stakeholders involved in the entrepreneurship training ecosystem in Australia.

Main Challenges of Researching and Teaching Entrepreneurship

However, despite the increasing research interest, the questions about the role of educational institutions in preparing graduates for creating different types of enterprises are still in the debate phase. (Aamir et al., 2019). Due to the abundance of various institutions, programs and courses that teach entrepreneurship and the lack of detailed policies and guidelines for designing, developing, and delivering these entrepreneurial educational programs, each educational institution has to build and design its own programs based on its resources and available expertise. The existing entrepreneurial policies do not provide enough “profundity”. For example, modern governments are trying to encourage universities to foster entrepreneurial activities in different curricula, including engineering, without providing clear definitions and policy documents, which is why institutions need to choose their own educational approach and teaching methods (Brown & Mawson, 2019).

At the same time, there is no consensus on what entrepreneurial competencies should be taught in entrepreneurship education, as there are many different frameworks and proposals from different stakeholders. For example, according to Mitchelmore and Rowley (2010), founders of startups should have four sets of competencies:

entrepreneurial skills, business and management skills, human relations skills, and conceptual and relationship skills. Several years later, these four groups were supplemented by the fifth competency: attitudes, or features. Valerio et al. (2014) support the idea that to develop an enterprise, it is necessary to have some business/management skills and knowledge, such as organisational theory or risk management abilities. Garzón (2010) and Alusen (2016), relying on the materials of the Management System International (MSI) and McBer and Company, outline ten essential personal entrepreneurial competencies required for an entrepreneur to launch an enterprise. They are opportunity recognition, persistence, commitment to responsibilities, ability to take risks, demand for efficiency and quality, goal orientation, information seeking, planning/monitoring and control, persuasion and networking, and self-confidence.

According to the EntreComp framework developed by the European Commission (2016), entrepreneurs and entrepreneurial employees should develop the following competencies to drive positive economic, technological and social changes: Ideas and opportunities (Spotting opportunities, Creativity, Vision, Valuing ideas, Ethical and sustainable thinking), Resources (Self-awareness and self-efficacy, Motivation and perseverance, Mobilising resources, Financial and economic literacy, Mobilising others), Into action (Taking the initiative, planning and management, Coping with uncertainty, ambiguity and risk, Working with others, Learning through experience).

Despite the popularity and importance of entrepreneurial education, there are currently no specific policies and universally recognised frameworks conceptualising

competencies that entrepreneurs should develop, which creates issues in teaching entrepreneurship.

Another issue of researching and teaching entrepreneurship is that while entrepreneurship is a complex and nonlinear process, many educators use linear (focusing on predictable outcomes) and process-driven approaches. Ferreras-Garcia et al. (2019) state that many universities and educational institutes implement business plan-oriented courses to teach future entrepreneurs. Business plan development is based on the concept that predicting or " imagining" inputs and potential outcomes of entrepreneurial activities is possible. However, this plan can be shattered under various external and internal factors in the current VUCA (volatility, uncertainty, complexity, and ambiguity) world.

Another popular process-based method to teach entrepreneurs is the case study approach. According to Neck and Greene (2011), a case method is a powerful tool designed to assist students with learning different decision-making options that entrepreneurs can face. However, this method does not prepare students for uncertain and emerging situations. The success of all the linear processes is possible if all steps are followed correctly, but entrepreneurship is not linear. Clearly, these methods do not take into account the complexity and uncertainty of the entrepreneurial process.

With the uncertainty of entrepreneurship, some researchers assume that the primary purpose of entrepreneurial education programs is to help students develop particular competencies that should equip them with practical knowledge, skills and values required during their entrepreneurial journey. Educational organisations should be focused on developing specific competencies to drive social, economic, and environmental change, which is reflected in different documents and policies (e.g.,

Organisation for Economic Co-operation and Development (OECD), 2018; Government of South Australia, 2018). Also, different researchers and organisations suggest focusing on competency development rather than linear approaches because there is a link between developed entrepreneurial skills and competencies, and entrepreneurial activity. Papagiannis (2018) declares that entrepreneurial education could influence and advance students' entrepreneurial skills and knowledge, increasing the desirability of students to pursue entrepreneurship and engage in entrepreneurial activities. Hernández-Sánchez et al. (2019) support the idea that entrepreneurial education programs focused on developing future founders' skills and competencies positively affect early-stage entrepreneurial activities. Thus, by focusing on developing certain entrepreneurial competencies, it is possible to prepare future entrepreneurs for an uncertain environment and increase the likelihood of their involvement in entrepreneurial activities.

Entrepreneurial education, therefore, plays an essential role in the economic development of Australia and other countries. Developing entrepreneurial skills and competencies in students from various disciplines, including engineering, can stimulate further growth. However, despite the advantages of these processes, only a small number of academic materials are aimed at understanding the role and nature of specific competencies in entrepreneurial experiences. In order to form universally recognised frameworks and models that conceptualise specific competencies, it is important to develop a consensus on the definition and the role of certain competencies, as well as create competency frameworks "which can act as a basis for investigating the essential nature and processes" which take into account the contextual characteristics of entrepreneurial and professional practices (Mitchelmore & Rowley, 2010; p. 106).

Entrepreneurship in Engineering

In recent decades, entrepreneurial competencies have become an increasingly important component of the holistic engineer portrait. According to Continental (2006), engineers of the 21st century must be technically competent, understand cultural characteristics, and be agile (flexible) as well as innovative and entrepreneurial. Fraser et al. (2017) state that the modern economy requires a new type of engineer who can enable a technological process and foster the emergence of entrepreneurship and innovation. Huang-Saad et al. (2020) support this, declaring that engineers need to use entrepreneurial approaches, thinking, and action to contribute to developing new technology and innovation. Gibb (2002) concludes that entrepreneurial competencies should be considered an essential part of all types of engineering projects, not just for creating technology startups.

Also, during recent decades, a range of materials from ASEE, which is one of the leading associations in engineering education, has been focusing on exploring the profile of a modern engineer and elaborating on the idea that engineers should possess well-developed entrepreneurial competencies and innovative thinking (e.g. ASEE, 2012; Li et al., 2016; Bosman et al., 2017; Harichandran et al., 2018; Shekhar & Huang-Saad, 2019; Bandera & Collins, 2022). Thus, more and more researchers and academics are highlighting the important role of entrepreneurship in developing the profile of holistic engineers.

Request for Engineers with Well-developed Entrepreneurial Competencies by Engineering Professional Associations

Professional bodies and associations have started encouraging the inclusion of entrepreneurial programs and courses into the engineering curriculum and developing

holistic engineers. The importance of entrepreneurial competencies and mindset for engineers is highlighted by the Australian Council of Engineering Deans (ACED) in the Engineering Futures 2035 scoping study:

"We should enhance comprehension of the role of engineering in society and the training of engineering ethics, humanity, nature and entrepreneurship" (Crosthwaite, 2019; p. 37).

The National Academy of Engineering's report, which aims to guide engineering education in the fast-changing world, states that engineers "have an obligation to society to be entrepreneurial" (2013, vi). Thus, different actors and stakeholders believe that entrepreneurial competencies should be incorporated into the engineering field.

Request for Entrepreneurial Engineers

The ongoing requirement for educating holistic engineers and the vital role of entrepreneurial competencies in engineering practice has led to the formation of the "entrepreneurial engineers" concept (e.g., Goldberg, 2006; Timmons et al., 2013). There are many definitions of entrepreneurial engineering. Lumsdaine and Binks (2003) call this type of engineer *technopreneurs* and define technopreneurship as a combination of entrepreneurial competencies, technical knowledge, and a deep understanding of various business processes such as marketing or finance. Polczynski and Jaskolski (2005) state that entrepreneurial engineering requires a combination of technical skills and the ability to engage in various business activities. Fraser et al. (2017) summarise these definitions by stating that entrepreneurship engineering means that engineers have well-developed entrepreneurial skills and knowledge, can identify and exploit technology-related opportunities, and must know how to transfer technology into products or services. Entrepreneurial engineers can offer the most advanced technical

solutions, considering customers' unmet needs and considering the potential impact and benefits of proposed solutions (Kriewall, 2010). Within this concept, it is assumed that engineers can apply entrepreneurial competencies and mindset in their work-related activities or create new ventures. According to Goldberg (2006, p. 2), "Entrepreneurial engineers meet the challenges of changing times as opportunities, seeking challenging and rewarding work together with an appropriate balance of intellectual, financial, professional, and personal growth".

Intrapreneurship and Engineering

The term "entrepreneur" is defined as an individual who creates and manages a new venture or business, taking into consideration existing risks (e.g., Schumpeter, 1939; Nichols & Armstrong, 2003). An "intrapreneur", however, is an individual working in an organisation who takes risks, solves business problems, and incorporates entrepreneurial practices into organisations (Williamson, 2013). While intrapreneurship is not a focus of this study, it is important to discuss this concept as the entrepreneurial mindset and interpersonal skills can also be valuable in the engineering workplace. A broad understanding of the potential benefits that entrepreneurial competencies can bring to different industries has given impetus to the formation of new research directions, which are "intrapreneuring", "corporate entrepreneurship", or "corporate venturing" (Antoncic & Hisrich, 2001). However, some researchers outline only minor differences between entrepreneurs and intrapreneurs. Instead of understanding the differences and similarities between intrapreneurship and entrepreneurship, other authors argue that entrepreneurship can be considered a synonym for innovations formed and implemented in the organisation's processes by internal employees (Carrier, 1996). In this regard, it can be noted that the terms entrepreneur and intrapreneur are

similar in terms of personal characteristics but differ in the context within which these specialists operate.

In the context of the engineering workplace, intrapreneurship can bring many different benefits to organisations. Menzel et al. (2007, p. 732) state that entrepreneurial and intrapreneurial technical specialists can provide "the basis of technological innovations and firm renewal". Osman et al. (2017) identified a positive correlation between innovative thinking and risk-taking, which are considered essential elements of an entrepreneurial profile and for the retention of talented engineering professionals. In this regard, it is critical to design and develop educational interventions for preparing intrapreneurial technical specialists; however, this study does not consider intrapreneurial profiles. Instead, the focus is on entrepreneurs as actors who can create new businesses.

Entrepreneurial Education in Engineering

As stated above, an entrepreneurial engineer, in addition to technical expertise and knowledge of business processes, is also expected to have an entrepreneurial mindset and skills. Entrepreneurial education is one of the ways to develop these attributes. Many academics (e.g., Barringer et al., 2005; Fayolle et al., 2006; Packham et al., 2010; Mueller, 2011) declare that entrepreneurial education positively affects students' practical knowledge, competence, and attitude. Also, entrepreneurial education can be valuable for everyone who works directly with entrepreneurs as partners or clients. (Maritz et al., 2019). Entrepreneurial education has another potential benefit, which is the formation of a specific mindset (entrepreneurial), which can be necessary for a variety of "future of jobs" positions (World Economic Forum, 2018). Due to the various advantages of the engineering practice, entrepreneurial education is

being paid closer attention to by different communities and bodies comprising academic, business, and government contexts. This has stimulated the creation of numerous theoretical and practical concepts for teaching entrepreneurial disciplines to different students, including engineers (Matlay, 2010). The entrepreneurship education approaches used to prepare more entrepreneurial holistic engineers are covered below.

Introducing entrepreneurship into other disciplines and teaching it outside of business schools increased significantly in the early 2000s (Morris et al., 2013). This growth was due to raising the awareness of innovation and technology's role in countries' economic development. This trend towards an increase in the number of entrepreneurial educational initiatives is still relevant today. The entrepreneurial education component is also included in engineering programs, and many stakeholders and actors, including governments and private foundations, support this growth. For example, the Australian Government supports and provides funding for many initiatives that seek to develop entrepreneurial skills in technical specialists. These are, for example, the Women in STEM and Entrepreneurship grants, establishing a BioMedTech Incubator grant, and the Innovation Connect initiative (Australian Government, 2022).

Globally, the most prominent actors on the market are the Kern Family Foundation and the National Science Foundation (NSF), which launched the I-Corps program in 2012. This program focuses on NSF-funded researchers to offer them educational activities to develop entrepreneurship and innovation skills (Nnakwe et al., 2018). One of the driving forces focuses on promoting the entrepreneurial mindset in engineering students and programs is the Kern Entrepreneurial Engineering Network (KEEN), established by the Kern Family Foundation (Blessing et al., 2008). KEEN is a

group of 45 partner institutions with a mission to describe the value of entrepreneurship for engineering students and graduates. KEEN and other professional associations and the increasing role of entrepreneurship in today's economy could have influenced the engineering professionals' and researchers' understanding of the role of entrepreneurship in engineering, which in turn has led to an increase in the number of scholarly works on this topic. As a result of these efforts aimed at promoting entrepreneurship among engineers, more than a quarter of the ASEE participating organisations had entrepreneurship programs in their engineering curriculum by 2008 (Shartrand et al., 2010). There is therefore a clear trend toward incorporating entrepreneurial activities and an entrepreneurial mindset into engineering education, and various researchers and professional associations demonstrate an increased interest in this topic (Fayolle et al., 2021).

Profile of an Entrepreneurial Engineer

In addition to emphasising the importance of entrepreneurship for technical professionals of various levels, researchers and professional associations discuss specific examples of the competencies and knowledge required for entrepreneurial engineers. Kriewall (2010) states that engineers with an entrepreneurial mindset (or entrepreneurial engineers) possess technological expertise for effective technology transfer and are also focused on solving customers' and community problems. They also know various business processes, so they must have a wide range of developed competencies to help them meet these requirements. KEEN defined "KEEN Student Outcomes" that are required for a future engineer who should be able to act as an entrepreneur in their professional activities and possess a range of diverse competencies, skills, and attributes (Petersen et al., 2012). This includes:

1. Being able to collaborate effectively in a team.
2. Critical thinking and creativity.
3. Being able to form and communicate the value proposition.
4. Learning from failure to succeed.
5. Managing projects and understanding the commercialisation models.
6. Being socially responsible for outcomes.
7. Taking into consideration both personal values (liberties) and a free enterprise philosophy when creating value.

Goldberg (2006), in their book "The Entrepreneurial Engineer", states that entrepreneurial engineers should:

1. Enjoy engineering.
2. Be able to set effective goals and understand personal motivation.
3. Effectively manage time and master space.
4. Be able to take into consideration important elements such as background and purpose.
5. Be able to deliver persuasive presentations.
6. Be able to build good human relations.
7. Act ethically.
8. Understand the culture of the venture as well as practise leadership.
9. Be able to pursue and assess technology opportunities.

However, despite the presence of various papers and research on the topic of entrepreneurial engineering competencies, it should be noted that there is no consensus on the competencies that should form the profile of an entrepreneurial engineer. Also, limited research focuses on specific components of an entrepreneurial mindset, for

example, self-efficacy or empathy, which are essential parts of the entrepreneurial engineer profile (Bell-Huff & Morano, 2017; Fayolle et al., 2021).

Rivas, in the book "Empathic Entrepreneurial Engineering: The Missing Ingredient" (2022) emphasises the importance of entrepreneurship and empathy for the professional engineering practice, as these characteristics increase the probability of building a sustainable and human-oriented world. This results from the assumption that entrepreneurship can encourage engineers to be more innovation-oriented, and empathy can help identify problems that affect others and convince them that a problem is worthwhile solving. Rivas (2022) also proposes a knowledge, persuasiveness, and empathy framework for solving and clarifying engineering/entrepreneurial problems that can be integrated into educational programs for preparing empathic entrepreneurial engineers.

Teaching Entrepreneurial Engineers

At present, one of the most common ways to prepare future engineers with an entrepreneurial mindset is an integration into the engineering programs of entrepreneurship-focused subjects or activities. Fraser (2017) suggests that universities in five English-speaking countries mostly use two models (Table 3).

There is the Engineering School Model, where entrepreneurship subjects and events are housed in engineering departments. For example, the School of Engineering at Princess Sumaya University for Technology incorporated mandatory entrepreneurship training into engineering programs to foster an entrepreneurial mindset in engineering students (Sababha et al., 2020).

There is also the Business School Model through which business schools offer and deliver entrepreneurial content. For example, Arias et al. (2018) propose enhancing future entrepreneurs' capabilities in higher education computer engineering programs by including technical and business subjects in the course curriculum. The researchers provided the example of a Master's Degree in Computer Engineering course, which consists of the following subjects: Strategic and Operational Management, Technology Integration for Embedded and Ubiquitous Systems, Management Skills, and Intelligent Systems Development. In this case, subjects were housed in the business school. Jones and Liu (2017) highlight other important attributes that should help incorporate entrepreneurship into the engineering courses' curricula, such as creating a business plan, financial literacy, marketing and business communication and law, and organisational behaviour.

Table 3

Models used to prepare engineers with entrepreneurial mindsets (Fraser, 2017).

	The Engineering School Model	The Business School Model	University Standalone Institution or Center
Australia	77%	23%	15%
Canada	67%	46%	4%
New Zealand	80%	20%	0
United Kingdom (UK)	92%	0	8%
United States (USA)	30%	62%	10%

Schuelke-Leech (2020) analyses the topics included in popular educational programs in the USA and Canada, which aim at preparing entrepreneurial engineers and

acquire the following results. Most covered topics are Strategy and Competitiveness (87.5%), Business Management, including business modelling and planning, deal structuring, decision-making and working with contractors (62.5%) and Design and Engineering which covers the whole product lifecycle from design to distribution (62,5%). Only 50% of programs teach students technology and knowledge management (e.g., intellectual property, patenting, technology adoption) as well as Financial Management. 37.5% of entrepreneurship courses have topics about Entrepreneurial Processes mostly related to pitching and presenting ideas and People management, such as team formation and leadership. The least popular topics are Managing New Ventures, including high-tech ventures (25%) and Innovation processes such as idea generation and commercialisation (25%) (Table 4).

Table 4

Topics covered in popular educational programs in the USA and Canada aimed at preparing entrepreneurial engineers (Schuelke-Leech, 2020).

Educational programs	Percentage of entrepreneurial topics
Business Management (business models)	62%
Entrepreneurial Processes (pitching)	37%
Strategy and Competitiveness (sales, stakeholder management)	87.5%
Managing New Ventures (creation strategies)	25%
People management (team formation)	37%
Financial Management (financing, funding)	50%
Design and Engineering (product development)	62.5%
Innovation process (idea generation)	25%

Technology management (intellectual property)	50%

In Australia, engineering students at various universities can also access many entrepreneurial subjects and activities, as the integration of entrepreneurial activities into engineering programs is one of the more popular ways of fostering entrepreneurial competencies and mindset in engineering students. For example, Engineering and Information Technology students from the University of Technology Sydney (UTS) have access to 76 subjects, including various entrepreneurial components (Litvinov et al., 2020). Students can access subjects offered by the Faculty of Engineering and Information Technology and other university bodies, such as the Business School.

Although the overall approach to developing entrepreneurial skills is the integration of entrepreneurial subjects and activities into the engineering curriculum, several challenges are associated with this approach. According to Kontio et al. (2006), the business process-focused approach and subjects designed by business schools do not consider the characteristics of technology and engineering practice. Wheadon and Duval-Couetil (2016) state that entrepreneurship educational activities should be tailored to different contexts. Another potential issue is a lack of curricular guidance and customised feedback for technology students working on business ideas or solving customer problems (e.g., Fu et al., 2010; Frydenberg, 2013; Hickey & Salas, 2013).

Additionally, due to the primary research focus on professional and managerial skills, the role of interpersonal skills for technology entrepreneurs is yet to be fully disclosed. In this regard, entrepreneurial education for engineering students lacks attention to context and interpersonal skills. However, some interpersonal attributes, such as empathy, are becoming essential with the overall popularity of design and customer-centric approaches. Considering these challenges, more and more universities

have created entrepreneurial and innovation centres with various entrepreneurial development programs such as incubators, accelerators, pre-accelerators, and pitch competitions.

Entrepreneurial Programs

This section will discuss the other type of entrepreneurial educational intervention, pre-acceleration entrepreneurial programs (pre-accelerators). Firstly, the background of this type of entrepreneurial program will be provided and then an analysis of the commonalities and differences between pre-acceleration programs and other widespread types of entrepreneurial programs (e.g., accelerators, incubators).

To begin with, universities and entrepreneurship-focused agents have implemented another strategy to develop students' entrepreneurial competencies: establishing dedicated entrepreneurial spaces that provide guidance for entrepreneurs and an environment for entrepreneurial extracurricular/educational activities. These programs include incubators, pre-accelerators and accelerators, mixed-use facilities and dorms, and the number of these spaces and programs has increased over recent years (Pittaway et al., 2020). These types of programs have quickly gained popularity as part of educational, entrepreneurial ecosystems.

Accelerators. Accelerators are short-term programs that encourage individuals (often from the same cohort) to design and develop business ideas and build startups. Five major Australian cities have well-developed and diverse startup ecosystems with various programs, including accelerators and pre-accelerators (Bliemel & Flores, 2015; Bliemel et al., 2016). So, nearly every university has at least one acceleration program (Maritz et al., 2022) focused on driving innovations and startups. According to Hassell (2020), the number of accelerators in Australia doubled from 17 to 36 between 2015

and 2018. Metcalf et al. (2021) assume that accelerators have become popular in the context of universities because they simultaneously fulfil both roles: (1) university accelerators as vehicles for university startups and (2) university accelerators as a source of entrepreneurship education, and the main goals of university-based entrepreneurial education is to develop students' skills, attributes, and competencies. Understanding how these programs contribute to forming entrepreneurial skills, self-efficacy, and identity is essential. Metcalf et al. (2021) find that accelerator programs are chosen as a source of entrepreneurial experiences, as these programs give students a chance to end up with early-stage entrepreneurial ideas using entrepreneurial models and mindsets. Cohen et al. (2019) also state that accelerators help new ideas reach the market and train entrepreneurship skills. Other authors assume that accelerators mainly focus on business development, while pre-accelerators focus on entrepreneurial skill development (Bliemel et al., 2016; Merguei & Costa, 2022).

University-based accelerators usually accept students who have already created a business, and have team members or even employees, although accelerators may accept single founders (Pauwels et al., 2016). Also, it is usually expected that most potential program participants have already completed some entrepreneurial phases, such as market analysis (Isabelle, 2013) or prototyping (Radojevich-Kelley & Hoffman, 2012). Therefore, accelerators are aimed at students who are not entirely "novices" to entrepreneurial activities and are familiar with entrepreneurial processes.

Accelerators are fixed-term cohort-based programs which typically include various structured educational activities and offer many services to their participants (Cohen et al., 2019; Maritz et al., 2022). The typical activities provided by accelerators are collaborating with mentors and coaches, and intensive training (e.g., communication

and presentation skills). Bliemel et al. (2016) provide the five defining features of accelerators such as seed funding, a homogeneous cohort of students and projects, co-location of students in the same space, pre-defined program duration (mostly, they last between 3 to 6 months), and presence of mentoring opportunities.

The most commonly offered additional services include working space (e.g., Connolly et al., 2018; Drori & Wright, 2018; Gutstein & Brem, 2018; Vandeweghe & Fu, 2018); free access to accelerator facilities (housing) (e.g. Bliemel et al., 2018; Brown & Mawson, 2019), help with product development (e.g. Grilo et al., 2017; Vandeweghe & Fu, 2018), access to funding and legal advisors (Grilo et al. 2017; Uhm et al., 2018; Glinik, 2019), scholarships and mentoring opportunities (Connolly et al. 2018; Glinik, 2019), help with resources for workshops and focus-groups (Gutstein & Brem, 2018), opportunities for networking and building a team (Wright et al. 2017), access to media resources and brand building assistance, research and development as well as post-graduate assistance (Pandey et al. 2017), marketing (including online) (Uhm et al., 2018), designing startup documentation and access to digital resources (Adomdza, 2016), Information Communications Technology (ICT) support (Radojevich-Kelley & Hofman, 2012), human resources as well as training and development assistance (Lall et al. 2013), and assistance with accommodating business environment (e.g., setting up a bank account or a phone number) (Vandeweghe & Fu, 2018). To conclude, accelerators provide many on-demand learning opportunities as well as a variety of different services and support.

In contrast to corporate accelerators, university accelerators focus primarily on two main goals: generating new ideas that can be diffused into the market and developing students' entrepreneurial competencies and skills (Cohen et al., 2019). On

this point, the designers of university accelerators pay special attention to the educational component by incorporating into the programs a variety of different entrepreneurial development interventions. For example, mentoring, formal workshops, and experiential training programs are widely used in Australian accelerators (Belitski & Heron, 2017). However, despite the educational component's importance in accelerators, there is currently a lack of requirements and standards for educational interventions that should be used to develop entrepreneurial skills (Maritz et al., 2022).

Incubators. Incubators are another type of entrepreneurial program which arequite common within the university environment. Unlike accelerators, incubation programs do not typically have a strict time frame and primarily provide co-working space, equipment, access to an incubator network of other entrepreneurs and some unstructured educational activities, such as guest speakers and learning circles (e.g., Cohen & Hochberg, 2014; Harima & Freudenberg, 2019; Kennett et al., 2020). A range of academic literature compares accelerators with incubators (e.g., Carayannis & Von Zedtwitz, 2005; Grimaldi & Grandi, 2005; Pauwels et al., 2016; Merguei, 2022; Merguei & Costa, 2022). However, incubators have a very different operational implementation, and acceleration programs (both accelerators and pre-accelerators that are discussed further) have their own unique characteristics (Merguei, 2022).

Pre-accelerators. This study focuses on the experiences of engineering students within pre-accelerators. In contrast to acceleration and incubation programs, pre-accelerators have some distinctive features. According to Bliemel et al. (2016; p. 31), "pre-accelerators are cohort-based organisations that accelerate nascent entrepreneurs before a prototype or startup exists". The main focus of these programs is the development of entrepreneurial skills and teaching about the essential entrepreneurial

phases. Therefore, participants are not typically expected to graduate with a business, product or commercialisation strategy. They only indirectly emphasise the results of a startup or business and do not prioritise them (Merguei, 2022). That is why, in most cases, these programs are open for students who do not have product and venture development experience and who are early-stage entrepreneurs with an idea only. In terms of the learning objectives, upon the completion of a pre-accelerator, students should understand the role of problems in the formation of business ideas, be able to identify customer needs, and take into account the characteristics of the market and customers, validate the idea and transfer it to products or services. That is why pre-accelerators are focused on aspiring entrepreneurial students with no previous experience in entrepreneurship, even before they have a startup or a product.

The pre-accelerator selection process is typically less competitive than entry into an acceleration program, and pre-accelerators are shorter (2 - 14 weeks against up to 52 weeks on average in an accelerator). In addition, pre-accelerators offer very structured programs with workshops, practice opportunities and meetings with mentors, while accelerators are less structured and provide more mentorship opportunities. Most pre-acceleration programs offer different educational activities, such as workshops or entrepreneurial talks with guest speakers (experienced entrepreneurs) and individual support, such as mentoring or peer-to-peer sessions (Merguei, 2022). This type of program usually culminates in a demo or pitch day when students present their progress, prototypes, or a minimum viable product. Merguei (2022) adds that these pre-accelerators are usually free of charge (no participation fee), have a quite intensive educational program structure (for example, regular weekly workshops or seminars), and the entry is less competitive compared with acceleration programs. At the same time, Bliemel et al. (2016) highlight that when designing pre-accelerators, it is vital to

pay special attention to the quality of the educational program and the cohort model. Merguei (2022, p. 6) concludes that if the entrepreneurship entry is considered a key performance indicator of a pre-accelerator, then the "combination of having many workshops, few talks, few hours spent with mentors, and high gender and expertise diversity lead to high entrepreneurial entry". That is why the quality of workshops and a diversified cohort are considered essential components of effective pre-accelerators.

To summarise, pre-accelerators, accelerators, and incubators are relatively new sources of entrepreneurial education. These programs first became common as private initiatives. They were then incorporated into universities' ecosystems to prepare entrepreneurial specialists in various disciplines, such as engineering and technology transfer, and to contribute to startup growth. However, these programs have yet to be thoroughly investigated. Pre-accelerators are complex programs that include many activities and experiences. Therefore, when designing an effective pre-accelerator, it is crucial to understand how programs affect particular skills and how it is essential to understand the role of specific elements in forming entrepreneurial skills and other important components of students' professional formation. With an understanding of the role of each element, it is possible to integrate specific components of entrepreneurial programs into the engineering curriculum for more effective training of entrepreneurial specialists (entrepreneurial engineers).

Entrepreneurship and Empathy

As mentioned above, various academic materials discuss the relationship between entrepreneurship and empathy. The next section provides examples of these works and discusses existing research investigating the phenomenon of empathy in an entrepreneurial context.

Many aspects determine the success of new startups. External factors depend on the socio-economic situation, environment, and internal factors, including the company culture, founder competencies, and team (e.g., Gemmell et al., 2012; Ezzedeen & Zikic, 2012). To create a successful enterprise, an entrepreneur must possess various competencies. For example, they must be able to identify opportunities (Shane, 2000; Chell, 2013), manage a business (Loué & Baronet, 2012), and have technical, interpersonal, and social skills, e.g., networking, communication, and collaboration (e.g., Hayton & Kelley, 2006; Baron & Tang, 2009; Chang & Rieple, 2013). In addition, entrepreneurs must be aware of existing approaches to developing and growing businesses, such as different human-centred approaches, including design-thinking, service design and interaction design methodologies (Gasson, 2003; Alkire et al., 2020). These approaches are primarily built on empathy and understanding the clients' perspectives, needs and feelings (e.g., New & Kimbell, 2013; Gasparini, 2015; Huq & Gilbert, 2017). Therefore, empathy is increasingly important in entrepreneurial activities.

In addition, empathy is considered an essential component of many critical entrepreneurial processes and stages, such as opportunity evaluation (Packard & Burnham, 2021), product design (Leonard & Rayport, 1997; Bairaktarova et al., 2016; Tang, 2018), creativity (Young, 2015), and dealing with competitors (Ghezzi, 2021). At the same time, when entrepreneurs empathise with potential customers, they can generate innovative solutions and design more innovative products (Leonard & Rayport, 1997). Empathy can help founders understand the emotions and hidden needs of current and potential customers, taking into consideration their circumstances, feelings, needs and pains. Based on this information, entrepreneurs can design and develop a product that genuinely addresses existing customer problems (Neck et al., 2019). Furthermore,

some academics consider empathy as a key factor influencing the success of a new venture (e.g., Chiles et al., 2010; McMullen, 2015) and an important component of an entrepreneurial mindset (Korte et al., 2018). Some other researchers even believe empathy should be one of the essential competencies when developing an entrepreneurial mindset in engineering students (Neumeyer & Santos, 2021). Considering the benefits of empathy and the fact that it is considered an essential component of many entrepreneurial processes, different academics and researchers have begun to pay special attention to its study and development.

Particular attention to empathy in entrepreneurship is confirmed by the many studies conducted to investigate it. In their literature review, Litvinov et al. (2023) identify eighteen academic papers from the Scopus and Web of Science databases that directly focus on the phenomenon of empathy in entrepreneurship (Table 5).

Table 5

The concept of empathy in entrepreneurial literature (Litvinov et al., 2023).

Year	Authors	Title	Journal	Approach
2015	McMullen, J. S.	Entrepreneurial judgement as empathic accuracy: A sequential decision-making approach to entrepreneurial action	Journal of Institutional Economics	Conceptual
2016	Prandelli, E., Pasquini, M., & Verona, G.	In user's shoes: An experimental design on the role of perspective-taking in discovering entrepreneurial opportunities	Journal of Business Venturing	Quantitative
2017	Ip, C. Y., Wu, S. C., Liu, H. C., & Liang, C	Revisiting the antecedents of social entrepreneurial intentions in Hong Kong	International Journal of Educational Psychology	Quantitative

2018	Bacq, S., & Alt, E	Feeling capable and valued: A prosocial perspective on the link between empathy and social entrepreneurial intentions	Journal of Business Venturing	Quantitative
2018	Khalid, S., & Sekiguchi, T.	The role of empathy in entrepreneurial opportunity recognition: An experimental study in Japan and Pakistan	Journal of Business Venturing Insights	Quantitative
2019	Ashraf, M. A.	Determinants of Islamic entrepreneurial intentions: an analysis using SEM	Journal of Islamic Marketing	Quantitative
2019	Urban, B., & Galawe, J.	The mediating effect of self-efficacy on the relationship between moral judgement, empathy, and social opportunity recognition in South Africa	International Journal of Entrepreneurial Behavior & Research	Quantitative
2019	Zakaria, M. N., Bahrein, A. B. A., Abdullah, A., & Rahim, R. M. A.	The determination of social entrepreneurial intention: a mediated mediation analysis	Academy of Entrepreneurship Journal	Quantitative
2019	Yu, T. L., & Wang, J. H.	Factors affecting social entrepreneurship intentions among agricultural university students in Taiwan	International Food and Agribusiness Management Review	Quantitative
2020	Le, T. T., Nguyen, T. N. Q., & Tran, Q. H. M.	When giving is good for encouraging social entrepreneurship	Australasian Marketing Journal (AMJ)	Quantitative
2020	Mohammadi, P., Kamarudin, S., & Omar, R.	Do Islamic Values Impact Social Entrepreneurial Intention of University Students in Malaysia? An Empirical Investigation into The Mediating Role of Empathy	International Journal of Economics & Management	Quantitative
2020	Lambrechts, W., Caniëls, M. C., Molderez, I., Venn, R., & Oorbeek, R.	Unravelling the Role of Empathy and Critical Life Events as Triggers for Social Entrepreneurship	Frontiers in Psychology	Qualitative
2020	Zhao, Y., Zhao, X., & Qin, Y.	Influence Mechanism of Dynamic Evolution of Chinese Entrepreneurs' Entrepreneurial Motivation on Performance—	Frontiers in Psychology	Qualitative

		The Role of Turning Points and Empathy		
2021	Usman, S., Masood, F., & Khan, M. A.	Impact of empathy, perceived social impact, social worth, and social network on the social entrepreneurial intention in socio-economic projects	Journal of Entrepreneurship in Emerging Economies.	Quantitative
2021	Packard, M. D., & Burnham, T. A.	Do we understand each other? Toward a simulated empathy theory for entrepreneurship	Journal of Business Venturing	Conceptual
2021	Younis, A., Xiaobao, P., Nadeem, M. A., Kanwal, S., Pitafi, A. H., Qiong, G., & Yuzhen, D.	Impact of positivity and empathy on social entrepreneurial intention: The moderating role of perceived social support	Journal of Public Affairs	Quantitative
2021	Tan, L. P., Pham, L. X., & Bui, T. T.	Personality traits and social entrepreneurial intention: the mediating effect of perceived desirability and perceived feasibility	The Journal of Entrepreneurship	Quantitative
2021	Keles Taysir, N., Asarkaya, C.	Personal Antecedents of Social Entrepreneurial Intention in Different Country Clusters and Fields	VOLUNTAS: International Journal of Voluntary and Nonprofit Organizations	Qualitative

In their review, Litvinov et al. (2023) conclude that empathy is commonly studied as part of specific processes or entrepreneurial characteristics, such as entrepreneurial intentions or opportunity recognition in the context of entrepreneurship. At the same time, they notice that empathy frequently occurs in the context of social entrepreneurship. In addition to discussing the focus and context of the study of empathy, the authors also provide an example of common definitions of empathy in entrepreneurship.

In the entrepreneurial literature, unlike in the engineering field (where there is a trend towards the formation of coherent empathy models), the approach toward empathy

research is more fragmented, primarily focusing on specific empathic components. This is seen in for example perspective-taking (Prandelli et al., 2016), empathic concern (Khalid & Sekiguchi, 2018) or empathic accuracy (McMullen, 2015) and their role in entrepreneurial education and venture creation process. For example, Mair and Noboa (2006) define empathy as an ability to perceive and share others' emotions, meaning that the focus is on the affective component. Coplan (2011, p. 44) defines empathy as a "complex imaginative process through which an observer simulates another person's situated psychological states while maintaining clear self– other differentiation." In this definition, the author focuses on the process of taking the perspective of others.

Considering the fragmented approach to defining entrepreneurial empathy in academic literature and the variability of definitions, there is a need to create an accepted definition and model of empathy that reflects the entrepreneurial context. Packard and Burnham (2021, p. 2) state that "we need an accepted theory of empathy. Unfortunately, while there are several extant theories of empathy (…), each defines ''empathy" somewhat differently, and none meets the requirements of modern entrepreneurship theory." Despite some differences between research focus and understanding the phenomenon of empathy in engineering and entrepreneurial fields, researchers, and academics in entrepreneurship and entrepreneurial education emphasise the importance of creating cohesive and accepted models of empathy that consider the contextual characteristics of practice.

There is a lack of papers investigating empathy teaching practices when it comes to components of entrepreneurial programs and courses focused on developing empathy in engineering students. Even though empathy is presented in the engineering curriculum, there is a lack of empirical research demonstrating the formation of

empathy using entrepreneurial programs and interventions. For example, Litvinov et al. (2020) review program curricula at a particular university (UTS). They state that many entrepreneurial subjects aimed at shaping entrepreneurial mindset in engineers include different empathy-related indicators, activities, experiences, and exercises. However, the authors add that despite indicators of empathy in the entrepreneurial subjects integrated into the engineering curriculum, educators, when choosing empathy-related activities, rely on popular methods rather than empirical data. Litvinov et al. (2021) also declare empathy could be formed as an accidental competence in engineering students due to participation in entrepreneurial programs such as accelerators. It is also still unclear how entrepreneurial activities influence the formation of an understanding of empathy among engineers and how specific elements of entrepreneurial programs contribute to its development in engineering students.

To summarise, contextual characteristics must be considered when teaching empathy to entrepreneurial engineers. In this study, the lived experience of empathy in engineering students within entrepreneurial programs (pre-accelerators) and specific elements of these programs that may foster this phenomenon will be explored. Before developing holistic empathy models for entrepreneurial engineers, it is essential to understand how engineering students with entrepreneurial experience understand and experience empathy and explore the processes of entrepreneurial practice that can help shape empathic tendencies in engineers. Täks et al. (2014) state that different engineering students' entrepreneurship experiences should be explored, focusing on clarifying how entrepreneurial competencies develop among engineering students to come up with effective educational models, practices and activities.

Conclusion

Empathy can be considered an inherent phenomenon to all engineering specialists (e.g., Strobel et al., 2013; Yeaman, 2020). Since the importance of empathy in various fields has been widely discussed, researchers, educators, and practitioners explore the opportunities and practices aimed to improve or ignite this phenomenon and offer different educational initiatives to foster empathy (e.g., Hess & Fila, 2016a, 2016b; Walther et al., 2016; Surma-aho et al., 2018; Wang et al., 2018; Levy, 2018; Walther et al., 2020).

In engineering education, it is also proposed to use different pedagogical approaches and activities to foster empathy among engineering students. This includes specific instructions in design-thinking. For example, different educational institutions such as Stanford School and the Institute of Design at Stanford (Institute of Design at Stanford, n.d.) encourage students to use empathy as part of the design-thinking process). This includes engaging engineering students in service-learning, activities focused on developing communication and collaborative skills, and ethics courses (Hess & Fila, 2016b). Transdisciplinary course models are also used to foster students' empathic abilities (Walther et al., 2012). However, despite the variety of approaches to teaching empathy and designing effective empathy development activities, educators and researchers should understand the role of empathy in different engineering processes and use empathy educational models and activities that are contextually relevant to practice. At the same time, it is essential to understand the nature and origin of the phenomenon of empathy and know the potential triggers that can foster it in engineering students (Brewer et al., 2017). According to Strobel et al. (2013) and Walther et al. (2017), this disregard for empathy occurs because of a lack of conceptual

frameworks and practical foundations of empathy integration into technical programs' curricula.

Along with the increasing interest in empathy research within the engineering field, academics and professional associations are emphasising the essential role of entrepreneurship in engineering (e.g., Rae & Melton, 2017; Shekhar & Huang-Saad, 2019; Huang-Saad et al., 2020). The increasing importance of entrepreneurship and entrepreneurial competencies for engineering practice led to the desire for *entrepreneurial engineers* who are focused on creating new ventures and can use entrepreneurial competencies in engineering practice. The typical way to form engineering entrepreneurs (developing entrepreneurial competencies in engineering students) is by integrating entrepreneurial subjects into the engineering curriculum. At the same time, entrepreneurial programs can be delivered by entrepreneurship innovation centres that offer engineers to participate in different entrepreneurial programs such as accelerators, incubators, or pre-accelerators. However, despite the variability of entrepreneurial educational intervention types, there is currently a lack of empirical models and frameworks that conceptualise an entrepreneurial engineer's profile and specific competencies, such as empathy. That is why, to design and deliver effective educational activities, it is important to understand the role of specific competencies in different processes and practices and create cohesive and agreed models that consider the contextual characteristics of entrepreneurial engineering practice.

Different studies have also emphasised understanding and assessing the role of entrepreneurial education in fostering and affecting students' empathy (Litvinov et al., 2020; Neumeyer & Santos, 2021). According to Bell-Huff and Morano (2017), the

simulation of experiences, real customers, and outcome-driven innovation can help foster empathy abilities in engineering project-based activities. Pellicane and Blaho (2015) also conclude that intensive entrepreneurial programs that involve real-life collaborations with different stakeholders positively affect the development of engineering students' empathy. However, it is unclear how the development process occurs and what other entrepreneurial program elements foster empathy in engineering students.

Considering the importance of empathy for entrepreneurial engineering, the fact that entrepreneurial education and entrepreneurship can foster empathy in engineering students, as well as the need for a cohesive understanding of the phenomenon of empathy taking into consideration the contextual characteristics of practice, this study will explore the experience of empathy in engineering students who take part in entrepreneurial programs such as pre-acceleration programs. The next chapter will present the research design to explain the choice of methodology, methods, research sites, and participants.

Chapter 3. Methodology

Introduction

This chapter provides an overview of the methodology applied and explains how the chosen methodological approach is used to address the research questions. Hermeneutic phenomenology is introduced, followed by an explanation of how this approach will assist in studying empathy in entrepreneurial pre-accelerators. The rationale for drawing upon hermeneutics phenomenology is discussed, and its methodological limitations are acknowledged. The chapter demonstrates how the chosen approach clarifies the characteristics, components, and essence of empathy. The research context is also described, focusing on the four entrepreneurial pre-acceleration programs whose participants were interviewed for this research. The selection criteria and recruitment process are explained, along with the descriptions of the chosen programs and interviewed participants. Finally, data collection and analysis procedures are described, including a discussion of how the methods applied effectively address the outlined research questions.

Research Aims and Questions

The literature review presented in Chapter Two demonstrates the necessity to consider the complexity of empathy, since existing research and understandings of empathy as used in engineering and entrepreneurial education do not reflect its complexity and multi-faceted characteristics. Forming a holistic understanding of this phenomenon in various contexts is essential, as the limited understanding and conceptualisation of empathy can make it much more challenging to incorporate it into the learning context. Transdisciplinary fields where empathy plays an essential role, like

entrepreneurial engineering, are especially vulnerable as empathy is commonly present in many entrepreneurial and engineering processes and activities.

In particular, it is important to note two challenges that influence existing research and teaching approaches of empathy that have formed the problem basis for this research. The first challenge is articulated by Adriaense et al. (2020, p. 63), which is the "conceptual and empirical elusiveness" of empathy. In this regard, when trying to study this phenomenon, researchers do not always pay special attention to the shapes and structure of the experience of empathy. They use definitions of empathy that are too broad (e.g., putting yourself in the shoes of others), or alternatively use fragmented approaches to explore its specific facets or dimensions. Fagiano (2016) states that empathy must be defined more broadly, considering historical and pluralistic conceptualisations of this phenomenon. At the same time, even though empathy is a multidimensional, dynamic and multiphase phenomenon, it is often considered narrowly. Therefore, to make models of empathy that may be used to give some practical recommendations on how to foster this phenomenon, it is important to form holistic understandings and concepts of empathy in various disciplines (Wiseman, 2007). There is a need to consider the complexity of empathy and understand all dimensions and phases, and so some authors propose reviewing the existing concepts of empathy and investigating the lived experience of those people who experience this phenomenon (e.g., Van Dijke et al., 2019; Swan, 2021).

The second challenge is the lack of understanding of the role of different contextual elements in shaping empathy within different processes or activities. Despite the importance of empathy in entrepreneurship and engineering fields and the widespread use of empathy-related activities and approaches in entrepreneurial

educational interventions, how these interventions contribute to the formation of empathy experiences is still being determined. At the same time, it is unclear how entrepreneurial context affects how engineering students describe and experience empathy. Since empathy involves a social dimension, it should be investigated in a natural setting to consider the complexities of human experience and the influence of contextual characteristics. Fagiano (2016, p. 35) adds that "different contexts within experience call for different conceptualisations and acts of empathy". At the same time, Slote (2010) states that empathy could be aroused in people "involuntarily" in certain circumstances. In this regard, to create practical developmental models of empathy in different contexts and disciplines, it is important to understand how people experience empathy and consider contextual characteristics and elements that can potentially prefigure prerequisites for manifesting this phenomenon in action.

Considering the problem associated with the "elusiveness" of empathy, the first aim in this study is to illuminate, highlight, and shape the forms of empathy in order to understand its elements, facets, dimensions and nature. This challenge requires conducting a more divergent approach since, when illuminating empathy, it is essential to be open to discovering new facets and characteristics of this phenomenon. However, it is important to remember that some phenomena may have a specific structure in certain contexts.

Therefore, the first aim of this study is: *to illuminate the engineering students' lived experience of empathy in entrepreneurial pre-acceleration programs* (Aim 1).

It is planned to obtain detailed descriptions of participants' empathic experiences (e.g., stories, entrepreneurial philosophy), considering their understanding of potential outcomes that empathy can bring, strategies and techniques used to empathise, and the

nature of this phenomenon. It is important to add that in parallel with the growing recognition of the role of empathy in engineering education and practice, there is increased attention from academics on the perceptions of empathy by students, educators and practitioners (Strobel et al., 2013; Hess & Fila, 2016a, 2016b; Hess et al., 2017b; Hess et al., 2019). Students' descriptions and perceptions of their lived experiences can help understand how they experience empathy, which will help explore its structure and shape.

As mentioned above, this study does not aim to propose a new clear definition of empathy. The goal is to identify some "silent" and "invisible" facets or elements of this phenomenon using a more innovative approach to researching empathy in entrepreneurial and engineering education contexts. Considering its complexity, this approach may pave the way to research that will conceptualise empathy.

Considering the first aim, which focuses on illuminating the experience of empathy within chosen contextual settings (entrepreneurial pre-acceleration programs), this study attempts to comprehend empathy through how students experience and describe it. In this situation, by focusing on how students experience empathy, an investigator can experience it with research participants and identify usually invisible elements.

Based on this aim, the following research question has been proposed: *How is empathy experienced by engineering students in pre-acceleration entrepreneurial programs? (RQ 1)*

To make specific learning design recommendations, it is essential to understand how certain elements of both learning and contextual processes affect the formation of engineering students' interpretations. The request to investigate the role of specific

learning practices and contextual elements in developing empathy within different educational contexts has been made in various studies (e.g., Strobel et al., 2013; Harwood et al., 2020).

Therefore, the second aim of this study is: *to understand what specific experiences of entrepreneurial processes shape engineering students' empathy (Aim 2).*

The plan here is to interpret the elements and experiences within pre-acceleration programs that shape the experience of empathy. Therefore, in this study, it is important to pay special attention to potential experiences that affect empathy and the environmental elements within which various experiences occur.

Based on this aim, the second research question has been proposed: *What are the experiences that shape empathy in pre-acceleration programs? (RQ 2)*

The first research question focuses on understanding empathy, which will be obtained through the analysis of how empathy is "lived" by engineering students. This second research question focuses on how engineering students make sense of the experiences that shape empathy. This study puts the sense-making process, and the way engineering students interpret experiences that shape the empathic experience at the centre of the analysis.

Considering these philosophical and methodological assumptions, the question "*How is empathy experienced by engineering students in pre-accelerator entrepreneurial programs*?" is part of a phenomenological inquiry. The focus is on understanding the experiences of the empathy phenomenon as a part of engineering students' learning and entrepreneurial experiences. That is why the research design focuses on illuminating the empathy experiences through "lived" accounts, allowing the

experience to emerge from context. The question "*What are the experiences that shape empathy in pre-acceleration programs*?" was developed to demonstrate the relationship between specific experiences within pre-acceleration programs and empathy, concentrating on how engineering students make sense of the experiences that lead to empathy manifestation. This question requires an approach that allows participants to share their experiences and make sense of and reflect on them. The phenomenological approach has therefore been chosen to address the above research questions, as this inquiry allows us to illuminate the engineering students' experience of empathy in detail and collect their descriptions to interpret the experiences that shape empathy in pre-acceleration programs.

Phenomenological Inquiry

Phenomenology is an umbrella term that includes several research approaches. Unlike positivism, the phenomenological approach sees the world as a subjective and dynamic reality. While the positivist paradigm is based on the assumption that reality can be objectively measured and separated from an individual, the phenomenological paradigm, on the contrary, is founded on the individual experiences of the explored phenomenon (Norlyk & Harder, 2010).

Phenomenological research originally came from psychology research focused on describing one's experience of being understood and their feelings about it (Husserl, 2012; Englander & Morley, 2021). Within the phenomenological research perspective, the researcher should strive to obtain a comprehensive description of an individual's lived experience and their thoughts, emotions and reflections about a phenomenon (e.g., Cohen et al., 2000; Ashworth, 2003; Lindseth & Norberg, 2004; Starks & Brown, 2007; Dangal & Joshi, 2020). Through detailed descriptions of experience, it becomes

possible to understand what meaning people attach to the described experience and then, at the analysis stage, to form the general meanings and essence of the experience shared by the studied group (Moustakas, 1994). At the same time, the researcher should not make assumptions about the phenomena before starting the research but first aim to understand it from the inside, and how the phenomena are embedded into context (Moran, 2002).

Edmund Husserl, the German mathematician, is considered a founder of phenomenology, later termed descriptive (or transcendental) phenomenology. Husserl rejected the objective observation of reality and insisted on the need to study how this reality is perceived and understood by people. Husserl's phenomenology aims to study people's living experiences, claiming that a researcher can avoid their own prejudices and reach "the core or essence through a state of pure consciousness" (Kafle, 2011, p. 186). Husserl's phenomenology considers the possibility of forming a bias-free view and suspending the researcher's opinion and subjectivity while collecting and analysing data using the "bracketing" technique (Giorgi, 2009).

Husserl's student, Martin Heidegger, challenged their teacher's approach arguing that the researcher cannot be free from subjectivity and one's personal experience when interpreting a phenomenon. An individual (researcher) also experiences the phenomenon through their background and understanding of reality. All aspects of a researcher's personality, including history, culture, and professional and educational background, shape the meanings of reality (Heidegger, 1962). Heidegger uses the term *lifeworld*, saying that "individuals' realities are invariably influenced by the world in which they live" (Lopez & Willis, 2004, p. 729). Their approach to

phenomenology is called hermeneutic or interpretive. Heidegger's tradition was further extended by Hans-Georg Gadamer and Paul Ricoeur (Thompson, 1983).

Although phenomenological philosophy is not limited to hermeneutic and transcendental approaches, these two research paradigms are the primary ones within phenomenology (Vagle, 2018). The Encyclopedia of Phenomenology identifies seven approaches to phenomenological research: transcendental, naturalistic, existential, generative historicist, genetic, hermeneutical, and realistic phenomenology (Embree et al., 1997). Phenomenological research has continued to develop and seek ways to overcome contradictions between the transcendental and hermeneutic approaches through blended approaches such as lifeworld research (Ashworth, 2003), and post-intentional phenomenology (Vagle, 2018).

For this research, hermeneutic phenomenology was chosen because the researcher follows the ontological assumption that "lived experience is an interpretive process situated in an individual's lifeworld" and considers that an observer cannot be bias-free (Neubauer et al., 2019, p. 92). Being part of the world means that a phenomenon can be understood by interpretive means. These ontological and epistemological assumptions underpin hermeneutic phenomenology.

Hermeneutic Phenomenology

Since there are several philosophical schools in phenomenology, justification of the chosen approach is vital for understanding how this study will be conducted and how the knowledge gained can be used (Lopez & Willis, 2004). This research employs Heidegger's hermeneutic (interpretative) phenomenology as a research inquiry. Hermeneutic phenomenology focuses on human lived experiences and the meaning-

making (sense-making) process of these experiences (Neubauer et al., 2019). It is used to shed some light, not on the subject itself, but on its meaning and how it is interpreted by people (Levinas, 1987; Holroyd, 2007).

Since this study explores empathy, which is partly emotional and subjective, the phenomenological perspective is considered appropriate for the conceptualisation of empathic experiences in engineering students within entrepreneurial programs. It is a research methodology "aimed at producing rich textual descriptions of the experiencing of selected phenomena in the lifeworld of individuals that are able to connect with the experience of all of us collectively" (Singh et al., 2019, p. 3). Hermeneutical phenomenology allows researchers to achieve a rich and in-depth investigation of a phenomenon without focusing on accuracy in favour of depth of understanding (Smith, 1997; Cohen et al., 2000). The focus is on direct experience and its trivial aspects, aiming to create a complete picture of understanding one's meanings and feelings (Wilson & Hutchinson, 1991).

Such in-depth understanding of all aspects of individuals' lived experiences can be achieved by obtaining their detailed stories about the experience, including context, description of other people involved at the moment, and individual's emotions, thoughts and perceptions. Understanding that an interviewee's background is also an integral part of this experience is essential. Researchers should always remember that individuals are the leading experts on the topic explored and primary sources of information (Koch, 1995). At the same time, hermeneutic phenomenology does not seek to reflect the absolute truth while allowing researchers to study individuals' subjective experiences and gain insights from them (Stephenson et al., 2018). This knowledge is precious at the initial stage of the topic study when there is no data on which to build hypotheses.

Since the empathy of engineering students within entrepreneurial pre-acceleration programs has yet to be explored and described in the literature, this study aims to shed light on this phenomenon and create prerequisites for further theorising.

Lived Experiences and Background

It is essential to discuss the concept of lived experience as, in phenomenological research, the phenomenon is being understood through exploring lived experiences and individual interpretations of these experiences. These lived experiences are not limited to a particular aspect of human life. A range of research demonstrates the exploration of lived experiences through phenomenology in a variety of domains, such as the postgraduate research sector (Pascal et al., 2011), teacher's experiences (Giles, 2008; De Gagne & Walters, 2010; Philipsen et al., 2019; Claflin, 2020), young people's experiences of using smartphones (Chan et al., 2015), nursing (Cheung, 2013; Porteous & Machin, 2018; Hostutler, 2018), curriculum design (Jedličková et al., 2021), parents of autistic children (Cashin, 2003), working-class students (Marquard, 2011), people who lost their siblings (Jartell, 2017), and living with conversion disorder (Auffray, 2017; Farsi et al., 2018).

Notably, every experience is "novel, emergent and filled with multiple, often conflicting, meanings and interpretations" (Denzin, 2001, p. 25). Therefore, phenomenological research is challenging because each person's experience is unique, subjective and depends on the individual's background (Ellis & Flaherty, 1992). Unlike transcendental phenomenology, hermeneutic phenomenology considers the individual's subjective experience and their interpretation of this experience through the prism of their background. That is why an individual's subjectivity, complexity, and uncertainty of the phenomenon are inherent in understanding lived experiences (Kuhl, 2000). The

researcher's experience also cannot be bracketed, and researchers must be aware of their own attitudes to the studied phenomenon. Instead of striving to completely exclude subjectivity in the interpretation of the described experience (which is not possible), the researcher should be attuned to the phenomenon. Van Manen states (2016) that a phenomenon can only be truly understood "from the inside" and by "actively doing it", but not through prior theorising.

The Rationale for Hermeneutic Phenomenology

There are several reasons for choosing hermeneutic phenomenology as a methodological foundation for this study. This research examined the empathic experiences of engineering students in the context of entrepreneurial pre-accelerator learning. The main research focus is on students' personal experiences, perspectives and interpretations of these experiences. Hermeneutic phenomenology makes it possible to study such individual experiences and uncover their hidden meanings (Laverty, 2003). Empathy is an internal process that takes place inside a person and depends on their attributes, values, background, and the person with whom they empathise. Hermeneutic phenomenology can allow a researcher to capture and interpret these internal processes (Reid et al., 2005).

Also, hermeneutic phenomenology allows making the lived experience of participants explicit for reflection as participants are encouraged to talk about their stories, reflect on them and interpret their feelings and thoughts (Rolfe et al., 2017). There is therefore an expectation to investigate and interpret the different experiences through their stories. Hermeneutic phenomenology encouraged me as a researcher to reflect on what participants tell me and explain their meanings and understandings of

their empathic experiences through this research project (Sharkey, 2001; Kafle, 2011), and to answer the "How" and "What" questions (Benner, 1994).

Hermeneutic phenomenology has been successfully implemented in education to illuminate a lived experience of a complex phenomenon and interpret its associated experiences. Zeivots (2015) used hermeneutic phenomenological inquiry to illuminate the lived experience of emotional highs in experiential learning and to interpret the triggers that lead to different emotional highs.

In addition, it is regarded as a research approach that "brings the researcher back to the humanity of those involved" (Stephenson et al., 2018, p. 267) and allows seeing the perspectives of an individual at the centre of the learning process. Hermeneutic phenomenology helps the researcher to understand particular interactions within the group and consider the ethical component if it is articulated by participants (Dangal & Joshi, 2020). It is also important to mention, as research on empathy within the entrepreneurial engineering field is under-represented in academic literature when choosing a methodology, that it was necessary to rely on existing research on empathy in other areas, such as medical education (e.g., Tavakol et al., 2012; Hooker, 2015), teaching (e.g., Numanee et al., 2020), and social work (e.g., Gerdes & Segal, 2011; Eriksson & Englander, 2017).

Limitations of Hermeneutic Phenomenology

The limitations of hermeneutic phenomenology also need to be considered in this study. The main limitation is understanding how to reliably interpret subjective information given by the study participants, and not distorting its true meanings (Plager, 1994). Some academics believe that since they explore the participant's intersubjective experience through their understanding of reality, the researcher constructs the reality

rather than interprets it (e.g., Cohen & Tripp-Reimer, 1988; Van Manen, 2016). It "translates" the participants' experiences into scientific understanding and knowledge while retaining their voices. In this regard, it is important to emphasise once again that in order for the participants' voices to be accurately heard, the researcher must be aware of the extent of their subjectivity and the influence of their own background on data analysis. Another similar criticism is that hermeneutic phenomenology does not convey the phenomenon itself but the interviewees' understanding of what is being studied (Ajjawi & Higgs, 2007).

It is important to mention also that hermeneutic phenomenological research does not allow the building of any hypotheses about potential research outcomes. Hypothesis building or attempts to predict results at the research design stage or during interviews contradicts the essence of hermeneutic phenomenology, which states that all interpretations, meanings and insights come only from interviewees who possess expert knowledge about the phenomenon (Crotty, 1998). Research knowledge arises from interactions between a researcher and a participant (Creswell & Poth, 2016). This aspect is believed to not limit the current research since empathy in entrepreneurial engineering has not been explored and described in the literature. Therefore, this research attempts to study empathy and individuals' empathic experiences from a baseline that will lay the foundation for further research.

Despite its shortcomings, hermeneutic phenomenology is an example of a methodology that can be actively used to understand the subjective living experiences of other people, in ways that other methods can barely allow.

Theoretical Assumptions

According to Lopez and Willis (2004), in the hermeneutic phenomenological approach, a theory can focus inquiry and help interpret a study's results. Therefore, this study, when designing, conducting research and interpreting results, was guided by the following theoretical assumptions:

Empathy is a Context-Specific Phenomenon

Empathy is a context-specific phenomenon of activation, and its nature depends on a particular situation or various contextual characteristics (Cohen & Strayer, 1996; Hoffman, 2000). This phenomenon is not static and, within the context of this research, is being shaped by both other experiences and elements of pre-acceleration programs (for example, environmental, educational, and social). Therefore, the research process and interpretation of the results relied on the fact that engineering students, when attending entrepreneurial programs, had the chance to interact with specific elements or experiences that influenced their experience and interpretation of empathy. This assumption is also related to the statements of other researchers, in that empathy can be facilitated under the influence of a variety of specific situations and materials (Davis, 1990; Walther et al., 2016).

Empathy is a Complex Phenomenon

Another assumption that guided this study and interpretation of the results is that empathy is considered a complex, multifaceted phenomenon (Walther et al., 2016), multi-phased (Kouprie & Visser, 2009), or multidimensional (Kaźmierczak et al., 2013). While researching and interpreting the results, the focus was thus placed on the participants' interpretations of the elements of empathy since, when describing their

own experience of empathy, the participants could rely on different constructs of this phenomenon.

Researcher Background and Positionality

Within the hermeneutic phenomenological research, the researcher's background is not bracketed and is assumed to influence the research process and its results (Laverty, 2003). The researcher interprets the participants' experiences, stories and interpretations through their own perspectives and understanding of the phenomenon. As a result, they become an active contributor to the research results. Therefore, explaining the background and positionality of the researcher is important for them to articulate and understand possible biases and the extent of subjectivity that the researcher is subject to, or is bringing to the research process (Moustakas, 1994; Van Manen, 2016). Although such reflection does not eliminate all biases, it acknowledges the researcher's perspective, and how it affects their understanding of the participant's experience and the phenomenon itself.

My interest in engineering and entrepreneurship was formed during ten years of my educational and professional experience. My roles as an undergraduate engineering student, a master's program in education student, a learning specialist and entrepreneur, have allowed me to gain a deep understanding of the various experiences of both engineers and entrepreneurs.

My first tertiary degree was in the field of Engineering. This experience allowed me to deeply understand and obtain first-hand experience with the educational processes of engineering students, the difficulties and challenges they face, and how they overcome them. Moreover, due to my knowledge of technical concepts and terms, I

could speak with many interviewees using specialised language when discussing technical aspects of their startups' feasibility. Also, I believe that being an engineering program graduate will lend credibility and authority in disseminating this study's results to engineering educators.

A master's degree in education (Learning and Leadership) was added to my educational background. This degree focused on innovative teaching practices and the theoretical foundations of different teaching and learning processes. It provided an understanding of the educational experiences of engineering students from a theoretical point of view and from the students' perspectives. This knowledge was extremely beneficial for knowing how social competencies develop and what affects this process.

During my PhD candidature, I tutored in the subjects "Entrepreneurship & Commercialisation" and "Design and Innovation Fundamentals" taught to undergraduate IT and engineering students. During these courses, students either aimed to improve an existing product or develop their own idea from the outset. As a result, I could see first-hand how engineering students go through their entrepreneurial journeys while I was interacting with them in class and during individual consultations. These conversations brought me even closer to students' experiences and the context of their work and study than being an engineering student myself.

How my Experience and Background Impacted This Research

My interest in every research domain (engineering, entrepreneurship, and empathy) has been developing throughout my life. Using the Breen's (2007) metaphor, I can consider myself an "insider researcher" as I explore the group to which I belong. This insider position has provided me with several advantages (Bonner & Tolhurst, 2002; Breen, 2007). First, I have a good understanding of the culture of the cohort in

which I study, so I can communicate with them naturally, discussing both the technical components and entrepreneurial activities in their startup products. Also, being an insider allowed me to build rapport with participants, as I shared my background at the beginning of the interview.

At the same time, it is vitally important to be aware of the shortcomings and limitations of my insider researcher position at all times, to avoid making any assumptions about participants due to my background and previous experience. I also needed to avoid creating the illusion of similarity, which would be contrary to the idea of hermeneutic phenomenological research (Delyser, 2001; Hewitt-Taylor, 2002).

Working on this thesis and reading diverse academic literature deepened my understanding of these topics and provided a crucial theoretical foundation for my experiences and views. Although during the entire PhD candidature, I reflected on and compared the experiences of the participants with my own experiences, the theoretical foundation of my research did not allow me to replace the participants' knowledge with my own position. So, this research attempts to reflect their voices and views. At the same time, I could relate to and appreciate many of their stories, and hopefully could understand them more deeply.

Research Context

This study includes participants from university-based pre-accelerators organised by Australian universities, so it is essential to explain why these programs were chosen for this study. Firstly, the geographic area of the study was limited to Australia, as the overall context is vital for understanding the phenomenon and the lived experiences of people. Although each participant's experience is unique, it occurred

within the same geographical, educational and social context, making it possible to find common context-based patterns in their experiences and provide some recommendations after the data analysis and discussion.

Further, it was important to determine which programs were eligible for the research. Since rolling out the National Innovation and Science Agenda in 2015 and supporting entrepreneurship ecosystems with AUD$23 million, there has been a significant increase in the number and variety of entrepreneurial training programs, including accelerators and pre-accelerators, incubators, co-working spaces, mentoring organisations, and angel organisations (Bliemel et al., 2016; Bliemel et al., 2018). In 2019, Australia had 172 acceleration programs across all states (Statista, 2020). The number of available supports has been increasing as well. For example, Victorian startup agency LaunchVic in its startup guide and toolkit for local government, offers nineteen types of support that can be implemented to grow entrepreneurs (LaunchVic, 2017).

This study focuses only on university-based pre-accelerator programs to ensure the homogeneity of the sample. Since acceleration programs can be organised and supported by various stakeholders, including commercial companies, startup agencies, and governments, it was decided not to include them as these programs have a different context. University programs differ in a highly selective cohort-based model, a higher involvement of the university in a startup's activities after the program's completion and interest in its growth and development (Bliemel et al., 2016). Also, it is important to consider that pre-accelerator cohorts are more homogeneous compared to other types of entrepreneurial programs, e.g., accelerators and incubators. While accelerator participants may be university graduates or professionals with diverse experience within

the field, a pre-accelerator cohort is mainly represented by university students with no or limited entrepreneurial experience. Since the current research focuses on engineering students, pre-accelerators are considered the most appropriate program to investigate.

Programs Included in this Study

Participants from four pre-acceleration programs were interviewed for this research. The pre-accelerators were the Peter Farrell Cup from the University of New South Wales (UNSW), the SPARK Ideation program from Deakin University, the Validate Program at the University of Queensland, and The Velocity Program at the University of Melbourne. All programs offer early-stage startup founders the necessary support, resources and guidance for turning their idea into a minimum viable product. These programs were chosen because the author was able to recruit participants of these programs (Programs summary is collated in Table 6).

Peter Farrell Cup

Peter Farrell Cup (https://unswfounders.com/peter-farrell-cup) is a structured program by the University of New South Wales offered annually. The program participation requirements are relatively low and are aimed at early-stage startup founders. Potential participants should have a business idea at the pre-revenue stage without significant investments. The program takes five weeks part-time when teams work on their ideas throughout five educational workshops on the following topics: customer discovery, prototyping, market and competition, business models, and pitching. In addition to educational sessions, participants regularly meet with mentors who provide individual support to help them develop their startups. Also, all entrepreneurs have access to Makerspace and the startup community, where they can

meet participants from previous Peter Farrell Cup cohorts or members of other UNSW entrepreneurial programs. At the end of the program, teams can present their startup at a pitch night and win a share of the $20K cash prize.

"Peter Farrell Cup (PFC) offers applicants the necessary tools, skills, guidance and support to take their ideas from that initial light bulb moment to test and pitch, and potentially launch a real business! The PFC builds up to a final pitch competition where participants get the opportunity to win a share of an incredible $20,000 cash prize pool, generously contributed by the Farrell Family Foundation, to help take their ideas to the next level" (University of New South Wales, n.d.).

Startup Ideation Program

The Startup Ideation Program (https://spark.deakin.edu.au/startup-ideation/) was offered by Deakin University within SPARK Deakin, an initiative to support new entrepreneurs. The program focuses on Deakin University students who have a business idea and would like to validate it and build their startup. The structured program takes nine weeks, and the team participates in weekly 3-hour workshops aiming to develop entrepreneurial skills and mindset. The workshops cover Design Thinking and Lean Startup methodologies, validation, prototyping, business model canvas, branding, marketing, and sales. In the end, teams can practise their pitches for the final Showcase. Additionally, participants have access to guest speakers and industry mentors for personalised feedback on their ideas and strategies. Also, they join the startup community of SPARK Deakin and have access to more experienced entrepreneurs from other programs.

"Startup Ideation is an unconventional Work Integrated Learning (WIL) program that allows Deakin University students to create their own startup with the

support of SPARK Deakin. Students work in teams or on their own to create a new product or service. Past participants have come out of the program with a live, revenue-generating product" (Deakin University, n.d.).

Ventures Validate Program

The Ventures Validate Program (https://ventures.uq.edu.au/programs/validate) is delivered as a part of Ventures, the entrepreneurial development initiative organised by the University of Queensland. The Validate program focuses on first-stage entrepreneurs to help them develop a product that solves problems and matches them with the right customers. This 10-week program is open to current students, employees and recent UQ graduates. It is important to mention that, unlike the Peter Farrell Cup, the program allows applications from individual entrepreneurs. During the program, participants are engaged in interactive educational sessions on various topics. They research their product and interact with potential customers to get feedback. Further, during the program, they work on designing a business model and building a Minimum Viable Product (MVP), developing branding and sales, and evaluating the product. The program includes support from mentors and pitch preparation for the final presentation. During the program's final week, ten teams present their products to a panel of judges to win a share of the $10k cash prize.

"Validate is designed to help you and your team develop a validated business model in an interactive learning space over a period of 10 weeks. In the workshops, you will focus on key skills and processes to enhance the likelihood of your startup's success" (University of Queensland, 2023).

The Velocity Program

The Velocity Program (https://www.themap.co/programs/velocity) is the part-time entrepreneurial program initiative provided by the Melbourne Accelerator Program, with the support of the University of Melbourne. However, this particular pre-accelerator is also supported by LaunchVic, a startup agency based in Victoria. Up to thirty-five resident teams in Victoria who will register their business in the state are invited to participate. Like other programs, the Velocity Program offers early-stage founders weekly workshops focusing on training in idea validation and market research, accountability, and connecting with customers. Apart from workshops, participants have mentors and support from the startup community through group meetings. At the program's end, ten startups can present their idea to the public.

"The Velocity program helps early-stage founders pressure test their startups - speeding up their discovery of first customers and pathway to product-market fit. Open to both for-profit and impact startups, it is important to us that both types of founders' influence and motivate each other to succeed in business and in impact." (The University of Melbourne, n. d.).

Table 6

Pre-acceleration programs included in this study.

Program	Selection	Duration	Mode	Workshops	Mentoring
Peter Farrell Cup	Pre-revenue stage; less than $3,000 of investments, if any; Team leader should be a current UNSW student	5 weeks	part-time	Yes, weekly	Yes
Startup Ideation Program	Being a current Deakin University student	9 weeks	part-time	Yes, weekly	Yes
Validate Program	Being a current UQ student, staff member or recent alumni	10 weeks	part-time	Yes, weekly	Yes
Velocity Program	Reside in Victoria; Register a business in Victoria	10 weeks	part-time	Yes, weekly	Yes

As described above, programs had a similar structure and duration which was between 5 and 10 weeks part-time with weekly workshops and mentoring opportunities.

Research Participants

Selection Criteria and Sample Size

Forming selection criteria for engaging research participants is one of the challenges in qualitative research. The focus and phenomenological approach used in this research has led to certain considerations for selection criteria. At the research design stage, several selection criteria were formulated:

- Criterion 1: an interviewee has experience participating in one of the selected programs (Peter Farrell Cup Program, Startup Ideation Program, Velocity Program, Validate Program) in 2021 or 2022.

- Criterion 2: an interviewee is an undergraduate or postgraduate student of an engineering program while participating in a pre-accelerator.

This research does not include participants who were undertaking postgraduate programs but had a gap between a bachelor's and a postgraduate program for more than a year. This decision was made because people typically had professional experience between courses, and their understanding of empathic experiences during the program may have been shaped not so much by the program but by their previous work experience.

Also, it was essential to determine the sample size. In the phenomenological research literature, there is no single answer about the correct number of participants required for a phenomenological study (Van Manen, 2016), although it is argued that it should be small (Bartholomew et al., 2021). Wertz (2005) states that sample size depends on the focus of the study and the research question. However, it is important to consider the participants' homogeneity or *unity of consciousness* (Giorgi, 2009). Participants should know experiencing or "living" the common phenomenon (e.g., Maxwell, 2012; Ritchie et al., 2013; Creswell & Poth, 2016). A number of researchers suggest a sample size of between 5 and 25 participants (e.g., Polkinghorne, 1989; Creswell & Poth, 2016). For example, Chance and Williams (2018), researching the lived experiences of Middle Eastern women who study engineering, interviewed 8 participants (engineering research), Appelin and Berterö (2004), studying the experiences of palliative care, interviewed 6 patients (healthcare research), while Zeivots (2015) interviewed 21 participants to investigate their experiences of emotional highs (education research). A systematic review of sample size in phenomenological studies (Bartholomew et al., 2021) indicated that the average sample size among

phenomenological studies is sixteen interviewees; however, many studies do not report the number of participants at all.

For this research, twenty students were interviewed. This number resulted from natural recruitment constraints, such as the limited number of programs selected for the study and the limited number of eligible participants who agreed to participate. This number of participants allows the researcher to obtain diverse descriptions of various experiences. It also allows the author to dive deep enough into each case without sacrificing the quality of data analysis; as always, there is a risk of being overwhelmed with a large sample.

After forming selection criteria and the sample size, the recruitment strategy was developed to engage relevant participants as they are another critical component of each research. A detailed description of the recruitment process was included in the ethics application, which was approved before commencing fieldwork (explained in more detail in the ethics and research data management section below).

Interviewees were selected through purposeful sampling to ensure a relatively homogeneous participant data source. Purposeful sampling is a common strategy for hermeneutic phenomenological research as it is critical to ensure that all research participants have relevant lived experiences, and will be able to generate valuable information and insights for further analysis (Llewellyn et al, 1999; Van Manen, 2016). As Laverty states (2003, p. 29), “The aim in participant selection in phenomenological and hermeneutic phenomenological research is to select participants who have lived experience that is the focus of the study, who are willing to talk about their experience, and who are diverse enough from one another to enhance possibilities of rich and unique stories of the particular experience”. Written confirmations were obtained from

the coordinators of each program, who gave their permission to involve program attendees in research interviews.

The recruitment occurred in three different ways: recruitment via direct contact, recruitment via program coordinators (or gatekeepers), and snowballing. The Participant Information Sheet and the Consent Form of this study are attached in Appendices A and B, and the participation invitation is provided in Appendix D. Program coordinators were contacted to seek their permission to interview program participants. The Participant Information Sheet with the Consent Form and the contact details were provided; therefore, individuals who expressed interest could contact the author and make further arrangements regarding their participation.

Another recruitment strategy involved direct contact with participants. Each program has an open-access website with a list of recent cohorts, including names of startups and founders and their contact details (LinkedIn page or email address). Therefore, this information allowed the researcher to reach out to potential participants, share some information about the research and invite them for an interview if they were interested. Direct contact was the most effective way of recruitment, and most participants were gained through direct contact. Finally, upon the interview completion, it was helpful to ask the interviewees to share information about this research study along with the researcher's contact details with other program participants who may be interested, creating a snowballing recruitment effect.

List of Participants

Twenty engineering students who participated in pre-accelerators in 2021 or 2022 (Table 7) were interviewed for this study. Most were university students at the time of participation in a pre-accelerator and at the time of the interview. However, five

graduated in 2020 and immediately enrolled in an entrepreneurship program at their university. Since there was no gap between their study and pre-accelerator enrolment, it was also possible to include them in the research sample. All had a bachelor's degree in engineering or were undergraduate students during the interview. Four of them were postgraduate students in engineering.

Five were females, and fifteen were males. This number was formed naturally without initial quotas on gender, but this proportion accurately reflects the current ratio of men and women present in accelerators and entrepreneurship programs in general. According to the Startup Muster Annual Report (2018), 31% of startups had one or more female founders. During the same year, LaunchVic (2018) reported that the entire startup ecosystem had 28% of female founders in Victoria. These figures align with a modern entrepreneur's global profile in the world's most startup-oriented economies. In 2016, the proportion of female founders in global entrepreneurial ecosystems was between nine and thirty per cent (Berger & Kuckertz, 2016).

Students worked on a wide variety of physical and software products. However, to preserve the participants' anonymity, the information about the nature of their startups was excluded from this thesis and transcripts.

Table 7

The list of participants interviewed for this study.

Participant	Gender	Years of study	Degree	University	Pre-accelerator
1	Female	2018 - 2021	Bachelor's degree, Mechatronics, Robotics, and Automation Engineering.	University of Melbourne	Velocity Program
		2022 - 2024	Master's degree, Mechatronics, Robotics, and Automation Engineering		
2	Male	2012 - 2018	Bachelor's degree, Industrial Engineering.	Instituto Nacional de México.	Velocity Program
		2019 - 2023 & 2021 - 2023	Master of Science, Solar Energy Engineering / Energy Systems (double degree)	University of Melbourne	
3	Male	2015 - 2022	Bachelor of Engineering - BE, Mechanical Engineering	UNSW	Peter Farrell Cup
4	Male	2017-2020	Bachelor of Engineering, Computer Science/Commerce	UNSW	Peter Farrell Cup
5	Male	2018-2022	Bachelor of Engineering and Commerce, Electrical Engineering	UNSW	Peter Farrell Cup
6	Male	2020 - 2021	Bachelor of Applied Science - Manufacturing Engineering.	The University of British Columbia.	Peter Farrell Cup
		2021 - 2024	Bachelor of Engineering - (Honours), Computer Engineering	UNSW	
7	Male	2018-2023	Bachelor of Engineering (Honours)/Bachelor of Science (Computer Science)	UNSW	Peter Farrell Cup
8	Male	2017-2020	Bachelor of Engineering - BE, Computer Science	UNSW	Peter Farrell Cup
9	Male	2012-2016	Bachelor of Technology (Mechanical Engineering).	National Institute of Technology Tiruchirappalli; RMIT University	Velocity Program
		2020-2021	Master's degree (Data Science)		

10	Male	2020 - 2024	Bachelor of Engineering - Computer Software Engineering	UNSW	Peter Farrell Cup
11	Female	2021 - 2023	Bachelor of Software Engineering (Honours)	Deakin University	SPARK Ideation Program
12	Male	2020 - 2023	Bachelor of Engineering - BE, Mechanical Engineering	UQ	Validate Program
13	Male	2021 - 2027	Bachelor of Advanced Science (Hons)/Bachelor of Engineering (Hons)	UNSW	Peter Farrell Cup
14	Male	2020 - 2026	Bachelor's degree, Commerce and Engineering (Hons), Finance, Mechatronics and Data Science	UQ	Validate Program
15	Female	2016 - 2020	B. Chemical Engineering/M. Biomedical Engineering, Engineering	UNSW	Peter Farrell Cup
16	Male	2020 - 2024	Bachelor of Engineering (Honours) - BE, Aerospace, Aeronautical and Astronautical Engineering	UQ	Validate Program
17	Male	2016 - 2020	Bachelor of Engineering and Master of Engineering (BE(Hons)/ME), Chemical and Environmental Engineering	UQ	Validate Program
18	Male	2016 - 2023	Bachelor of Engineering - BE, Mechanical and Aerospace Engineering	UQ	Validate Program
19	Female	2014 - 2018 2019 - 2022	Bachelor of Engineering, Electronics and Communication Engineering. Master of Engineering Science, Telecommunications Engineering	SRM University UNSW	Peter Farrell Cup
20	Female	2014 - 2018 2019 - 2022	Bachelor of Science (Honours), Computer Science. Doctor of Philosophy - PhD, Engineering	University of Colombo. University of Melbourne	Velocity Program

Ethics and Research Data Management

Prior to data collection, each project conducted by UTS researchers must receive approval from the UTS Research Ethics Committee and undergo a risk evaluation associated with participation in the study. The assessment is based on the National Statement on Ethical Conduct in Human Research, which guides human research in Australia. This study was rated low risk (the UTS HREC reference number: ETH22-7166).

It is also important to explain how the collected data was stored, as this is another vital aspect of any research project. A Research Data Management Plan (RDMP) must be created for each study at UTS to describe how the researcher stores the digital and physical data collected. The RDMP for this research is attached in Appendix C. All data is stored in the UTS-provided online collaboration space (OneDrive), and only the author and supervisors have access to the transcripts and audio recordings of the interviews. In addition, to provide confidentiality and maintain anonymity, the participants' names and their startups' names were removed from the transcripts.

Informed written consent is an essential part of a research project to confirm that participants are fully informed about the study's purposes and potential risks, and have voluntarily agreed to participate (Nijhawan et al., 2013). All information about this research and potential risks was explained in the Participant Information Sheet and the Consent Form, which was given to each participant prior to scheduling the interview to allow them to read it carefully, ask questions and assess their readiness to participate in the study. Both documents are attached in Appendices A and B of this thesis.

The nature of phenomenological research requires that the researcher should always remember that despite all efforts to identify potential risks while designing research and interview protocols, unpredictable risks may appear during the interview (Walker, 2007). Since phenomenology is interested in identifying lived experiences, some participants may consider the discussion topic a sensitive area of inquiry (Lee & Renzetti, 1990). To minimise potential risks, participants were informed about the research aims and the range of questions that would be asked. They were also clearly informed that all information they share would be presented in a generalised way in the final thesis without any potential for revealing their identity (Van Manen, 2014).

Data Collection

In all phenomenological research, understanding the participants' experiences occurs through interpreting their stories and reflecting on these experiences, thoughts, and emotions. Such data can be collected in a variety of ways that allow detailed descriptions to be obtained. These can be in different forms, as in for example differentiated interviews (Regts, 2018), reflective writings (Philipsen et al., 2019), and the researcher's reflexive journals (Auffray, 2017; Kendrick, 2018).

For this hermeneutic phenomenological study, semi-structured interviews were chosen as a data collection method. According to Magaldi and Berler (2020), semi-structured interviews typically focus on exploring the chosen topic and are led by an interview guide. This data collection method usually involves both open-ended and structured questions within a loose structure. This is commonly used across a range of qualitative research approaches (e.g., Larkin & Thompson, 2011; Zeivots, 2015; Jartell, 2017; Claflin, 2020). This method is quite flexible and allows the researcher to understand how the individual lives through and understands the experience that occurs

to them. Unlike a structured interview, which rigorously directs an interview, a semi-structured interview allows more freedom for the researcher. It allows an interviewee to lead the conversation more towards describing the lived experiences most relevant to them (Brinkmann, 2014).

The interview guide is attached in Appendix E. Questions were not intended to constrain conversations but rather guide them. The discussion began with general questions about the participant's opinions on the role of entrepreneurship to encourage them to speak and build rapport. The following questions were more like prompts intended to lead the participants to talk about the specific experiences and stories they experienced during the pre-acceleration program. The questions focus on the program's context, interactions with other people during the program, and empathy itself. The questions provided a short prompt, and then the participants could tell the experiences or stories they considered the most relevant.

As already mentioned, this study has two primary research aims: (1) to illuminate the experience of empathy and (2) to interpret the experiences and elements in pre-acceleration programs that may shape or prefigure empathy. Therefore, the following questions aim to collect engineering students' accounts and empathy descriptions that can help achieve Aim One and answer the first research question:

1. What does empathy mean to you? How would you define empathy?
2. What would you say if someone asks you what is going on in your mind when you empathise?
3. How do you empathise with others?
4. Describe your empathy experience during the program.

The following questions to collect data that can help achieve Aim Two and answer the second research question:

1. Tell me what empathic experiences you think may exist in a pre-accelerator.
2. Tell me about empathy that you had during the described experiences (e.g., decision-making, customer validation, opportunity recognition).
3. What role do empathic interactions play for an entrepreneur?
4. What positive or negative outcomes can empathy bring to both entrepreneurial activity and your professional career?
5. In what situations did you have the opportunity to use empathy?
6. What activities of the pre-accelerator encouraged you to use empathy?

The interviews were conducted one-on-one via Zoom using an official UTS Zoom student account. Online interviewing allowed both parties (researcher and interviewees) to avoid being physically present in the same room and eliminated concerns related to COVID-19. The fact that some participants lived in other cities also made it very challenging to conduct a face-to-face interview. Ultimately, the COVID-19 restrictions demonstrated that such meetings could effectively occur online, saving participants' time and probably providing a higher response rate. Also, the participants were in a more relaxed natural setting (e.g., at home or university), which is crucial for the research quality (e.g., Mertens, 2015; Van Manen, 2016). Since this study did not aim to capture non-verbal expressions, the online format was considered appropriate, and video recording was not required. All interviews were audio-recorded, transcribed and saved anonymously with an ID according to the RDMP. As an acknowledgment of the time spent during an interview, participants were compensated with $50 as an electronic gift voucher.

Data Analysis

Phenomenological data analysis should "highlight 'significant statements' that provide understanding and insight with regard to how participants experience the phenomenon" (Bloomberg & Volpe, 2018, p. 106). Being a flexible approach, phenomenological research does not have a strictly prescribed method of analysis (Van Manen, 2016), and researchers choose data analysis strategies based on their research purposes. A data analysis approach should allow them to grasp an "essence" description of participants' lived experiences (Moustakas, 1994). For example, Husserl's descriptive phenomenology is represented by several methods of analysis developed by Van Kaam, Colaizzi, Giorgi and Fischer that aim at describing the phenomenon from the point of view of the interviewee (e.g., Colaizzi, 1978; Giorgi, 1985; Valle, 1998). In hermeneutic phenomenology, there is also the freedom to choose the data analysis method depending on the study's goals. There are various methods, including but not limited to the hermeneutic cycle (Kafle, 2011; Hellman, 2016; Claflin, 2020; DeCicco-Jones, 2021), Ricoeur's theory of interpretation (Tan et al., 2009; Moland, 2022), thematic analysis (Carey-Pace, 2021), interpretive profiling (Oerther, 2020), interpretive writing (Giles, 2008), and many others.

This study incorporates the six stages data analysis method proposed by Ajjawi and Higgs (2007), which is built on previous methodological research derived from hermeneutic phenomenological perspectives (Titchen & McIntyre, 1993; Lincoln & Guba, 2000; Titchen, 2000; Edwards & Titchen, 2003). This approach allows for systematically identifying the lived experience interpretations of participants and analysing them with consideration of the researcher's lenses and background (Eakin, 2015; Bynum et al., 2019). Researchers do not set hypotheses or assumptions prior to

research but follow the participants' interpretations of their experiences, thoughts and emotions (Reid et al., 2005). The iterative process of this type of analysis encourages researchers to relate the research text to their own experiences and cross-check the interpretations with the original transcript and interpretations of the participants themselves (Ajjawi & Higgs, 2007).

This approach is due to its acknowledgement of the researcher's active role in the analysis process. Since this research explores participants' stories through the lens of the author's background, the iterative analysis process helps get closer to their worldview. However, the main criticisms of interpretative research are its subjectivity and lack of standardisation, which is why different researchers may generate different results after analysing the same data set. As a researcher, I was aware of this concern and aimed to ensure that I gave voice to the participants' experiences, not only expressed via my interpretations of their experiences. Participants were the only experts in their individualised experiences, thoughts and emotions, and my role as a researcher was to interpret their interpretations (Reid et al., 2005). In addition, this study follows the rigorous data analysis procedure that gave this research analysis the structure and standardisation, the transparency of results, and the interpretation process. The analytical procedure is described in Table 8.

Table 8

Data analysis stages implemented during this study.

Stage	Tasks
1. Immersion	• To transcribe the audio recording into text data sets • To complete the initial reading and interpretation
2. Understanding	• To identify first-order codes with NVivo software (participants' constructs)
3. Abstraction	• To identify second-order codes (researcher's constructs) • To combine second-order codes into sub-themes
4. Synthesis and theme development	• To combine sub-themes into themes • To compare themes
5. Illumination and illustration of phenomena	• To link themes to the academic literature • To construct stories based on themes
6. Integration and critique	• To receive feedback and critique from other researchers • To finalise interpretation and reporting

Note: adapted from (Ajjawi & Higgs, 2007).

During data analysis, I relied on the analysis procedure described by Ajjawi and Higgs (2007). The data analysis in this procedure includes six stages: immersion, understanding, abstraction, synthesis, illumination of phenomena, and critique.

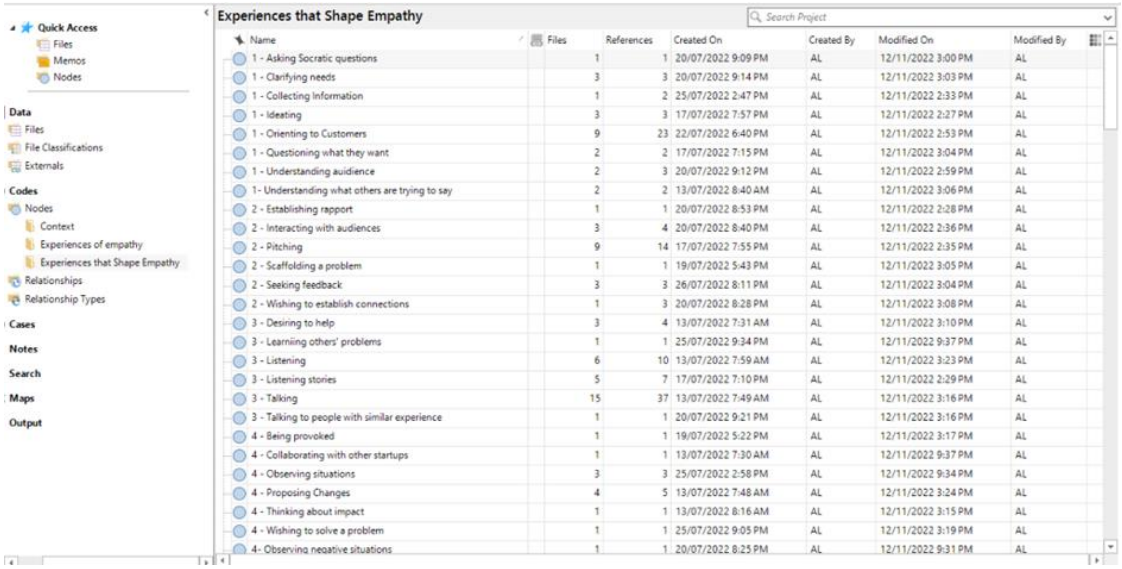
First, all audio recordings were transcribed into text documents. According to the RDMP, all transcripts were saved on UTS OneDrive. The analysis started with reading and re-reading the transcripts to immerse and dive into the context. Re-reading was essential as each reading provided additional insights and further understanding of participants' lived experiences. Throughout the transcripts, I left notes, which later on were supplemented and became more meaningful for theorising the data.

To analyse transcripts and create codes, I used the NVivo, a qualitative data analysis software. The access to this software was provided by UTS. Qualitative software is intended to improve the effectiveness of working with and storing large amounts of qualitative data. Nvivo also allows for comparison, review and combining different pieces of texts, including researchers' notes and comments, and facilitates the visual representation of information (Creswell & Poth, 2016; Jackson & Bazeley, 2019). In addition, such research software ensures the rigorous use of detailed documentation of the whole data analysis process (Jackson & Bazeley, 2019).

Within the first cycle of transcript analysis, I aimed to identify first-order constructs and capture participants' words and phrases when describing their empathy-related experiences or thoughts using an open-coding approach (see Figure 1). First-order constructs will be widely presented in the reporting section of this thesis to introduce readers to the initial wording used by participants and provide insights for this research. After that, I generated abstractions or second-order constructs based on the participants' constructs. Abstractions were developed through the researcher's reflection on the first-order constructs, including a review of participants' interpretations, considering my personal experience, and theoretical knowledge. Some abstractions were repeated throughout the analysis and grouped into themes and sub-themes.

Figure 1

Examples of first-order constructs for the category experiences that shape empathy.



Name	Files	References	Created On	Created By	Modified On	Modified By
1 - Asking Socratic questions	1	1	20/07/2022 9:09 PM	AL	12/11/2022 3:00 PM	AL
1 - Clarifying needs	3	3	20/07/2022 9:14 PM	AL	12/11/2022 3:03 PM	AL
1 - Collecting Information	1	2	25/07/2022 2:47 PM	AL	12/11/2022 2:33 PM	AL
1 - Ideating	3	3	17/07/2022 7:57 PM	AL	12/11/2022 2:27 PM	AL
1 - Orienting to Customers	9	23	22/07/2022 6:40 PM	AL	12/11/2022 2:53 PM	AL
1 - Questioning what they want	2	2	17/07/2022 7:15 PM	AL	12/11/2022 3:04 PM	AL
1 - Understanding auidience	2	3	20/07/2022 9:12 PM	AL	12/11/2022 2:59 PM	AL
1- Understanding what others are trying to say	2	2	13/07/2022 8:40 AM	AL	12/11/2022 3:06 PM	AL
2 - Establishing rapport	1	1	20/07/2022 8:53 PM	AL	12/11/2022 2:28 PM	AL
2 - Interacting with audiences	3	4	20/07/2022 8:40 PM	AL	12/11/2022 2:36 PM	AL
2 - Pitching	9	14	17/07/2022 7:55 PM	AL	12/11/2022 2:35 PM	AL
2 - Scaffolding a problem	1	1	19/07/2022 5:43 PM	AL	12/11/2022 3:05 PM	AL
2 - Seeking feedback	3	3	26/07/2022 8:11 PM	AL	12/11/2022 3:04 PM	AL
2 - Wishing to establish connections	1	3	20/07/2022 8:28 PM	AL	12/11/2022 3:08 PM	AL
3 - Desiring to help	3	4	13/07/2022 7:31 AM	AL	12/11/2022 3:10 PM	AL
3 - Learning others' problems	1	1	25/07/2022 9:34 PM	AL	12/11/2022 9:37 PM	AL
3 - Listening	6	10	13/07/2022 7:59 AM	AL	12/11/2022 3:23 PM	AL
3 - Listening stories	5	7	17/07/2022 7:10 PM	AL	12/11/2022 2:29 PM	AL
3 - Talking	15	37	13/07/2022 7:49 AM	AL	12/11/2022 3:16 PM	AL
3 - Talking to people with similar experience	1	1	20/07/2022 9:21 PM	AL	12/11/2022 3:16 PM	AL
4 - Being provoked	1	1	19/07/2022 5:22 PM	AL	12/11/2022 3:17 PM	AL
4 - Collaborating with other startups	1	1	13/07/2022 7:30 AM	AL	12/11/2022 9:37 PM	AL
4 - Observing situations	3	3	25/07/2022 2:58 PM	AL	12/11/2022 9:34 PM	AL
4 - Proposing Changes	4	5	13/07/2022 7:48 AM	AL	12/11/2022 3:24 PM	AL
4 - Thinking about impact	1	1	13/07/2022 8:16 AM	AL	12/11/2022 3:15 PM	AL
4 - Wishing to solve a problem	1	1	25/07/2022 9:05 PM	AL	12/11/2022 3:19 PM	AL
4- Observing negative situations	1	1	20/07/2022 8:25 PM	AL	12/11/2022 9:31 PM	AL

The data were analysed iteratively. I reviewed the first five transcripts, identified initial first-order constructs, and formed sub-themes. After forming the draft of sub-themes, I discussed my findings with supervisors and revised them according to their feedback. Then, I reviewed the other five transcripts. These iterations occurred during the whole data analysis process. Moreover, throughout combining the sub-themes and themes, I constantly rechecked the newly formed list by re-reading the transcripts, referring to first-order constructs to ensure that clustered themes did not contradict the data and participants' words.

Further, I worked on illuminating and illustrating the phenomena by linking my findings to the literature and theoretical knowledge in the entrepreneurial engineering field. Within this phase, I used various theoretical approaches when illuminating the empathy experience and interpreting the experiences that shape it. All definitions and theories used in the analysis are presented in the results section to demonstrate the logic behind choosing one or another topic name or subtopic. The process of writing the

discussion was also iterative. I repeatedly examined first-order constructs to ensure the faithfulness of the insights and constantly changed and adapted the proposed model. This approach aligns with academic recommendations on phenomenological research that includes the process of writing and rewriting as an essential stage of data analysis to ensure a complete and detailed understanding of the studied phenomenon (e.g., Cohen et al., 2000; Hellman, 2016; Van Manen, 2016)

The final step of the analysis, which involves critique and feedback from other researchers as well as final reporting, was not purely singled out as a separate stage. During the whole research process, I was constantly sharing research progress and insights with the aim of receiving feedback from peers, supervisors and academics. I had regular meetings with my supervisors, where they reviewed my second-order constructs to ensure that it was faithfully connected to first-order constructs. They also gave me feedback on synthesising sub-themes and themes and the model, which will be discussed later in this thesis. In addition to these discussions, I shared my findings and insights with a broader research audience. For example, I presented the research findings at local and international conferences. I also presented my research at university and faculty research events to receive feedback from other research students and university academics. Finally, the oral presentation for the Stage Three Candidature Assessment for doctoral researchers was successfully completed in March 2023 as a confirmation of readiness to submit.

Hermeneutic Circle

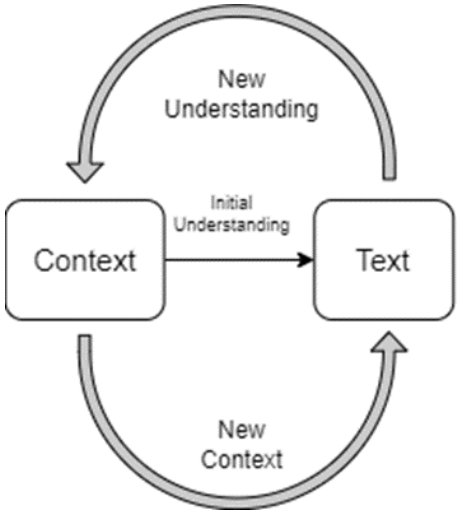
A hermeneutic circle (presented in Figure 2) is one of the components of the hermeneutic research approach and the chosen data analysis strategy. The hermeneutic circle is the iterative way of interpreting and understanding the phenomenon through

continuous iterations between data and context/knowledge. Bontekoe (1996) described the hermeneutic circle as a movement from part to whole. Whole means understanding the explored phenomenon, and parts mean the actual data or text transcripts of participant interviews. This circular approach allows the author to remain open to the participants' insightful interpretations of their experiences, and to illuminate the explored experiences within a particular context. Through this process, the author can link the text and participants' voices with the literature.

As a procedural matter, I constantly referred to the transcripts during the data analysis and while working on the results and the discussion sections. Initially, I outlined the general features of empathic experience that were quite broad and abstract. However, via deep diving into the descriptions and interpretations of the participants' experiences, I updated and reviewed the structure of the results and wording many times to truly reflect the words of the participants, not my own. Thus, this text was being developed gradually through "understanding emerging in the process of dialogue between the researcher and the text of the research", as described by Ajjawi and Higgs (2007, p. 623).

Figure 2

Hermeneutic Circle



Reflexivity

During the research process, it was vital to understand how my personal experiences, views and understanding of empathy influenced how I conducted interviews, analysed and interpreted the research results. As mentioned earlier, within hermeneutic phenomenological research, the researcher's background is not bracketed and is an equal contributor to the project. However, throughout the research journey, I made efforts to acknowledge my impact and perspective and present the participants' voices, not only my own.

Willig (2008) proposes two types of reflexivity: personal and epistemological. "Personal reflexivity involves reflecting upon the ways in which our own values, experiences, interests, beliefs, political commitments, wider aims in life and social identities have shaped the research" (Willig, 2008, p. 10). Epistemological reflexivity means that a researcher has "to reflect upon the assumptions (about the world, about knowledge) that we have made in the course of the research, and it helps us to think

about the implications of such assumptions for the research and its findings" (Willig, 2008, p. 10).

As a part of personal reflexivity, I must admit that my personal entrepreneurial experience and engineering degree could impact my understanding of the learning processes in these areas. I have gone through the same stages as an engineering student and working on my own startup. Moreover, I understood that a large amount of literature also impacted my understanding of empathy, which could be different from the participants' understanding. To acknowledge personal influence, I kept a reflective journal in which I recorded my thoughts and impressions immediately after each interview. This reflective journal helped me at the analysis stage when I constantly referred to it to distinguish the voices of the participants from my own interpretations.

Epistemological reflexivity includes reflection on how the chosen research approach and design "construct" the results. Initially, hermeneutic phenomenology was chosen as the research paradigm as it is open to collecting participants' interpretations without building hypotheses from the literature prior to the research. As a researcher, I wanted to explore empathy in the context of pre-accelerators, and this understanding has yet to be formed in the literature. Phenomenological research implies the possibility of interpreting complex constructs using various tools and approaches. Therefore, it is worth noting that when conducting research and reflecting on the results of the analysis, I constantly returned to the phenomenological literature and checked how complex constructs are interpreted in phenomenological research.

It is worth noting that the semi-structured interviews, chosen as the data collection method, provided many insights. Initially, I questioned whether semi-structured interviews would limit the participants during an interview or, on the

contrary, make them feel lost. However, this format was convenient for both parties. The participants had the opportunity to lead the interview in the direction where they had more experiences and more stories to share. From my perspective, I could direct the interview further if the interviewee struggled to answer or had nothing to add to their response.

While working on this thesis, I understood the sophistication of the interpretative paradigm and hermeneutic phenomenology approach. As mentioned earlier, the analysis was iterative, meaning that I reviewed several transcripts, generated first and second-order constructs, referred to my reflective journal, formed and revised sub-themes, and then discussed my findings with my supervisors and updated them again after these discussions. As a result, my topics became much deeper and more detailed. However, the development and deepening of topics are most clearly visible in comparison. Intermediate results were presented in the conference paper for the Frontiers in Education (FIE) 2022 Conference (Litvinov et al., 2022). This work was written following an intermediate analysis of eleven interviews and contained preliminary results and insights. Subsequently, and after submitting the final paper for this conference, I conducted nine more interviews and continued to work on data analysis, which resulted in much deeper and more detailed constructs. Therefore, up to the very end of the data collection and analysis phases, my themes were revised. Moreover, it resulted in the development of a model of empathy that will be discussed further in this thesis.

Research Quality and Rigour

Similar to other types of research, credibility is essential in phenomenological studies, as it ensures the value of the research. Multiple approaches and guidelines aim

to address this aspect and help authors evaluate the quality of their work (e.g., Lincoln & Guba, 1986; Beck et al., 1994; Elliott et al., 1999; Yardley, 2000). In this thesis, I relied on the Practical Guide for Doing Hermeneutic Phenomenological Research (Dibley et al., 2020) and suggestions developed by De Witt and Ploeg (2006) to assess the quality and rigour of my research.

Credibility means *the integrity of the study processes* demonstrating how the author produced research findings. This can be achieved through the transparent and detailed description of how data was collected and analysed and by using interviewees' words to demonstrate their experiences (Dibley et al., 2020). I thoroughly described data collection and analysis processes in the methodology section to address these criteria. Figure 1 describes how I developed themes and moved from transcripts to the synthesised themes and the model. In addition, I used participants' wording to support my statement in the results section.

Dependability refers to "the ability of a study designed in a particular way, with different participants who have had the same experience as those in the original study, to produce findings which resonate with the existing qualitative knowledge about that experience" (Dibley et al., 2020, p. 151). In addition, it should be clear how other researchers can repeat the study; therefore, dependability is connected with credibility as it also refers to a detailed description of the research procedures. Shenton (2004) also suggests including data samples and used techniques.

Confirmability refers to the ability "to demonstrate that findings emerge from the data and not purely from their own presuppositions" (Dibley et al., 2020, p. 152). As previously stated, the investigator cannot be free from their subjective experience and background when conducting hermeneutic phenomenological research. Therefore, it is

essential to acknowledge and reflect on potential bias rather than trying to eliminate it. To address these criteria, I deeply reflected on my background and how it relates to the research topic and participants before conducting interviews. In addition, I constantly reflected throughout the data analysis and referred to transcripts and verbatim quotes to ensure that the results present participants' interpretations of empathic experiences.

The last criterion is transferability, which refers to "the ability of the reader to take the findings of a qualitative study and, having assessed the similarities between the components of the research and the setting they plan to transfer findings to, make the judgement that the outcomes of the reported study are relevant to and applicable in their own setting" (Dibley et al., 2020, p. 153). Although phenomenological research does not aim to produce results that can be generalised to other individuals or contexts, authors can assist readers in understanding how the findings connect with the literature. The discussion section presents a detailed explanation of how insights from this research relate to the existing knowledge.

Besides credibility, dependability, confirmability and transferability, it is important to discuss rigour in hermeneutic phenomenological research. Firstly, a researcher should demonstrate a balance between the theory, the participants' voices, and their experiences of everyday life (De Witt & Ploeg, 2006). As mentioned, I was reflecting on my own experience in writing and meetings with my research supervisors. I also used participants' words throughout the thesis to support my statements and clarify the insights for the reader. Also, when interpreting the results of this study, I relied on existing theoretical frameworks and definitions of empathy elements and experiences that shape empathy. Chapter Four presents all the definitions used when interpreting this study's results. At the same time, various theoretical frameworks have

been used to explain and justify the connections between the identified facets of empathy. These explanations are presented in Chapter Five. In addition, De Witt and Ploeg (2006) mention the importance of actualisation and add that the research findings and insights should resonate with a reader and provide insights for future research and practice. The summary of strategies to ensure research quality and rigours is presented in Table 9.

Table 9

The summary of strategies implemented to address the quality and rigour of this study.

Criteria	Purpose	Strategies
Credibility	To demonstrate how the author produced research findings	Description of data collection procedures (Data Collection), including the attached interview guide (Appendix E). Description of data analysis procedure (Data Analysis). The use of quotes to support research findings in the results section (Research Fundings). Demonstrating examples of themes development (figure 1)
Dependability	To demonstrate how the findings fit into the existing knowledge	Description of data collection procedures (Data Collection), including the attached interview guide (Appendix E). Description of recruitment strategy (Research Participants). Interview transcripts are available upon request
Confirmability	To demonstrate that findings emerged from the participants' interpretations	Reflection on researcher's background and positionality (Researcher Background and Positionality). Reflection during the analysis stage (Reflection on the Findings). Weekly meetings with supervisors to discuss the research progress. Checking research results and themes with participants.
Transferability	To demonstrate how findings can be transferred to other contexts	Description of data collection procedures (Data Collection), including the attached interview guide (Appendix E). Description of data analysis procedure (Data Analysis). Discussion section that links findings with the literature (Discussion)
Rigour	To demonstrate "the expressions of rigour" (De Witt & Ploeg, 2006)	Reflection on researcher's background and positionality (Researcher Background and Positionality). Reflection during the analysis stage ((Reflection on the Findings). Weekly meetings with supervisors to discuss the research progress. Discussion section that links findings with the literature (Discussion).

The use of quotes to support research findings in the results section (Research Fundings)

When ensuring the rigour of this qualitative and interpretive research, Walther's et al. (2013) Quality Management process-oriented model was taken into account. This framework is designed to ensure that a researcher selects the methods, strategies and tools that contribute to research reliability and validation. Within this model, the authors outline two phases, which are “handling” and “making” the data that generate different results for two types of “clients” (internal that include study participants or a group of researchers involved in a study and external that include communities of researchers, other stakeholders and a team engaged in research). Different aspects of reaching quality in qualitative interpretative research are proposed. For example, within a theoretical validation, the following strategies were used, such as outlining clear selection criteria (Making the data) and asking participants to discuss not only the advantages of empathy but also its negative aspects to form a cohesive unbiased understanding of this phenomenon (Handling the Data). Within the processual validation, this research used iterative and comparative data handling strategies. At the same time, participants were not limited in their ability to describe various incidents within pre-accelerators to capture all potential manifestations of empathy. Regarding communicative and pragmatic validations, participants from different pre-acceleration programs were invited into this study to ensure that the generated knowledge represents the voices of a diverse entrepreneurial community. At the same time, feedback from various stakeholders was used when interpreting the results of this study. The researcher also followed up with several participants to review the interpretations and formed themes to ensure that the results of this study genuinely reflect the participants' understanding of empathy. Finally, the cross-checking techniques when generating

knowledge, checking transcripts by different researchers, training in qualitative research methods, and detailed and transparent research stages were conducted to ensure process reliability.

Methodological Limitations

The main methodological limitations of this study are related to the subjectivity and lack of standardisation originating from hermeneutic phenomenology. The researchers should recognise their subjectivity and attempt to eliminate bias towards their own knowledge, ultimately moving away from the participants' interpretations. As a result, the researcher "can decontextualise the interpretation from the original text" (Benner, 1994, p. 80). This risk is inherent in all human sciences. As Benner (1994, p. 80) also states, "hermeneutic phenomenology tries to address this risk by remaining close to the original text and by uncovering biases for scrutiny". Moreover, Westerlund (2014, p. 210) points out that "It is possible for every phenomenological concept and proposition drawn from genuine origins to degenerate when communicated as a statement". Dreyfus (1990) calls it "levelling to banality".

It is essential to acknowledge the limited generalisability of phenomenological research. Primarily, qualitative research aims to provide detailed descriptions and insights into the explored phenomenon and share participants' views and perspectives rather than trying to generalise findings (Dahlberg & McCaig, 2010). Therefore, the findings from this research are relevant for engineering students within entrepreneurial programs, and future research sections will uncover this aspect in more detail. Furthermore, hermeneutic phenomenology does not aim to predict future actions or events, and it is not a tool for planning the future, as individuals share their experiences that have already happened. Within the hermeneutic phenomenological study,

researchers can only understand the experience, how participants interpret these experiences, and their emotions, feelings and perceptions (Benner, 1994). To overcome the lack of standardisation, I aimed to strictly follow the described data collection procedures, constantly referring back to the original transcripts during data analysis to ensure that the original interpretations and meanings of the participants were preserved and not biased.

The final limitation relates to participant selection. As described in the Research participants' section, purposeful sampling allowed recruiting participants with relevant experience and educational background; however, students still need to self-select to participate in the study based on their preferences, interests and priorities. Therefore, there potentially can be a limitation related to the personal qualities of individuals, which have not been a focus of this research.

COVID-19 Impact

COVID-19-related restrictions imposed some limitations. Most pre-acceleration programs selected for this study were held online as gatherings were either banned or severely restricted, especially during 2021. Only the pre-accelerator attendees at the beginning of 2022 participated in some face-to-face activities. Thus, to some extent, the format of conducting pre-accelerators limited the frequency and format of interaction between participants and other stakeholders. Although this study did not aim to examine the differences between the impact of offline and online programs on the empathic experience of entrepreneurial engineers, the online format was taken into account. I acknowledge that participating in an online-only program may have affected how participants formed and interpreted their understanding of the empathy phenomenon;

however, the effects of this comparison was outside the scope of this study. For now, differences in program delivery modes can be seen as a limitation.

COVID restrictions also led to another limitation of this study in terms of the format of the interviews. Due to COVID restrictions and the fact that not all participants were in the city where I lived, the interviews were conducted online via Zoom. This online format has its own limitations, which are important to acknowledge. Obviously, online communication made establishing rapport with the participants harder, which was essential for this study because participants were asked to talk about the emotional moments of their entrepreneurial experience. To overcome this limitation, several questions about entrepreneurship, in general, were included in the interview guide to give the interviewee time to feel comfortable talking about their experiences and speak more openly with me. In addition, technical difficulties arose in some cases due to interruptions in the Internet connection, so either the interviewees or I had to repeat ourselves, which also distracted them from the process.

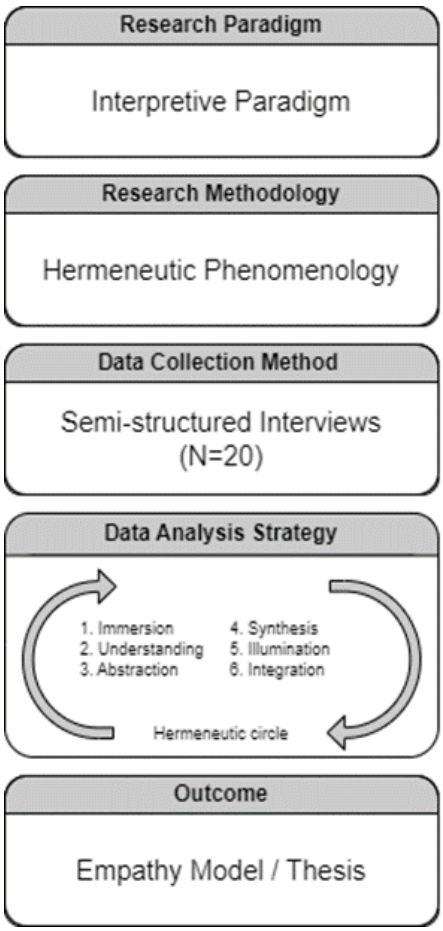
Conclusion

This chapter provided an overview of the methodological approach used in this study to answer research questions. Hermeneutic phenomenology is selected as an adequate and suitable methodology for this study. This methodological inquiry focuses on the lived experience and is concerned with the sense-making and interpreting processes of participants' experiences. This approach suits the research questions as RQ1 and RQ2 are concerned with the lived experience of empathy and engineering students' interpretations of experiences that shape empathy.

This chapter discussed the main aspects of research design, including detailed information about the research sites, the selection criteria and participants' backgrounds, and data collection and analysis methods. Figure 3 summarises the research design.

Figure 3

Research design



This research focuses on four Australian universities' pre-acceleration entrepreneurial programs, and twenty engineering students who participated in these programs were interviewed using an in-depth semi-structured interview method. Then, the collected data were analysed using Ajjawi and Higgs's (2007) six-stage data analysis approach to interpreting engineering students' lived experience of empathy and interpreting their sense-making process of the experiences that shape empathy. The next

chapter presents the findings related to both research questions. It focuses on the accounts that involve descriptions, metaphors and other indicators of the lived experience of twenty engineering students who experienced empathy during their entrepreneurial pre-acceleration programs.

Chapter 4. Research Findings

Introduction

This chapter presents the findings related to the two research questions presented as drivers for this research project. It focuses on the accounts that involve descriptions, metaphors, and other indicators of the lived experience of twenty engineering students who have confirmed an experience of empathy during entrepreneurial pre-acceleration programs. The chapter also demonstrates the situations (elements of entrepreneurial programs) when the engineering students experienced both types of experiences: (RQ 1) empathy experience and (RQ 2) experiences that shape their experiences of empathy. Overall, the lived empathy experiences of different participants have different lengths and complexity. This difference is due to the diversity of the participants' characteristics: their different educational and cultural backgrounds, professional and project experiences, values, and beliefs.

Lived experience can involve various descriptions (in-depth, complex) of a phenomenon as it is lived (Finlay, 2009). As recommended by Moustakas (1994), the findings can be supported by participants' verbatim quotes as it helps communicate their unique interpretations and experiences of empathy, and this is supported by discussion. This approach is widely used in phenomenological research (e.g., Giles, 2008; Philipsen et al., 2019; Claflin, 2020). Since every phenomenological study is the exploration of lived experiences and individual interpretations of these experiences, it is essential to draw upon participants' wording when building interpretations of the explored phenomenon. In addition, each sub-theme has participants' metaphors and relevant wording to highlight key aspects and meanings of each sub-theme for the reader.

This study presents a variety of descriptions of the experience of empathy, which in turn demonstrates the variability in the understanding of this phenomenon by the participants and the different levels of confidence in discussing it. The participants' reactions to questions about empathy were very diverse. In some instances, the first reaction was confusion; for some, it was the difficulty in describing it. For example, the first expression of Participant 15 was the phrase "Mm hard", followed by a long pause. In contrast, other participants did not have any problems describing their experiences of empathy. Some participants mentioned they did not have any prior knowledge about the definition of this phenomenon and, when describing the experience, relied on their own understanding of what it means. "I've been trying to figure out what it is. I've heard of that word a lot, but I don't really have a definition for it" (Participant 6). When describing their experience, other participants mentioned the definitions they learned during their previous study "I'm doing a course in Design, and we were talking a lot about empathy" (Participant 10).

Findings From RQ 1 (How is empathy experienced by engineering students in pre-acceleration entrepreneurial programs)

This section presents the research findings related to the first research question (How is empathy experienced by engineering students in pre-acceleration entrepreneurial programs?), which focuses on exploring the lived experience of engineering students' empathy during their participation in entrepreneurial pre-accelerators. Two themes emerged during the data analysis. Theme one is "Empathy as a multiphase process", and theme two is "Empathy as a phenomenon related to other attributes and orientations". Table 10 below presents a summary of these themes, sub-themes and related keywords and participants' metaphors.

Table 10

Themes and Sub-themes that address RQ 1

Themes	Sub-themes	Participants' metaphors and wording
Empathy as a multiphase process	Pause and be conscious	Pause, take a moment, be conscious.
	Immerse into the experiences of others	Put yourself in the shoes of others, understand other people's emotions/background/situations or feel what other people feel.
	Relate to one's own experience	Relate, own experience, what I would do.
	Synthesise	Build blocks, combination, sum-up.
	Simulate an experience	Simulate, how they might react, project onto different situations.
Empathy as a phenomenon related to other attributes and orientations	Open-mindedness	Be open, open mindset.
	Being able to let go own ideas	Take a step back, be comfortable making mistakes.
	Thinking about consequences	Be careful, be considerate about the impact.
	Reflexivity	Ask yourself, think in mind, reflection on something.
	Orientation to grow and learn	Learn from others, personal growth.
	Win-win orientation	Help each other, care about others to help yourself.
	Problem-solving orientation	Validate a problem, explore a problem, fix a problem, solve a problem.

Theme 1 - Empathy as a Multiphase Process

This section provides the results of data analysis and examples of students' accounts demonstrating that empathy in entrepreneurial programs can be experienced as a multiphase process. Five different phases were identified from the students' descriptions of their empathy experiences. These are:

(1) Pause and be conscious

(2) Immerse into the experiences of others

(3) Relate to one's own experience

(4) Synthesise

(5) Simulate experience

Each phase is discussed separately and supported with examples of students' descriptions of their empathy experiences to demonstrate the relationship between the phases. It is important to mention that most descriptions of empathy do not always include all five phases. So, each participant does necessarily experience all of them when empathising. These five phases represent a synthesis of descriptions obtained from the entire cohort.

Sub-theme 1 - Pause and be Conscious

Participants' metaphors and wording: pause, take a moment, be conscious.

When describing the experience of empathy in entrepreneurial pre-acceleration programs, some study participants outline the phase of attunement. In this study, I relied on the Kossak (2021, xi) definition of attunement, which is ''an immersion in the present moment and a sensory awareness of ourselves, others, and the space we inhabit". Within this phase, when empathising, engineering students try to make sense of the situation and contextual characteristics where these situations occur, and consciously think over the elements that shape the experience or perspectives of others. The students' attunement to the context in which they are and the people they plan to empathise with, characterises this phase. This phase involves two components which

are: pausing and being conscious. The wording used by engineering students to describe this notion is "*make pause*", "*take a moment*", and "*being conscious*".

An example where some participants pause or take a moment to attune to the context can be seen with Participant 2, who believes that to begin thinking through the situation or thinking about the experience of others, it is important to pause and make sense of what is happening. "I guess first you need to stop. You *make a pause.* You think about what the situation is and then think through it." (Participant 2).

Participant 17 also believes that it is essential to take a moment and adjust to the context and the person, as it helps to be completely immersed in the process of empathy and not to turn off their attention.

> I think one of the things I would do is *just take a moment.* I think it can be easy, sometimes, to invalidate someone and stop listening when someone is saying something. Whereas I think empathy is more about [immersion]. (Participant 17)

Some participants claim that the pause phase helps them attune to the context and the other person's world, helps control their initial reaction, and avoids jumping to conclusions about other people's situations and experiences. For example, Participant 8 emphasises that it is easy (assuming that the initial reaction does not reflect the experiences of others properly) to immediately draw a conclusion about the other person's experience, relying on the initial reaction and impression. "You have to *pause* and think before you empathise (…) it doesn't just happen naturally. Because the natural response is selfish, right? You're immediately thinking about how it makes you feel." (Participant 8). The pause allows participants not only to realise what is happening (attune to context and another person) but also to suppress the initial reaction to consciously going through the whole experience of others.

Participant 12 stresses “consciousness” as an element of the empathy experience, saying that [when empathising with the audience] “the way to do it *is to be conscious.* There is a wider audience, right? The chance that someone has a heart issue is quite high.” (Participant 12). So, it is important to attune to the contex, be fully aware of or sensitive to others’ experiences and situations and understand whom you are dealing with.

To summarise, during one of the phases of the experience of empathy, participants attune to the context and other people’s worlds through a pause or by taking a moment. Another element of this phase is a conscious immersion into this context, which is characterised by attention to the various aspects of a given context and other people’s experiences.

Sub-theme 2 - Immerse into the Experiences of Others (Other-oriented)

Participants’ metaphors and wording: put yourself in the shoes of others, understand other people’s emotions/background/situations, or feel what other people feel.

The next sub-theme emerging from the engineering students’ descriptions of their experience of empathy is an immersion into the experiences of others. This theme represents the other-oriented phase, when an empathiser immerses in the experience of others and tries to imagine/feel how other people think or feel in their circumstances. The first reaction of some engineering students was to provide a short and commonly used definition of empathy, which is “putting yourself in the shoes of others.”

For example, Participant 11, attempting to describe empathy, says that “*putting yourself in other people’s shoes* would be empathy.” Excerpts of other interviewees

support this idea describing empathy as "basically *putting yourself in somebody else's shoes*" (Participant 2) or "being able to *put yourself in the other person's shoes*" (Participant 4).

However, students gave more details about this phenomenon and the process of immersing themselves in the experiences of others after they were asked some clarifying questions and were encouraged to describe situations where they had a chance to experience empathy in more depth. They paid attention (focus) to different components and characteristics of the experiences of others when putting themselves in the shoes of others. For example, Participant 4 states that "empathy to me is being able *to put yourself in the other person's shoes* to understand the problem or situation."

Participant 14 mentions that when putting oneself in the shoes of others, try to understand the specific circumstances that other people come across.

> Not only *being able to put yourself in their shoes but understanding what circumstances they have come across in their life* that could make them feel sad or angry or disappointed or act in a certain way. (Participant 14)

Other participants put themselves (immersed) in the experiences of others and focus on other people's backgrounds (their world, where they are coming from), and their personal characteristics.

> Let's say empathy with customers is being able to see how they think and how they feel from their point of view. (…) let's say, understanding where they might *come from and analysing things like their background*, education level, how they were raised and things like that. (Participant 4)

> You know, to put yourself in someone else's shoes, but trying to understand, where *they are coming from,* their world, core experience, their situation, what that means to them. (Participant 18)

Some participants explained that when putting themselves in the shoes of others, they try to feel what other people feel, focusing more on their emotions. Participant 9 believes that they are "putting themselves in the shoes of others to feel more what the *other person felt*." Participant 2 added that this process of immersing is not only about understanding the experiences of others but also about feeling other people's emotions:

> It's basically putting yourself in somebody else's shoes. Try to feel it when it comes to emotions and try to understand it when it comes to incidents. Not only feel those emotions but try to understand what they're going through. (Participant 2)

Some engineering students, in the context of entrepreneurial pre-acceleration programs, also describe the experience of empathy as putting themselves in the shoes of others and mention that they are trying to do both things: understand others' situations and understand what other people feel. For example, Participants 16 and 10 use "understanding" when referring to feelings and emotions. For Participant 16 empathy is "being able to *put yourself in someone else's shoes, understanding what someone else is feeling and what they're going through*" (Participant 16), while Participant 10 reports when describing empathy that "the best thing would be to try and *put yourself into their shoes and understand how they think about a situation*. Being able to understand what they feel, try to understand what they're feeling at the time."

Participants also try to understand what led the person (prerequisites) to the behaviour/reaction they experienced or are experiencing at the moment, and the context around them. They say, “it’s essential to understand each other. So, yesterday, she was going through some stress and translated it into a reaction or a way to act. *And so, we try to understand what’s going on and what makes this happen*” (Participant 2) and describe what they do and think to understand another person’s context:

> I’ll talk you through how I relate when talking to others. So, her house was almost burnt down by bushfires. Her neighbours all lost their houses. It’s a very traumatic experience for her family. We came in just wanting to interview her to get a few more ideas about what had happened and how we might be able to make technology to fix the problem or maybe make it not as severe in the future. So, the first thing I needed was a step in to understand the *context* in which this other person was operating (Participant 5).

For many participants, one of the phases of the empathy process is an other-oriented immersion into experiences that aims to understand other people's situations, backgrounds, and feelings, or feel what others feel. When immersing in the experiences of others, participants focus on different indicators and aspects of another person, such as contextual characteristics, prerequisites, or people’s backgrounds. Moreover, immersion occurs in the cognitive and affective dimensions as participants focus on thoughts and feelings.

Sub-theme 3 - Relate to One’s own Experience (Self-oriented)

Participants’ metaphors and wording: relate, own experience, what I would do.

The third sub-theme is “relate to one’s own experience”. This sub-theme demonstrates the self-oriented process, which focuses on relating the experiences of others to their own experiences or perspectives. The phase of relating to one’s own experience can occur in two different ways. Either by comparing it with the real past or existing situation or one’s own experience, or by “Imagining” how/what I would feel/act/think if I were in this situation/context, or another person.

Some participants related others’ experiences to their own experiences by recalling similar experiences they had in the past. Their previous experiences, memories, feelings, and emotions had been triggered in this case. Participant 2 mentioned that when they came across something unknown when empathising, they tried to recall their previous experience to make sense of these new experiences when interacting with others.

> For me, empathy it’s something that is unknown and that I am trying to understand first. And if it’s something that is *known to me, that I’ve experienced* similar things to that before, it’s basically that I understand that particular situation. (Participant 2)

When empathising with others, some engineering students imagine how they would behave/feel or go through a particular situation, considering their own experience, knowledge, and feelings. Some students achieve it by asking themselves, “How/what would I do ….” Participant 15 describes the experience of empathising with others as “How would I approach that” saying “*I think that in terms of empathy, that’s probably asking yourself the question of* ***how I would approach that****?*”

Participant 1 attempts to feel what the other person is feeling by asking, "How would I be feeling in that situation?” while the other person is telling their story.

> Imagining what it would be from another person's perspective. But all I do is just think about *how I would be feeling in that situation*. I think about if someone's telling a story about what they've been through, I imagine myself going through that same situation. And imagine what I would feel. (Participant 1)

Participant 2 also asks a series of questions, for example, "imagine that *you are going through the same thing.* How do you think you would react? How do you think this would affect you? How would you try to solve it within yourself?". These questions are about potential reactions to the same situation and its impact, which activates the imagination process. Participant 4 emphasises that understanding the experience of others relies on one's own experience (perspective) since assumptions about missing elements of the experience of others (for example, their reactions towards something) are made based on one's own experience.

> I think empathy, in some ways, is understanding how one person reacts towards something. We make certain assumptions that *if they've gone through the same things as we have*, they must react the same way that we have. Also, at times, conversely, if perhaps they're from a different background, they might react very differently to this situation. But *we try to model it based on people and experiences that we've gone through ourselves*. (Participant 4)

To summarise, this sub-theme represents the self-oriented process/phase when engineering students relate to other people's experiences by imagining themselves in the context/situation in which other people are placed, or the activation of one's own related experiences.

Sub-theme 4 - Synthesise

Participants' metaphors and wording: build blocks, combination, sum-up.

This next sub-theme demonstrates how participants synthesise their own experience and the experience of others by forming combined mental models (their own experience/perspective combined with the experiences/perspectives of others). During one of the phases, participants immerse themselves in the experiences of others and then relate these experiences to their own perspectives. During the synthesis phase, participants combine both types of experiences to make sense of the situation and form a fuller understanding of the experiences of others through their own experiences. Participants build mental models by "adding blocks" or "filling the gaps" (missing information) from the experience of others with blocks of one's own experience or adding new layers to the experience of others. In this case, participants form a new combined experience that may differ from the genuine experience of others, since the missing elements of the experiences of others can be filled with elements of one's own experience.

Participant 18, when empathising, firstly immerses in others' perspectives and compares them to their own. Then, they use the metaphor of "building blocks" to demonstrate that they continue to ask themselves a series of questions to make sense of the experiences of others. At the same time, the participant acknowledges the impossibility of adequately recreating (copying) other people's experiences due to the impossibility of understanding and identifying all the elements of the experiences of others.

> I am trying to understand the ideas from their perspective. I am trying to do this to understand a similar context (compared to mine). Then I can start to build a

> picture (…) start to *build almost blocks* (…) you start with "this is the situation, how they're feeling about it, and there is the how and the why. And so that's what I'm trying to empathise with, why that's the problem they think. It's not so much what the problem is but what the core feelings are about it. How and why those feelings are in place. Our past experience, Our past understandings, and our own worldview as a whole. So, trying to dig around, but there is no way of understanding exactly what others experience (…). Trying to empathise is like when you build a picture with the whole. This is the situation; you're trying to draw the bigger picture with various bits and pieces. (Participant 18)

Some participants describe the synthesis phase as a sum or combination of other people's experiences and their own experiences. For example, Participant 16 views empathy "as not only a good way of interacting with other people but being able to *add other people's experiences to your own***.** So, you become *a sum of many people* in the long run." Participant 4 highlights that they are adding different layers to the experiences of others when empathising with them. The participant notes that each layer was viewed through the lens of subjectivity, which in turn adds their own interpretations to others' experiences (pieces of experience) when making sense of certain elements of these experiences. For example, Participant 4 states that personal background plays an important role in understanding and interpreting the personality of other people.

> Empathy is like building an understanding of the other person, and you can just keep *adding layers* to it. You keep adding things that you can see. For example, personality. That could be one factor, for example, culture, as we mentioned previously, it could be another facet. How they were raised, and where they were

> born. We add more layers, it becomes a deeper level of empathy with another person (…) but the interpretation of personality. I'd say it's very subjective. Personally, I have to say there is an element of the subconscious, habits that guide how I empathise with people and understand their characteristics. (Participant 4)

In conclusion, this sub-theme is characterised by synthesising one's own experience and the experience of others. In this situation, participants form new combined experiences (mental models) by "building blocks" or "adding layers" of the experiences of others to their own experiences. However, this new experience may not be the same as the experience of other people with whom they have empathised. This combined experience may differ from the genuine experience of other people due to the impossibility of fully understanding and identifying all the elements of the experiences of others.

Sub-theme 5 - Simulate Experience (Other-oriented)

Participants' metaphors and wording: simulate, how they might react, project onto different situations.

The next sub-theme is "simulating experience". Within this phase, the participants simulate the synthesised experience by projecting it onto a wider group of people or attempt to simulate this synthesised experience in other conditions. This phase is other-oriented, as participants try to predict the behaviour or reactions of various groups of people (others). In this regard, two parallel processes may take place in this phase: the projection of the combined experience in a broader group of people, and the simulation of this experience in different conditions and situations.

Participant 1, in describing the experience of empathy, mentioned that the projection occurred through building an abstract character (combined experience) saying “Once again, think about how the character would be feeling. You’re always going to *project* your own understanding and your own perspectives onto *different situations.*” Then, there is a simulation phase of this character's experience in various conditions.

Participants may use synthesised experiences to simulate the potential reaction of customers to the product. For example, Participant 4 uses empathy to predict (simulate) the reaction of the target audience (customers) to the product in various situations. The participant stresses that it is important to understand the experience or perspective of others to simulate a response, and also that personal interpretation of other people’s characteristics (for example, personality) might affect the simulation results.

> Empathy involves trying to examine what they might feel or *how they might react* towards a certain particular situation. Depends on how you apply empathy. Whether it be in relationships like “how might this person react to what I say or what I do?” or it can also relate to building products. For example, how might this person find this useful? Or how might they react to the product characteristics? Because you make assumptions about how they might react based on what you think about their personality or things based on factors like culture, religion. And then, based on your understanding of that, you try to model your understanding of how they might react towards a particular situation. (Participant 4)

Some participants also highlight that empathy could be used to simulate the behaviour of potential customers. Participant 10 thinks empathy can be helpful to understand "*how they would interact* with our product and try to understand how they feel at the time", while Participant 11 found themselves "thinking about the customers and people that *would actually be using it (product)*."

To summarise, within this phase, participants describe one of the phases of empathy as the projection of their understanding of other people's perspectives onto larger groups of people, and the simulation of their experience in various situations to understand their reactions (e.g., to the product or feelings associated with this product).

Examples of Students' Excerpts Demonstrating the Multiphase Nature of the Process of Empathy

Five phases of empathy emerged from engineering students' descriptions of their experience of empathy. Many participants did not outline (mention) all five phases in their descriptions of their empathy experiences, and they did not directly use language related to processivity. It also cannot be concluded that engineering students experience empathy in the order (sequence) shown above. However, it is common that several phases of the empathy process occur in the excerpts of many participants. Below are examples of excerpts demonstrating several phases in the students' descriptions of empathy.

For example, Participant 2, when describing the experience of empathy, mentions three phases, which are immersing into experiences of others (putting oneself in the situation of others), relating to their own experience (recalling the experience that was experienced in the past), and the synthesising phase of adding different layers:

> I don't know if this makes sense, but it's trying to understand other people's emotions or the way they feel or the way they cope with their experiences and their challenges. For me, empathy it's something that is unknown and that I am trying to understand first, and if it's something that is known to me, that I've experienced similar things to that before, it's basically just that I understand that particular situation. I guess *putting myself in this situation* (that other person's experience) of years behind an idea and trying to implement it (…) Then, since *I already have experienced* or recorded data within my brain about that, then I just put that *layer* (…) because I know they are experiencing this particular situation. But if I don't feel like I have experienced that situation before, it's basically just trying to simulate how that would be in my personal experience. (Participant 2)

Participant 8 mentions phases that could be related to three sub-themes. They mention phases such as pausing, understanding what they are coming from and their history (immersing into the experience of others), and asking themselves the question: how would I feel if this happened to me? (Relating to their own experience). Also, in this description of empathy, moments of synthesis could be distinguished when the participant compared their understanding of characteristics and elements of others' experiences to their own experience by focusing on moments that conflict with their understanding and experience.

> You have to *pause* and think before you empathise to make it comfortable for the other person to open up (…) [Then] Try to understand *where they're coming from, what their history is, and how they might have gotten to that conclusion* (…) [Then] *put yourself in somebody else's shoes* and try to

> understand another perspective that *conflicts* with what you believe(…) to put it is just *how would I feel if this happened to me?* **(**Participant 8**)**

Participant 13 provides comments that can be interpreted and related to four phases: immersing into the experiences of others by listening to what others say, seeing how they react and asking different questions, relating to their own experiences by "figuring out something in own life that is on the same emotional magnitude, synthesising by "placing pieces of puzzles together", and then using this synthesised experience to simulate it in relation to some specific problems.

> It is a slight framework that I take when empathising. The first thing for me is *hearing what their situation is* (…), and after gathering that and seeing *how they react while saying it*, because some people may say, I went to school, for example, with this kid whose father died in our last year of schooling. He got diagnosed with a very aggressive form of cancer, and he was told he had three weeks to live. And when this kid told everyone, he laughed about it; he was like, you know, my dad just died, which was very odd because you would not expect that when someone so close to you has just passed away. But I think hearing the way that they describe it says a lot about their personality and how they themselves are dealing with their emotions. And so, the next step for me would be to try and *figure out something in my life that* is on the same emotional magnitude. And from that, try and *place all of those puzzles, pieces of the puzzle together*, how they are feeling, how I would feel, how they are reacting, maybe why they're reacting that way, and then how I can respond to the best suit, how they're feeling at the moment (…) and then *empathise with a new set of*

> *problems* and try and think if we were in their shoes trying to solve a specific problem. (Participant 13)

Participant 13 comments on the critical role of two phases in the experience of empathy for forming a more detailed understanding of the situation of others. These are immersing themselves in the experience of others (Immerse into the experiences of others) and seeing the experiences of others through their own perspective (Relate to one's own experience).

> I feel it would not be as useful if I understood their situation. Because a part of empathy, I believe, is not just understanding the situation *but being able to put yourself in their shoes to feel their situation* (through your own perspective) as well. And so, if I were to collect their data, then I'd be like: 'You're sad.' But seeing that they're sad and saying, 'Oh, I would also be in such grievances *if this happens to me*.' Then I can respond much better as *if I have gone through the same thing with them* figuratively, of course. (Participant 13)

To summarise, this theme demonstrates empathy as a process that involves several phases. Each phase has its purpose and outcomes, such as (1) attuning to people and context (pause and be present), (2) understanding and feeling over others' perspectives (immersing into the experience of others), (3) trying to understand how one's own experience can relate to the experience of others (relating to own experience), (4) building synthesised experience to make sense of the situation (perspectives of others) and build the whole picture, and then (5) simulating this experience in other circumstances and projecting this synthesised experience to a wider group of people to understand their potential reactions and behaviours.

Theme 2 - Empathy as a Phenomenon Related to Other Attributes and Orientations

When describing the experience of empathy, many participants made connections to other qualities and orientations. Across different accounts, the following personal attributes and orientations have been identified. They are:

(1) open-mindedness

(2) being able to take a step back

(3) thinking about consequences

(4) reflexivity

(5) orientation to grow and learn

(6) win-win orientation

(7) problem-solving orientations

In this study, 'orientation' is defined as the state of being oriented toward achieving specific outcomes such as growing and learning, as well as helping yourself and helping others (Walther et al., 2016), while attributes are defined as a quality or characteristic of someone that is "exerting a directive or a dynamic influence upon the individual's response to all objects and situations to which it is related" (Kapur, 2018, p. 3). The attributes affect what a person can do, their behaviour, actions, and processes, such as being able to recognise and accept the experiences of others, think about consequences, and question and evaluate the experiences of others. These attributes and

orientations act as the foundation that supports and underpins the process of empathy (may be part of the empathic experience), or 'work together' with empathy.

Sub-theme 1 - Attribute: Open-mindedness

Participants' metaphors and wording: be open, open mindset.

One of the attributes that emerged from participants' accounts when describing the experience of empathy is open-mindedness. In this study, when interpreting participants' accounts, the researcher relied on the Van der Zee and Van Oudenhoven (2001, p. 279) definition of open-mindedness, "referring to an open and unprejudiced attitude toward out-group members and different cultural norms and values". Open-mindedness can help engineering students recognise and accept the experiences and perspectives of others as a source of knowledge, even if they are different or in conflict with their perspectives. In addition, open-mindedness shapes the willingness to consider new opinions and positions.

When describing their experience of empathy, some participants mentioned that open-mindedness is an essential element of their experiences of empathy. For example, Participant 9 suggests that being open-minded helps get different points of view (e.g., non-technical) and use this knowledge to make the future of other people better:

> I think about how it has a pattern. I think it shows that you keep an *open-mindedness* with everyone. I come from a technology background doing a technology startup. I saw people were not coming from a technology background, but what it does (empathy) it makes you realise that it is not necessarily what you have learned or whatever you experienced that leads you to

> the right path. You have to empathise with where you are to really get the best out of people or to create a really good future. (Participant 9)

Participant 15 mentions that openness to different answers to questions and openness to different perspectives of various stakeholders are essential components of empathy and could help students during the design phase.

> Not everyone will engage with that in the same way, but by being *open*, by asking a different question. This is empathy. I don't know whether that's me using empathy, but it's me trying to engage the empathy of my audience. I guess you're using empathy when you are in the design phase because when you're working with different stakeholders, people are going to have different views and (by being open) you need to consider it. (Participant 15)

Participant 2 also makes a connection between empathy and an open mindset and states that the experience of empathy includes understanding and accepting opposite points of view, ideas, and sides.

> Empathy it's just having an *open mindset* or other people's ideas, other people's perspective, which might be entirely different, or even actually on the opposite side of what you're trying to do... it might be entirely the opposite to what someone might be trying to do. (Participant 2)

To summarise, this sub-theme demonstrates that engineering students make connections between considering, accepting, and recognising different ideas/perspectives and empathy when participating in entrepreneurial pre-acceleration programs. At the same time, some accounts demonstrate that open-mindedness is considered an essential component of empathy.

Sub-theme 2 - Attribute: Being Able to Take a Step Back

Participants' metaphors and wording: take a step back, be comfortable making mistakes.

The second sub-theme that emerged in the narratives on experiences of empathy is being able to take a step back from one's own bias and position. Within this sub-theme, participants highlight that their empathy experience includes the ability to accept the fact that their own opinion or understanding of the situation is not always correct, followed by the ability to take a step away from their own position. The wording to describe this notion is "being comfortable with making mistakes" or "taking a step away".

Participant 17 claims that the ability to feel comfortable when making mistakes is a foundation of empathy as it helps avoid acting in a reactionary manner or in a standoffish way, which in turn can affect both the product and the quality of communication.

> I think to get to that point of empathy, you have to be comfortable with the fact that you've *probably made mistakes*. There are probably issues with the business, with the product. It's not an opportunity for you to get defensive and feel hurt but an opportunity to listen to what they're saying and be comfortable with the fact that you've made mistakes and that there might be errors in business and understanding. This is the foundation for empathy because otherwise, you're going to feel reactionary, and you're going to take it in a standoffish way. (Participant 17)

Participant 8 states that the experience of empathy also involves admitting that other people's perspectives may differ from their own (pluralism). Therefore, for the empathy experience, it is essential to acknowledge that participants can be wrong and then take a step away from their own perspectives and ideas.

> There are also biases around that, especially if they've got a conflicting opinion to you. You need to *take a step away* from your ego and your mindset and then try to understand where they're coming from, what their history is, and how they might have gotten to that conclusion that you don't agree with. I think that's very difficult to do (…) I think the foundation to be able to do that is probably accepting that you're not always correct. I think there are a lot of people that haven't even taken that step. So, understanding that really somebody else has pretty much the same capacity for knowledge and understanding as you do. And so, I think just in general, being able to admit that you're wrong. (Participant 8)

This sub-theme demonstrates the importance of letting one's own point of view and ideas go when empathising with others, which may be different to one's understanding of a subject or situation.

Sub-theme 3 - Attribute: Thinking About Consequences

Participants' metaphors and wording: be careful, be considerate about the impact.

Across different accounts, many experiences of empathy are connected to thinking about the impact and potential consequences of their own actions and decisions that can affect the lives of others. Participant 12 states that when empathising with team members or a wider audience, it is important for them to be aware that words (e.g., used

during a presentation) or actions could affect other people in different ways. They need to acknowledge this impact. That is why an empathiser should consider other people's reactions and perceptions when making decisions, as these decisions may affect others. Participant 12 states that when empathising with others, they have to be careful when choosing words and thinking about what to say, as some people may have personal problems related to the topic of the presentation or discussion.

> There is a wider audience, and the chance that someone has a heart issue is quite high. Or someone who knows a close relative or something. So, you *must be careful* about how you write your speech. Not just in selling your product but not offending people. You don't want to talk carelessly about that kind of stuff. (Participant 12)

Participants 15 and 20 believe that the process of empathy, in general, implies not only understanding the position and experience of others but the potential consequences of one's decisions for various stakeholders. In this regard, in the process of empathy, they also ask "How does it impact another person?"

> I think that you use empathy in understanding why they want yellow. Why did they want blue? Is there a way that I can meet in the middle and compromise? But then, probably deeper than that is understanding how that will *impact* your stakeholder. (Participant 15)

> So, when you are working in a team and when you are that person who drives that team, or when you are taking those decisions, you learn how might not happen to all the people, but the leadership experience that you get from entrepreneurship titles helps you to think about other people in your team when you're making a decision, think about how *it impacts* them, be more *considerate*

> *about the decisions that you make and how it impacts* each and every person. (Participant 20)

In conclusion, this sub-theme demonstrates the connection between empathy and thinking about impact, which is characterised by understanding the consequences of one's own decisions on the lives of others.

Sub-theme 4 - Attribute: Reflexivity

Participants' metaphors and wording: ask yourself, think in mind, reflect on something.

Another attribute that has emerged in the accounts of engineering students in the entrepreneurial context related to empathic experiences is reflection. This study follows the Pee et al. (2000, p. 755) definition of reflection, which is the "process of actively and consciously engaging with experiences in order to learn from them. (…). Reflection enables new experiences to be integrated into existing frameworks of knowledge." When interpreting this sub-theme, the author relies on the keywords from this definition, namely "questioning own experience". The wording that characterises this subtopic is "asking yourself" when empathising with others.

Participant 3 practises reflection (asking oneself) when empathising with others, trying to analyse their information about the context and other people's characteristics. In this case, the participant searches for different explanations and interpretations related to the context and another person.

> I *ask myself* a series of questions, like, what do you know about this person? How well do you know them? What is the information you have? So, most of the time, where they're from in Sydney and what their profession is, what

> they're studying at uni, whatever, that gives you a pretty good basis. And you just ask yourself a series of questions. (Participant 3)

Participant 13 states that during their experience of empathy, reflection helps them to comprehend their own feelings and project them onto other people. In this situation, reflection occurs through the analysis of the participant's own previous experience, aiming to understand what exactly caused or triggered certain feelings:

> I think the specific of how it would make us empathise would be, at the end, when we do a *reflection on it.* We have to describe how we felt up there and how we felt watching other people up there because it can be very easy sometimes to disassociate. And you are watching someone giving a pitch, and you are thinking, wow, this is such low effort. You know, have they even though properly about their business model? There is no confidence in the way that they speak on stage. And it is really easy to become hypocritical about the situation. However, when you reflect on how you felt up there, and you think that "everyone is looking at me so judgmentally, you know, it is very stressful. I am speaking a lot faster than I usually would because I feel the pressure then." When you look at how you have critiqued others and how you felt up there, you can be a lot less harsh to those people because you remember. Actually, I was up there, and I knew I would do better myself under different circumstances. So, I will not judge them as hard. (Participant 13)

Participant 5 also highlights and stresses the importance of internal dialogue to understand the experience of clients, as an understanding of their position would help them speak on their behalf.

> *In your mind, you think and ask yourself*, "Okay, this is how I would feel in this situation." I can express that to somebody else. I can express that when I'm designing the product, how I might feel when I see my product. I lived through all this. Without having to go and actually ask a person, a real-life customer, every time. It also gives you the ability to talk on behalf of your customer because you've empathised with them. You can tell people, on behalf of them, how they would likely feel. (Participant 5)

The descriptions of empathy experiences mentioned above demonstrate that internal dialogues are used by engineering students to explore and learn more about other people's experiences (usually about customers or other stakeholders). In this regard, the questions that study participants ask in their minds are usually aimed at obtaining additional information about others. In this regard, participants mention that the process of questioning their own experience is considered an essential component of their empathy experience as it helps to consciously analyse their own experience and project it to the experiences of others.

This section considered the attributes associated with or part of the experience of empathy. These attributes include a person's qualities and characteristics that determine how participants behave and experience certain things, such as empathy. In some situations, these attributes not only affect the way they empathise but are also essential components of this experience. Without these attributes, this experience would look different or not occur at all. Therefore, these attributes can be considered as facets or elements of the experience of empathy because without them, empathy may not arise or ignite at all.

Unlike attributes, which are considered facets or elements of an empathic experience, orientations shape the direction of this experience (like a vector) and encourage participants to think about achieving specific outcomes and represent mental dispositions that prefigure (influence) how engineering students engage in activities. This study identifies three types of orientations that affect how empathy is experienced by engineering students in entrepreneurial pre-accelerators. These are an orientation to grow and learn, a win-win orientation, and an orientation towards solving problems. In the following section, I will discuss these orientations, demonstrating examples of students' accounts supporting my interpretations.

Sub-theme 5 - Orientation to Grow and Learn

Participants' metaphors and wording: learn from others, personal growth.

One of the orientations that students mention when describing their experience of empathy is "orientations to grow and learn". Participants state that they empathise with others to grow and learn something new about others. Unlike open-mindedness, which is characterised as an ability to recognise and evaluate the experiences of others, this sub-theme is described as an orientation towards improving oneself and learning something new for personal development.

Participant 19 states that "there are places and activities in the program when you need to have that tone [of voice] and empathy. It really helps me *grow* personally." Therefore, when empathising and understanding the perspectives of others, the participant thinks about personal growth, particularly about the tone of voice when doing a pitch, and how to improve the quality of communication. Participant 19 also adds that their empathy experiences are shaped by wanting to learn about others through various questions or observations aimed at understanding the experiences of others.

These empathy experiences are also shaped through difficult conversations or the various challenges and failures that arise when interacting with others, or in creating various solutions.

> You will undergo a lot of difficult conversations, and through the PFC, I listened to what my mentor was saying (...) was quite rude and blatant (...). I spoke in the first place in a rude tone, but when you listen and when you really think about what they are saying, it really helps with the conversation. The way you are reciprocating to people (...). I was crying. [That is the *growing process*] (...). But it's very important *to learn* with hope and keep working (...) it won't happen on the first go. It will take multiple failures, but it's important to keep trying, and when you speak to people and hear about experiences, *you will learn more.* (Participant 19)

Some participants notice that empathy experiences also help them to learn from the mistakes of others, which in turn also stimulates their personal growth.

> I no longer like to learn from my mistakes. I always do. However, sometimes I make my own mistakes in all types of situations. That is why *I learn from others*. I find it more beneficial because at least you don't get negative. You don't get directly hit in the face with your own mistake. That is rather learning from someone else's mistake or journey. It's basically trying to understand them by putting myself into a situation. (Participant 2)

Participant 10 also learns how to make better decisions based on the experiences of others and states "for me, you can *learn from them* and make better decisions in life for yourself."

In conclusion, it is important to note that by some accounts, the experience of empathy is related to a learning orientation, when participants empathise to learn from others to achieve different outcomes such as an ability to make better decisions and personal growth.

Sub-theme 6 - Win-win Orientation

Participants' metaphors and wording: help each other, care about others to help yourself.

Another orientation that has emerged from accounts of engineering students is a win-win orientation. This orientation sets the direction of the experiences of empathy and means that engineering students attempt to benefit themselves and also help others when interacting with them. Participants first learn about the experiences of others, which can provide them with insights into the target audience or market. They then try to help others by offering them more customised solutions, for example.

Participant 2 states that when empathising, it is important to keep in mind the position of other people and also remember their own benefits. They describe the result of such an approach as "*when you get to care about the other enough, or maybe you get to care about yourself* enough to care about the others". At the same time, they add that "having empathy is, first, focused on other people. Because you're trying to understand [them] by being empathic, you also get to understand things that will be *beneficial for you.*" Participant 9 believes that when empathising, they have a chance to learn more about others, particularly customers and the market. In addition, they state that this understanding could help to develop better ideas and do the best for them.

> To be able to normally get the best out of them, but to be able to *do the best for them* (…) It has been really reinforced that you have to empathise with your customer. You have to empathise to really get the best out of people or to create a really good feature for them. (Participant 9)

Some participants do not use broad wording such as "make things better for people" when discussing benefits. In contrast, they believe that when experiencing empathy, they can achieve specific outcomes, such as creating customised products or building more effective communications (or bonds) with customers.

> The biggest benefit is the bond building. I try to use this all the time, whether it is in entrepreneurship, whether it is in my degree as a student or whether it is at my job in the city. I try to create bonds with people through shared emotional experiences. And in return, *we can help each other* with other things that come along. So, after we have created this bond, if someone were to ask a favour of me because we have already created it, I would feel a lot more likely to help them. And vice versa, they would feel more likely to help me out because we have created this bond together. The negative of it takes a bit of time and effort, but anything in life does. So, that is a minute necessary evil, but I would not say that there are any negatives to being able to create bonds with people. It is very important. (Participant 13)

Participants report that having a customised product or bond benefits others and ensures a winning situation for others. As, for example, Participant 4 states "there is a motive behind empathy. Let's say for a business owner; it might be understanding their customers. Because understanding their customers *helps them* build better products. At the same time. It fits better customer needs." In this regard, the participants may imply

indirect benefits that can emerge from the results of the activities of entrepreneurs, such as customised products.

In conclusion, some participants in the experience of empathy adhered to the win-win orientation. This orientation encourages participants to think about their own benefits and keep in mind the position of other people trying to bring them some value too.

Sub-theme 7 - Problem-solving Orientation

Participants' metaphors and wording: validate a problem, explore a problem, fix a problem, solve a problem.

The final sub-theme that emerged from the students' descriptions of empathy experiences is a problem-solving orientation. When describing the experience of empathy, engineering students often mention understanding a problem and aiming to solve it as one of the potential outcomes of empathy experiences. The participants use the following wording to highlight the orientation of empathy to understand and solve different types of problems: "validate a problem", "explore a problem", "fix a problem", and "solve a problem".

Participant 12 states that they tried to understand peoples' pain points and perspectives when empathising, and whether the newly acquired knowledge about customers' experiences is then used to "fix a problem" by considering their perspective.

> I think the whole idea of empathy is trying to get your customers' point of view and understand their pain points and how they might think of a certain product or service. And how you might best be able to *fix a problem* for them in a way

> that they want it to be fixed and not in a way you want it to be fixed. (Participant 12)

Participant 11 also states that empathy experiences and the perspectives of other people (including team members) help the participant to validate the problems of others when proposing a solution. The participant adds that the process of mapping out a 'tree' of perspectives could be used to delve deeply into the problem and its causal roots.

> The other part would be when I'm talking to my peers who are participating in the startup ideation. I can actually empathise with them because we're all going through the same stage of trying to *validate our problem* and talk to customers. We almost face the same set of difficulties, and we're not too sure if a problem is really right. We've worked for six, seven weeks now, and everyone still has this thing in the back of their mind where they're just not sure if this is actually going anywhere or they've wasted all of their six weeks just *exploring a problem*, exploring into a solution that has the problem that has no solution, for that matter… So, when you pick a problem and map out this whole tree, you try to put yourself in people who have this problem and try to think of how it affects them and what causes *the problem.* (Participant 11)

Participant 14 claims that empathy and the whole process of entrepreneurship should be oriented toward solving human problems. They add that during the pre-acceleration program, the participant changed their understanding of empathy, and now define it as an ability to understand societal issues and problems.

> I feel like in most cases, empathy has to come from a problem, and that's why it's such an important thing as an entrepreneur as you're trying to *solve problems* (…) a little bit of empathy for the problem I was trying to solve.

> Young people getting into housing is very tough, so that was the empathy I was trying to solve... My definition of empathy changed in the context of entrepreneurship, being that to be a good entrepreneur, you need to empathise with the problem being solved. Prior to that, it might have just been to be an entrepreneur; you need to empathise within the team. My definition of what empathy meant was just restricted to the ability to understand someone's perspective, whereas now it's being able to understand a societal issue and empathise with it more. (Participant 14)

In conclusion, when describing the experience of empathy, engineering students often associate this phenomenon with an orientation towards understanding problems to propose a solution that may potentially solve or fix this problem. In this context, when empathising, participants are trying to understand the experience of others by focusing on pain points and their challenges.

This section demonstrated that engineering students in pre-acceleration programs experience empathy as a multiphase process consisting of five different phases and a phenomenon related to four attributes. It is also guided by three orientations. In this study, attributes are part of the empathic experience (facets), and orientations provide a direction for this experience which encourages participants to think about the specific outcomes that empathic experience can lead to. This chapter also focused on interpreting how engineering students experience this complicated phenomenon in their own unique ways.

Examples of Engineering Students' Excerpts Involving Multiple Attributes and Orientations in Their Descriptions of Their Experiences of Empathy

This section presents engineering students' accounts that demonstrate the relationship between the process of empathy and various attributes and orientations. These accounts involve students' descriptions of empathy, where they mention these attributes and orientations. During the analysis, several attributes and orientations present in each engineering student's descriptions of empathy were identified. Examples of such accounts are provided below.

For example, the excerpts of Participant 17 demonstrate the presence of the attribute "Being able to take a step back" stating that "I think to get to that point of empathy, you have to be comfortable with the fact that you've probably made mistakes" (Participant 17). At the same time, the Win-win and Problem-solving orientations are reflected in their excerpts. This participant stresses that the important parts of empathy are the orientation towards solving other people's problems. These are interpreted as a Problem-solving orientation and bringing value to other people and improving their own startup, which is interpreted as a Win-win orientation.

> Basically, make something that is *solving a problem* and *delivering value for customers and additionally for investors*. Being able to understand their frustrations and pain points are at the heart of delivering a successful product. You're not trying to build something for yourself. You're trying to build something that is delivering value for other businesses or customers or whatever. And in order to do that, you need to know What are they after? What do they need from it? And what is the role of it in their life? And also, on the feedback side, you can't enact feedback accurately if you don't truly understand where it's

> coming from. So that's where empathy is important. If you just stop listening when someone starts saying something because you don't agree with it or you don't understand what they're saying, then your product is never going to improve for them or their experiences. By exercising empathy, you are probably more likely to *get something useful out of that for your own startup and journey*. (Participant 17)

Some other attributes and orientations can also be found in the descriptions of the participant's empathy experiences. For example, Participant 15 states that empathy includes the ability to be engaged in dialogue with oneself by creating and answering questions about the experiences of others to better understand their perspective.

> How do I weigh that up? I think you use empathy in understanding why they want yellow. Why did they want blue? Is there a way that I can meet in the middle and compromise? That *reflection* is a part of empathy, and it is probably deeper than understanding how that will impact your stakeholder. (Participant 15)

Participant 15 also notes that when empathising, they think about helping others while realising that this helps them progress faster with their product or startup and grow individually.

> If you still like each other and you still respect each other, then you're great. That is how shared experiences can build empathy with your co-founder, which is very important because their limitations and their life may impact the progression of your solution, so [use] empathy as a tool. How are you going to get advice? How are you going *to get people to help you*? If I want to talk to someone, how *can I give them a little bit of myself* so that they can go, "Oh,

> hang on, *I want to help this person*."... Those things also *help you grow.* (Participant 15)

Further, in their descriptions of empathy, Participant 15 also notes that empathy is associated with an orientation towards solving the problems of others. They mention that the processes of interactions with other people when discussing problems and potential solutions are closely related to empathy.

> Initially, it was a hundred percent *problem orientated.* We wanted to *solve a problem*, and then when we entered the PF [Peter Farrell]. We had gotten six months to prototype, and we were like, "Okay, it's not enough to have an idea. It's not enough to have a prototype unless this is in a hospital. It's not going to have the impact that we initially set out to achieve." (...) I guess talking to other people about *their problems* and asking them, "Well, what do you think is a solution? What do you think about that?" That back-and-forth conversation with people in a similar progressive state (...), there's a little bit of vulnerability there. You're both on the same playing field. So, there's already empathy there. (Participant 15)

In Participant 6 descriptions of empathy, the relationship of empathy with various attributes and orientations can also be tracked. For example, when discussing how modern educational programs can be more empathy-oriented, they mention that for them, empathy is associated with the ability to ask themselves the right questions about other people's perspectives (Reflexivity), and to think more about the consequences of one's own actions (Thinking about consequences).

> Empathy is *asking yourself* questions. [it] would be about the money that you've raised or what you're valued. And we tend to think about financial stuff more

> when we talk about startups. But I'd say if we shifted the focus towards *impacting customers*, say, asking questions like "What's your customer base?", "What is your satisfaction rate of the customers?" I think if we made the startup founders more concerned about the *impact***,** about customer satisfaction, about the happiness of your customers, I think we'd make more empathetic [programs] and startups in general. (Participant 6)

In addition to the above attributes, Participant 6 underlines the importance of three orientations in empathy stating that “you *learn* if you are empathetic towards your customers, your potential users, you can sell better to them because you know what's going on in their heads” (Participant 6). This relates to the importance of having the desire to learn new information about other people when empathising; this can be noticed in their descriptions of empathy (Orientation to grow and learn). They also add that if a person has a high level of empathy in the entrepreneurial context, they think about how to solve other people's problems and what kind of stakeholder can help them identify needs and problems (Problem-solving orientation).

> Maybe I can do something to fix the *problem*. So, it need not be direct communication with stakeholders but understanding your surroundings and just looking for people and [understanding] what they're feeling [can] *solve their problems.* I'd say experience is also a key factor in being more empathetic. (Participant 6)

Finally, Participant 6 stresses that empathy involves the desire to do better, which also brings great satisfaction (happiness) to oneself.

> There is nothing that makes *you happier* than the fact that you *helped someone who's struggling* (...) The moment when they thank you for that, I think that's

going to be one of the best feelings in the world. I think being empathetic makes *you feel satisfied while helping others.* (Participant 6)

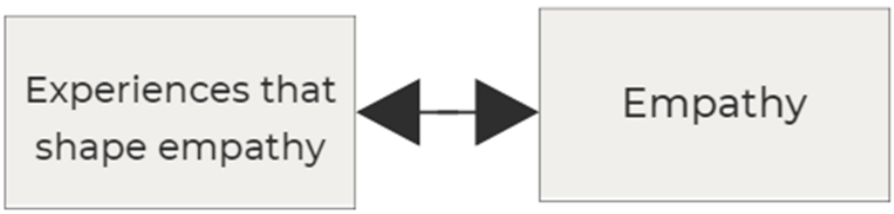
To summarise, this section provided examples of engineering student excerpts demonstrating that when students describe their empathy experiences, each of these descriptions includes multiple attributes and orientations.

Findings From RQ 2 (What are the experiences that shape empathy in pre-acceleration programs?)

The previous section presented the findings related to the first research question, which focuses on illuminating and interpreting the lived experience of empathy. This section is concerned with the second research question (*What are the experiences that shape empathy in pre-acceleration programs?*), focusing on the different experiences in pre-acceleration programs that shape the experience of empathy (See Figure 4). The focus of this second research question was to **interpret** the experiences that lead to empathy, and which shape it. At the same time, in this section, when interpreting the experiences that shape empathy, the logic was followed that empathy itself could also have some impact on experiences that shape it.

Figure 4

Conceptualising findings for RQ 2



To study experiences that shape empathy, participants were asked to recall their experiences of empathy in various situations and provide detailed descriptions of these situations. The following question was the starting point:

- In what situations did you have the opportunity to use empathy?

This opening question was followed by the author asking clarifying questions to try to encourage participants to reflect on specific activities and the factors that led them to experience empathy. One example is:

- What activities of the pre-accelerator encouraged you to use empathy?

Four experiences that shaped the empathy experiences emerged from engineering students' descriptions. These experiences are:

(1) starting with a broad question

(2) talking with a purpose

(3) being touched through listening to stories

(4) observing "clicking" situations.

These experiences might be interconnected and intertwined. For example, when talking to other people, an empathiser can also be touched by one of the stories that may lead to empathy. The same can be experienced by an empathiser who observes a "clicking" situation (the word "clicking" emerged from participants' descriptions, meaning when something in an engineering student's mind suddenly clicks, attracting their attention and encouraging them to empathise) as the other experiences can also emerge/connect and shape empathy (e.g., a broad question or touching story). Empathy

can also impact how participants talk to others or ask questions. In this section, I discuss each experience separately to conceptualise each experience while these experiences can be intertwined. At the end of this section, the engineering students' quotations are presented, demonstrating that experiences shaping empathy can be intertwined (when several experiences simultaneously can encourage engineering students to empathise). Table 11 shows the summary of themes.

Table 11

Themes and sub-themes that address RQ 2

Themes	Sub-themes	Participants' metaphors and wording
Themes	Starting with a broad question	I empathise with how, what, or why.
	Talking with a purpose	Talk to others.
	Being touched through listening to stories	Get a little touch of their perspective through listening and listening about traumatic experiences.
	Observing "clicking" situations	See what clicks, watch wow situations.

Theme 1 - Starting With a Broad Question

Participants' metaphors and wording: I empathise with how, what, or why.

The first theme related to experiences shaping empathy that emerged from engineering students' accounts is "Starting with a broad question". In this study, engineering students (when describing the experience of empathy) state that different broad questions could encourage them to induce an empathy experience. The experience of empathy can include various questions aimed at either understanding one's own

perspective/experience or understanding other people. However, in the context of this research, broad questions mean questions related to the situation, a specific problem or task, and are not primarily aimed at understanding the experiences of others. These questions usually are open-ended and focused, starting with the “how”, “what”, and “why”. They occur in the mind and are not asked verbally.

For example, Participant 18 states that a lack of understanding of the context and subsequent thinking about a broad question, “What is going on?” induced them to focus on other people, including their emotions and situations. In this excerpt, the general question encourages the participant to ask questions that focus on other people, such as: why do they experience that? How do they experience that?

> I believe my approach to trying to empathise is to understand *what’s going on.* I’m trying to empathise with how someone is feeling and what’s going on with someone. Why is that the problem that they’re facing? It’s not so much what the problem is. It is the core feelings about “how” and “why”. (Participant 18)

A similar example can be observed in the description of the empathy experience of Participant 10. They claim that the desire to understand how to deliver an idea encourages them to focus their attention on clients and ask questions regarding other people's experiences, as in, for example, “How would they try to do that?”.

> Our idea was to get more information out of customers. So, *how do we deliver that idea* to our customers? How *would we allow our customers to get more information* out of [Technical features of a product]? So, we would empathise with *how they would try to do that.* (Participant 10)

In conclusion, one of the experiences that shape empathy is a guiding question that can encourage participants to empathise with others. This "broad question" encourages students to empathise by being immersed in the experiences of others, asking more specific questions that usually focus on other people, or comparing other people's experiences to their own perspectives.

Theme 2 - Talking to Others

Participants' metaphors and wording: talk to others.

Another type of experience that prompted engineering students to empathise with others is talking to others. Multiple descriptions of the empathy experiences of engineering students indicate that participants begin to empathise during conversations with other people, or after they have finished talking. Participant 15 suggests, "one thing [to empathise] is you drive out west and go camping and *just talk and talk and talk* for like three days straight." Some discussions may have a particular goal (e.g., solve a problem, or discuss a product), while others are just casual chats with peers or tutors. Some participants, answering the question about the experiences that shape empathy, state that talking to others can encourage them to empathise. For them, it is not just a routine chat, as they usually want to get something out of this communication (they had a goal for this talk). Participant 18, describing activities that could encourage them to immediately use empathy, replied, "it comes down to sitting down and *talking to others*." Later, they add that during the ongoing discussions within the pre-acceleration program, they usually want to understand something from this communication, such as "How can they work this together?":

> We have a [Technical feature of a product] management system supplier. They had issues, and so there was all this stuff around borders, and it was really just a

> *sit-down and talk*. How can we work this together? A bunch of us came together... a lot of calling and networking, building those relationships, empathising, and helping each other out. (Participant 18)

When Participant 9 answered the question about activities that can encourage empathising, they also mention that empathy might appear during a conversation with others and add that these conversations are usually driven by a specific goal (for example, to understand users' experience with software).

> By talking to customers, by *talking* to our managers, *talking* to my peers or my associates, I think every decision that you make is based on empathy. But when you start going and *talking* to people like retailers, you should not forget to ask them, well, what software do they use? Do they find it useful? (Participant 9)

Therefore, talking with other people can shape and encourage engineering students to empathise with others. It can be either a conversation with a specific goal (intentional) or a simple casual talk with other people (not necessarily a stakeholder).

Theme 3 - Being Touched Through Listening to Stories

Participants' metaphors and wording: get a little touch of their perspective through listening and listening about traumatic experiences.

Another experience that shaped engineering students' empathy in an entrepreneurial context is "being touched through listening to stories". This experience is characterised by others' stories that the participants listen to. In this situation, some engineering students state that they experience empathy after they hear a story that elicits an emotional response and attempt to understand/feel the experiences of others and imagine what a person would do in this situation. A touching story is understood as

a story that evokes strong feelings/emotions in a listener due to the proximity of the relationship with the speaker, or through the process of relating this story/situation to one's experience. Participant 16 states that other people's stories might encourage them to empathise by imagining a situation and potential actions.

> For me, it would be (activities that encouraged me to empathise) when I did some [inaudible] like listening to their *stories*, just their thoughts about investing in the markets and where they were going….when I try to empathise with people if they are telling a story to me or they're saying this is an event that happened in their life. I typically try to imagine myself in that situation or in that position and think about how I would act or how I would react. Obviously, that's an imperfect way of empathising, but that's how I approach it. (Participant 16)

Participant 15 explains that when listening to the stories of others, there is sometimes a touching moment of knowing other people's perspectives, that can subsequently encourage them to empathise. They say, "if you listen to someone, you can maybe *get a little touch of their perspective* or what they are, not demeanour. And then you can go and use (empathy)." In this account, the participant clearly distinguishes empathy and a particular experience that leads them to empathy, highlighting the sequence of these experiments.

Participant 14 described a traumatic story that had happened to a guest speaker. For them, this story turned out to be touching because they connected it with their personal experience (they imagined their girlfriend in the same situation). This connection encouraged them to immerse themselves in the experience of the speaker to understand the seriousness of the problem.

> An example could be that we had a guest speaker come in who, unfortunately, was sexually assaulted. She made an app for people at bars. I think it's called XXX, where you whisper the word 'XXX', and the security comes out and makes sure you're safe and removes the person that is causing you distress and talks to you about it and gives you prolonged psychological support and allows you to have that sense of justice. Where before that, you'd just be powerless if someone did something bad to you in a club as a female, none really going to do anything because everyone was too scared to cause a scene. That's a very *traumatic experience*. It's pretty hard to imagine. I also had a girlfriend at the time, and if someone did that to my girlfriend, there would be no real way to solve that issue. Now there is. This is a real problem that needs to be solved, and that's how something as confronting and provoking as that is. I greatly think it gave me a passion for their business case and their idea, and the problem they were trying to fix. (Participant 14)

To conclude, this theme implies that empathy can be elicited or shaped in participants after or during listening to stories that evoke strong feelings/emotional reactions in them.

Theme 4 - Observing 'Clicking' Situations

Participants' metaphors and wording: see what clicks, watch wow situations.

The final theme that emerged from engineering students' accounts related to experiences that shape empathy is "observing 'clicking' situations". A 'clicking' experience (which might happen when a person observes a certain situation) evokes in the observer a wide range of emotions. The word "clicking" was initially used by a participant when describing their empathy experiences in some uncommon or unusual

situations. This word has been chosen as it describes well how observed experiences evoke (click) interest or other feelings that further encourage engineering students to experience empathy. This can occur, for example, in the shift from interest to sadness. To illustrate, Participant 6 in answering the question about activities that can encourage their empathy, states that if someone is an empathic person, then when observing some situations (such as scolding a waiter) may trigger some feelings and encourage them to start empathising and trying to understand the feelings of others.

> So, if you're an empathetic person, and if you sit in a restaurant and you see the owner scolding the waiter. Then something in your mind suddenly *clicks that*, you know, the waiter needs a better experience at this place, even though he is an employee there. And maybe I can do something to fix that. So, it needs not to be a direct communication with the waiter but an experience. Understanding your surroundings and just looking for people and what they're understanding, what they're feeling. I'd say (seeing an) experience is also a key factor. (Participant 6)

Participants can also observe an unexpected or sudden situation, such as an ill-prepared pitch, experience a "wow" effect as a result that can lead/shape their experience of empathy, and then imagine themselves in the shoes of others to understand what led to "such a low effort".

> You know, you are *watching* someone give a pitch, and you are thinking, *wow*, this is such low effort. You know, have they even though properly about their business model? There is no confidence in the way that they speak on stage. And it is really easy to become a hypo critic about the situation. However, when you reflect on how you felt up there, and you think that "everyone is looking at me

> so judgmentally, you know, it is very stressful. I am speaking a lot faster than I usually would because I feel the pressure then." When you look at how you have critiqued others and how you felt up there, you can be a lot less harsh to those people because you remember. Actually, I was up there, and I knew I would do better myself under different circumstances. So, I will not judge them as hard. (Participant 13)

Empathy can also be stimulated by unexpected observed reactions that differ from the usual patterns, such as a nervous reaction from the audience or the unexpected behaviour of a team member. Participant 2 stated that when they saw something different from the normal reaction or behaviour, it made them empathise by thinking about why the other person was behaving in this way.

> It's just going to be around me, but, like yesterday, we were about to go to a team celebration. And my flatmate was going through some stress, and that *translated into certain actions.* We both are coexisting, living together. I guess, essential to understanding each other. And so yesterday, she was going through some stress which *translated into a reaction* or a way to act. And so, I am trying to understand *what's going on* and what makes this happen. I try not to react to that. (Participant 2)

The engineering student accounts in this section demonstrate that empathy can be shaped by observing experiences that evoke different feelings. The main difference between this theme and theme three ("Being touched through listening stories") is that, in this case, the reaction is caused not only by listening to stories from other people but also by seeing some situations that occur.

This section provided examples of students' accounts demonstrating four different experiences that shaped engineering students' empathy experience in pre-acceleration programs. Empathy can be shaped simultaneously by several identified experiences. However, these experiences do not exist separately. The boundaries between them can be blurred and intertwined so that together they play an equally important role in forming empathy. The examples of engineering students' excerpts demonstrating that experiences can be intertwined are presented below.

The Interconnectedness of Experiences

This study reveals that, in some cases, the experiences of empathy were formed under the influence of several experiences simultaneously. Therefore, when assessing their impact, it was difficult to conclude which experience has a greater effect on empathy, and also what elements of these experiences encourage engineering students to empathise since all of them together can have an equally significant impact on empathy experiences. These experiences are intertwined in real life, and some or all of the identified experiences may encourage engineering students to empathise. Therefore, when discussing themes and a model developed from interpretations of these experiences, it is essential to remember that the boundaries between them are only conceptual, aiming to provide clarity for the reader.

The engineering students' accounts below demonstrate the intertwined nature of experiences. This means that multiple experiences simultaneously can encourage engineering students in entrepreneurial pre-accelerators to empathise. For example, in Participant 6's description of their own experience of empathy, it can be observed how the intertwined experiences encourage them to start experiencing different phases of empathy. They notice that after seeing how other people face problems, and also after a

little chat with them, they begin to immerse themselves in the experience of others (by asking various questions and reading emotions), and then relate their experience to their own (by imagining what would happen if they had the same experience).

> Having a problem, this is what gives out a lot is their emotions as well. You usually find that when someone is facing a problem, you see it, they are not in control of their emotions. It's very difficult to keep a straight face when you have experienced significant loss. I tend to ask people if they're going through something. They tell me, and I imagine a bad thing happening to me, and usually, that's enough to understand that someone's going through a great problem. You just need to care about them enough to help them through it as well. Very difficult to have an expressionless face. So, first, you try to read their emotions. You try to figure out what would happen if you had the same experience. So, if I were to look for empathy in someone, I'd think I'm fairly good. (Participant 6)

Participant 18, in their description of empathy experience, mentions that they began to empathise after/during communication with clients (Talking to others), and under the influence of a desire to understand the situation that was shaped by the question of "*what's really going on?"* (Starting with a broad question).

> In Validate, you talk to customers. (…) We build a customer profile, and everything is based on customer needs. That's why it was about '*let's talk to people*, do some research on *what's really going on.*' We start engaging with different people trying to think about the problem and the solution, but also about the model itself as well. (Participant 18)

Participant 18 also adds, “if I see what they're doing and why they are doing what they're doing because of some mistakes they make. Yes, that's a mistake, but why think about it in a certain way? Why does it happen?” supporting an idea that observing other people making mistakes (Observing ‘clicking’ situations) can also encourage the participant/observer to start empathising by trying to immerse themselves in the experiences of others, aiming to understand why this situation is happening. This observed experience may also cause an emotional reaction due to a lack of understanding (*Why does it happen?)*.

From Participant 18's descriptions of their experience of empathy, it can be observed that empathy may be shaped under the influence of several experiences simultaneously (e.g. Talking to others and Starting with a broad question). Participant 17 also mentions Talking to others and Starting with a broad question experience in their descriptions of empathy experiences. They note that when talking to different people within an entrepreneurial context about success stories, parallel broad questions appear in their minds, such as “How do they achieve that?”. These experiences encourage them to start using empathy and putting themselves in the shoes of others.

> I think if you're empathising with them, then it allows you to extract the most valuable lessons from their journey. I think when someone comes in and *talks* about why their business failed, you can look at it on a very surface-level basis, or you can really try and understand and empathise, getting down to the root causes. Then that will allow you to inform your own journey and pathway. I think even when someone is *talking* to you; you can look at it in a very surface-level way, like, 'Look at this guy, he is so successful.' You would really like to follow what they're saying and try to empathise with *why they made certain*

> *decisions, how they achieved that.* By exercising empathy, you are probably more likely to get something useful for your startup and journey. (Participant 17)

Participant 8 mentions three types of experiences in their descriptions of empathy that can encourage them to empathise. They note that they form a broad question (Starting with a broad question) such as "*How do they use our product?*" while talking to others about potential product improvements (Talking to others) and observing how others interact with their platform (Observing 'clicking' situations).

> I like to take notes when I get on a call with a user, or I *see them using our software. I ask them* what they want to see done better. I think probably the closest thing to user journey maps is we *have (observe) recordings of people using the platform themselves* without us there. And being able to analyse *how they use it* and then being able to empathise with them. (Participant 8)

This section provided examples of engineering students' accounts describing empathy experiences. These accounts reveal that experiences that shape empathy can have an intertwined structure. As mentioned above, the word intertwined has been chosen because engineering students note that some experiences can simultaneously affect empathy, and therefore, it is difficult to figure out the role and weight of each experience in shaping empathy.

Elements of Pre-acceleration (Entrepreneurial) Programs that Prefigure Conditions for Both Types of Experiences

It is also important to contextualise the elements that impact the construction of empathy to capture the essence of a phenomenon. When a researcher tries to capture the construct of a phenomenon within a specific context, it is essential to tell a holistic story

considering the role of contextual characteristics, as this approach helps to suspend imposed meaning and understand all the facets of a phenomenon (Heidegger, 1962). That is why this study also explored the elements of programs within which conditions can be created for both types of experiences.

As mentioned above, this study aims to illuminate empathy experience from engineering students' lived experiences and interpret experiences that shape empathy. It is worth noting that when analysing, interpreting and connecting the experiences of empathy and experiences that shape this phenomenon, four different program elements have emerged from students' accounts which are:

(1) the design process

(2) the community of practice

(3) diversity of opinions

(4) market

These elements represent the contextual characteristics of entrepreneurial programs that prefigure conditions for the experiences of empathy and the experiences that shape this phenomenon.

The mere presence of these elements in the structure of an educational program does not mean that participants will experience empathy. However, common patterns emerged that students often experience empathy and experiences that shape empathy within these elements of entrepreneurial pre-acceleration programs, and the identified elements contribute to the emergence of situations/contexts for empathy experiences. For example, the market analysis or design process could take place without empathy.

However, engineering students repeatedly mentioned that they experienced empathy and experiences that shape empathy within these elements. Table 12 summarises the elements of pre-acceleration (entrepreneurial) programs that prefigure conditions for both types of experiences, while Figure 5 reflects the relationships between the elements of pre-accelerators and experiences that shape empathy within these programs. In this study, the experiences of empathy and the experiences that shape empathy take place in specific contexts shaped by the elements discussed below.

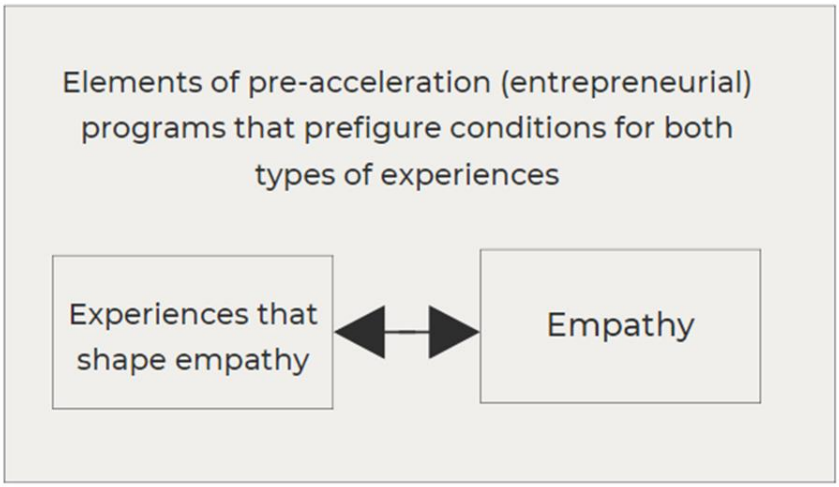
Table 12

Elements of pre-acceleration (entrepreneurial) programs that prefigure conditions for both types of experiences.

Themes	Sub-themes	Participants' metaphors and wording
Themes	Design Process	The success of a product, improve a product based on their needs, solve their problem.
	Community of Practice	Go through the same things with peers towards a common goal.
	Diversity of Opinions	Different, diverse.
	Market	Customers, sales, market validation, market strategy.

Figure 5

Relationships between elements of pre-accelerators and experiences that shape empathy.



Element 1 - Design Process

Participants' metaphors and wording: the success of a product, improve a product based on their needs, solve their problem.

Design tasks or design processes are one of the elements in pre-acceleration programs that may prefigure the conditions for both types of experiences (experience of empathy and experiences that shape empathy). According to Taura and Nagai (2013), the design process can be defined as the process of developing a product or solution to fulfil specific requirements. This study focuses on two key constructs that form the definition mentioned above: concept or product generation and user requirements that involve their needs or problems. Considering the constructs that emerged from literature and engineering students' accounts, the following wordings and metaphors represent this theme: 'Success of a product' or 'Improving a product' demonstrating the product development component and suggesting features "based on their needs" or propose

product features that “solve their problem”, thus demonstrating a focus on user requirements.

For example, Participant 3 claims that the rapid prototyping phase (usually considered an essential design process phase) is about empathy. This phase and descriptions of an experience of empathy were shaped by broad questions (e.g., why they thought that) and a discussion with other participants to understand other peoples’ thoughts (Talking to others).

> I then had to realise this is what designers do. They spend a long amount of time behind the scenes, perfecting the form, and that is their role. So, you just have to understand their previous experiences, why they think that amount of time is necessary for the *success of the product* (…) For example, the rapid prototyping taking that to the roundhouse was all about using empathy to think about why they thought in a particular way and *suggest features that they might use based on what we knew about them*. It was never stated that you must use empathy to get there …However, when we had one of our rapid prototypes, we walked up to people and said can you play with our prototype and tell us what you think. (Participant 3)

This excerpt shows that engineering students believe that empathy is used “on demand” and can be activated through discussions with other people. Participants also noticed that empathy might not necessarily be present in the design process (it was never stated that you must use empathy to get there).

Participant 17 also believes that improving a product or a service (concept), getting customer feedback, and focusing on delivering value to people considering their perspective might prefigure empathy. At the same time, during the design of the product

phase, a ‘clicking’ situation (the participant observed the reaction and body language of a stakeholder and concluded that it was not their direct duty to help a team) was also experienced which in turn shaped the experience of empathy.

> The whole point of your business is to deliver something that’s for others to benefit from and get value out of it. I think our empathy is centric on those iterations of feedback and *improvement of the product or service*. And then again, for engineers, it’s fundamental to improving and optimising a system that’s serving multiple stakeholders…I mean, actually, empathy is probably more so in that when I was getting frustrated that she (One of the stakeholders in a focus group that was responsible for testing a product) wasn’t getting back to us, between that first meeting we had and the second meeting, and, you know, we had to exercise empathy to understand that. Like helping us with our product is not her job. Her job is as an engineering consultant, and she is spending time with us to improve our product. And it took a lot of empathy to be like, yeah, she’s like boasting to us for a few months, but this is not her main job. We have to empathise that she’s busy and has other daily jobs. (Participant 17)

Additionally, it is worth noting that in the design process, various tools can be used to understand users' needs, which is also part of the design process. These tools can prefigure conditions for empathy experiences and experiences that form empathy. For example, a product persona tool helps to visualise a hypothetical profile of potential users discarding their goals, characteristics, and interests.

> I think we certainly can sometimes lack the ability or miss opportunities to empathise with other people. To solve this problem, I think we can use the *product personas*, at least from my experience, is a really good way to think

about who will use your product. What are their interests and influences? How they may interact with your product. (Participant 12)

In conclusion, the design process that includes the creation of a concept or product considering various specifications, such as users' problems and needs, can prefigure conditions for the use of empathy and experiences that can shape empathy.

Element 2 - Community of Practice

Participants' metaphors and wording: go through the same things with peers towards a common goal.

Another element of pre-acceleration programs that may prefigure conditions for empathy and experiences that shape empathy is the Community of Practice (CoP). According to Wenger (2011, p. 1), "Communities of practice are groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly". Usually, this community emerges to achieve specific shared goals (Kalocsai, 2013). In the context of this research, startup founders and their peers (students from other startups) work on similar problems and tasks and share a common interest in entrepreneurship (e.g., building customer-centred products and enterprises). At the same time, participants highlight that an important aspect when empathising is that they all go through similar difficulties together, which in turn supports the fact that these groups can be perceived as communities of practice. The metaphor that represents this element is "going through the same things with peers towards a common goal".

For example, Participant 1 claims that empathy and experiences that shape empathy could arise between people who work together on the same problem and go through the same stages.

> I think it's because we were *all going through the same thing*. It was much easier to share a mutual understanding of the feeling that we were all going through….Maybe host more activities for all the different founders in the cohort to work together. I think one thing that was done really well was at the end of it: we had a little picnic thing together. (Participant 1)

Participant 11 adds that empathy for peers might arise because all participants went through the same phases and were driven by the same goals (e.g., solving a problem). Therefore, they could imagine the difficulties the other peers face.

> The other part would be when I'm talking to my *peers* who are participating in the startup ideation. I can actually empathise with them because we're all *going through the same stage* of trying to validate our problem and talk to customers. We almost face the same set of difficulties, and we're not too sure if a problem is really right. We've worked for six, seven weeks now, and everyone still has this thing in the back of their mind where they're just not sure if this is actually going anywhere or they've wasted all of their six weeks just exploring a problem, exploring into a solution that has the problem that has no solution, for that matter. (Participant 11)

Participant 13 believes that when everyone goes through the same processes, it is easy to imagine the difficulties (struggles) other participants face. They add that this understanding could help them to build a bond and "the biggest empathy" with other participants and companies.

> Maybe, empathy was a pretty good relatability tool for the Peter Farrell Cup because we were all startup entrepreneurs. And so, we had all *gone through some struggles together*, right? So, we did not know each other before the

> competition, but we had all been working on an idea before the competition. And so, we had all struggled to find competitor analysis or doing, you know, producing business models. And so, when in the competition we saw people struggling with that, we could be like, what do you know, we have struggled with that as well. And we could use that as a really quick way to create a bond with someone, and the biggest empathy experience was when another company said, wow, what do you know? There is already a company out there that does the exact same thing that we do. We just could not find them through our Google searches. (Participant 13)

Participant 3 stresses that in addition to situations where all participants went through similar difficulties, other scenarios could prefigure empathy. They described situations when a common goal united everyone since understanding the goal can also help to imagine how other participants experience certain things.

> Because you do forget that *everyone's* working towards the *common goal*. So, you just have to empathise and realise why they are doing certain things, even though it's frustrating. It is just another tool to get the job done, (I guess, that is how empathy can be activated). (Participant 3)

In this regard, another element of pre-acceleration programs that can create conditions for empathy and experiences that shape empathy are communities of practice when participants go through similar difficulties and are united by a common goal.

Element 3 - Diversity of Opinions

Participants' metaphors and wording: different, diverse.

The third element that may prefigure conditions for empathy is the diversity of opinions. In this study, the diversity of opinions implies that engineering students in pre-acceleration programs may meet with a variety of people who have multiple perspectives, backgrounds, or ideas different from their own. In this regard, in the context of entrepreneurial programs, students believe that various opinions and points of view can create conditions under which experiences will appear that shape empathy and create conditions for empathy. This theme is characterised by the words "different" or "diverse". For example, Participant 4 believes interactions with people from different cultural backgrounds can "build" their empathy stating, "That's why I'm meeting a lot of people and interacting with a lot of people from *different backgrounds* and countries. I think it will definitely help with building empathy, especially with different types of people."

Pre-accelerators can involve engineering students from different engineering fields (e.g., mechanical, electrical, civil) who can bring diverse ideas and views. Therefore, interacting with individuals from different backgrounds and ideas can stimulate program participants to think about the question, "How do other engineers see the world?" or "Where did they pull that from?" (Broad questions). These questions can, as a result, also shape their experience of empathy. As when Participant 3 was asked about the activities that influenced their empathy, they stated that when working with biotechnological engineers, the participants heard answers to questions that differed from their own opinions. As a result of this interaction, they want to understand others' views that differ from theirs.

> I guess the whole thing was about meeting a diverse range of people. I met a lot of biomedical startup entrepreneurs, which is a group of people that I wouldn't hang out with. And they have all *different ideas* about how things should be done and about how they see the world. And that came out every time a question was asked in a pitching session or in a rapid prototyping session. They sometimes gave answers that were very different to what I would've said. That encouraged me to be like, "where did they pull that from? Oh, it's because he's developing nanotechnology that injects, I don't know, opioids into someone's bloodstream". And it's a level of thinking that I'll never attain. (Participant 3)

Also, diversity can be achieved through working with people who run different types of startups at different stages of development.

> We had a smaller cohort where we always interacted with them. And there were *startups at different levels*. So we were not on the same stage, and there were also people working on different things. So, it's not just some work. Some people were completely focused on improving work productivity or completely different things like making travelling easy for people or different concepts. (Participant 20)

Within entrepreneurial pre-acceleration programs, engineering students have a chance to interact not only with peers from different backgrounds but also with various stakeholders who may also have different perspectives or experiences. For example, Participant 17 mentioned that during the pre-acceleration program, they had a chance not only to immerse themselves in the experiences of team members (e.g., co-founder) but also in the experiences of other engineers involved in the product design phase.

> I don't know. It was to deliver the patience that was required. It meant that we understood how important it was to have *more than just one* engineer working with us. They're all busy; they all have daily tasks. They all have Key Performance Indicators that are not at all related to us. And so, it made us more patient and understanding, and that meant us reaching out to more engineers so that when they get busy, that's fine. If we're talking to ten and six of them, get super busy, at least another four will be able to help us. It also allowed us to be more in our conversations and demeanour, like starting the call with thank you so much for your time. If you think about meeting me, my co-founder and a client or an investor or whatever, if my co-founder and I have got that *diverse background and diverse schools of thought*, then there's a higher chance that one of us is going to get what they're saying. And I think having someone inside the organisation that can see it immediately makes it more likely for me to see it as well. It relaxes me a little bit. It's like as a team, you're more likely to be able to get what someone is saying If you have a diverse background. (Participant 17)

In conclusion, the diversity of opinions that can be achieved through interaction with engineers (peers) with different backgrounds, participants of different types of startups, or working with different stakeholders can prefigure conditions for experiencing and shaping empathy.

Element 4 - Market

Participants' metaphors and wording: customers, sales, market validation, market strategy.

Finally, the fourth element that may prefigure conditions for empathy is the market. According to Goodwin et al. (2019), the market involves the interaction of

buyers and sellers defined within the bounds of broad product categories. This study focuses on the participants' desire to commercialise their product (sell), and their understanding of the importance of customers for their startup. In this regard, within the framework of this theme, I identified situations that when focusing on clients/customers or trying to understand the market as a whole, engineering students experienced empathy and experiences that shape empathy.

For example, Participant 11 expressed their opinion that pre-acceleration programs' primary goal is to create commercialised products to fulfil customers' needs. In this regard, within the framework of these programs, it was important for them to focus on customers and empathise with them, as customers shape a market. That is why customer interactions (an experience that shapes empathy) may foster or shape empathy.

> When you're talking to your potential *customers***,** that's when empathy really kicks in, and it's important because you need to put yourself in other people's shoes at least before you proceed with the next question….But I do find myself thinking about the customers and all the empathy stories that I told you about earlier. (Participant 11)

Participant 5 also believed that in the context when participants understand that they must design a product that could be sold to potential customers, there might be a need to form a broad question (an experience that shapes empathy) such as "Who's actually going to buy your product", and then apply empathy.

> Market research is one of them. Okay. I can make it. Here's my business. I'm going to *sell these*, but then you get to the stage where you're like, okay, "who's going to buy this?". Then you need to apply empathy. So, I think it's either that *market***,** I don't know what you would call that. I don't know if that falls under

> market research for us. It did. It's like, who's actually going to buy it? Who's actually going to buy your product? My customer is going to purchase this, and you're already empathising. (Participant 5)

Other participants believed that the market and processes related to a market could also prefigure conditions for both experiences that shape empathy and empathy experiences. Some participants noted that empathy could emerge from (or be taught through) the market validation phase/research. Participant 6 thinks "one of the most integral workshops for us in the Peter Farrell Cup was *market validation*, and that's where a lot of empathy comes into the picture as well" while Participant 12 describes it "as part of Validate [program], our focus was on *market validation*. We had to survey a whole bunch of people. They all wanted to enter the housing market, and they all wanted to be able to invest, but they just couldn't. A lot of them thought that it was unfair and basically not equitable. So, I guess that teaches you empathy."

Participant 16 noticed that the development of a go-to-market strategy and the validation phase encouraged them to immerse themselves (through interviews) in the experiences of others, focusing on learning their values and needs.

> Trying to develop a good *go-to-market strategy*. So, the go-to-market strategy develops empathy because you get to see what other people actually value. Everyone values different things, but you want to find a set of values that most people want. And in the validation form is where you have to interview people, and you have to use empathy there because you have to make sure you don't offend them, and you ask the right questions. So that would be good to implement, I think. Maybe talking to people and developing market strategies and validation techniques. (Participant 16)

Therefore, it can be noted that in pre-accelerators, engineering students focus on customers trying to create products that can be commercialised. Therefore, the market itself and market-related processes (such as market validation or developing a market strategy) can prefigure conditions for empathy and experiences that shape empathy.

The Interconnectedness of Elements

It is important to note that in this section, the elements that prefigure conditions for empathy experiences and the experiences that shape this phenomenon can be intertwined (interconnected) and represent complex structures. In connection with this, the boundaries of these elements are rather conceptual (interpreted) and not clearly expressed in practice. For example, Participant 15, discussing their experience of empathy, mentioned that this phenomenon is an important part of the design phase and plays a vital role when interacting with various stakeholders. This means that in this context, empathy and experiences that shape empathy occur under the influence of several elements at the same time, namely Design (as the participant mentioned the design phase), and Diversity (as the participant mentioned communication with various stakeholders and peers).

> I guess you're using empathy when you are in the *design phase* because when you're working with *different stakeholders*, people are going to have different views. I would definitely have more group time. For example, at the very beginning, we might have had an intro night or something. I can't remember. But having some form of interaction that is not orientated towards the sole focus of the idea. So, you can have it, but, for example, I have an idea to make a pressure sensing. Well, the first night, you are in your team, right? In 15 minutes, you have to change the team, and you now have to come up with a new

> idea for the same problem as another person. Right. And in an idea's hub, that is a hundred percent is going to be okay. (Participant 15)

Participant 5, in their descriptions of empathy, noticed three elements that sustain the experience of empathy, which are: Market (conducting the market research and focusing on customers), Design (mentioning the Design of products phase) and Diversity (interviewing six people who shared their different views).

> You have to be empathetic to your *customer*. You have to be empathetic to what they say, as they're actually the ones. It's cliche to say, but they're always right. But they're the people who are going to be buying the product. So, when we went out to do market testing, which we'd already done to be extremely empathetic to their needs and their concerns. A hundred people and only six give you really tangible, actual pieces of evidence that actually help your product and the rest give you. But you have to be empathetic to their experience and why they think it's important and approach *all their views* and all their inputs with an open mind. That's my opinion. And so, I used empathy when I did the *market research.* (…) I can express when I'm *designing the product*, and how I might feel when I see my product without having to go and actually ask a person, a real-life customer, every time. And then I guess it also gives you the ability to talk on behalf of your customer because you've empathised with them. You can tell people, on behalf of them, how they would likely feel. (Participant 5)

The above-mentioned engineering students' excerpts demonstrate that, in some cases, the elements can be intertwined, representing a complex structure that prefigures empathy and experiences that shape empathy.

This section presented the contextual elements of entrepreneurial pre-acceleration programs that may prefigure conditions for experiencing empathy and experiences that shape this phenomenon. The engineering student's accounts demonstrate that in the context of the pre-accelerators, the elements mentioned above can impact empathy individually or form more complex structures in which these elements are intertwined and interconnected.

Conclusion

To summarise, this chapter was concerned with discussing the results related to two research questions, which are:

RQ 1. How is empathy experienced by engineering students in pre-acceleration entrepreneurial programs?

RQ 2. What are the experiences that shape empathy in pre-acceleration programs?

This study aimed to illuminate the lived experience of empathy and to interpret the experiences that shape empathy and elements of pre-acceleration programs that may prefigure conditions for the appearance (sustaining) of both types of experiences.

The results of this study firstly demonstrate that empathy is experienced by engineering students participating in entrepreneurial pre-acceleration programs as a multiphase process and as a phenomenon related to different personal attributes and orientations. As a multiphase process, empathy involves five phases (Pause and be conscious, Immerse into the experiences of others, Relate to one's own experience, Synthesise, and Simulate an experience). As a phenomenon related to different personal attributes and orientations, it has seven attributes and orientations: open-mindedness, being able to take a step back, reflectivity and thinking about consequences, orientation

to grow and learn, a win-win orientation, and a problem orientation. In this study, attributes and orientations represent facets of empathy that allow engineering students to experience all the phases of this phenomenon.

The results of this study also demonstrate that the empathy experience may be shaped by different experiences (starting with a broad question, talking with a purpose, being touched through listening to stories, and observing 'clicking' situations). In addition to these experiences, the empathy experience is shaped under the influence of various elements of pre-acceleration programs that represent their contextual characteristics that may prefigure situations or conditions for both the experience of empathy and experiences that shape this phenomenon. These elements are the design process, the community of practice, the diversity of opinions, and the market. Both experiences that shape empathy and program elements can form more complex structures in which experiences are intertwined, creating unified experiences, and in which program elements can also be connected to each other, forming combined elements.

Chapter 5. Discussion

Introduction

This chapter discusses two claims arising from this study and utilises existing scholarly materials and theories in support of these claims. The various qualities of empathy and experiences that shape it are discussed, and a model of empathy in engineering entrepreneurship is proposed. These claims are as follows:

Claim 1 - Engineering students in an entrepreneurial context describe empathy as a complex construct with processual (multiphase) characteristics and a multifaceted nature.

Claim 2 - Engineering students in an entrepreneurial context believe that different experiences shape the experience of empathy and can be prefigured by elements of entrepreneurial programs.

Phenomenological research focuses on interpreting a phenomenon through the lived experience of its participants. Due to the nature of the phenomenological approach, these interpretations may be subjective because they come from participants' individual experiences. To make practical recommendations for educators that can help them design and deliver educational activities to develop or foster empathy, it is essential to support all claims and statements with existing literature and frameworks. Therefore, these claims are tied in with the literature and existing understandings, models and frameworks of empathy that have informed this phenomenological research.

Further, this chapter proposes a model of empathy that demonstrates how empathy is experienced in entrepreneurial programs (pre-accelerators) and the experiences that shape and elements of entrepreneurial pre-acceleration programs that

prefigure the phenomenon of empathy. This model can inform the design of educational activities to foster and develop empathy in entrepreneurial engineering students.

Claim 1

Claim 1 - Engineering students in an entrepreneurial context describe empathy as a complex construct with processual (multiphase) characteristics and a multifaceted nature.

The results of this study demonstrate that when engineering students describe their experience of empathy in the context of entrepreneurial pre-acceleration programs, they highlight the complexity of this phenomenon by noticing different phases and components/facets. They also acknowledge its processual characteristics. This is based on participants' word choices (e.g., verbs) and the metaphors they use when discussing their empathy experiences. The word choices demonstrate some actions and outcomes that these actions can achieve, as in for example, "*put yourself in somebody else's shoes*", "*understand something*", "*imagine how I would...*", "*add other people's experiences to your own*", and "*become a sum of many people.*"

Apart from processual characteristics of empathy, participants also outline their individual characteristics and the attributes that influence how they empathise. This is characterised not only by using processual wording and metaphors but also by adding descriptions of what attributes and orientations engineering students need to have to empathise, such as "*when you empathise, you need to be open*", "*when empathising, you need to be able to take a step back*", "*empathy is about learning*", and "*empathy is about solving problems.*" In this regard, the complexity of the empathy phenomenon is characterised by its multiphase nature and its multiple facets and orientations.

As mentioned earlier, researchers from various fields note the complexity of empathy and its multifaceted and multiphase nature. Gibbons (2011) states that empathy is a dynamic and complex construct determined by various factors. Hess and Fila (2016a) operationalise empathy as a construct that involves affective and cognitive dimensions and self/other orientations. Walther et al. (2016) propose a multidimensional model of empathy in engineering, outlining different facets that shape empathy in the field. Kouprie and Visser (2009) also propose a framework of empathy that conceptualises it as a multi-phased phenomenon. The literature supports the claim that empathy is a complex and multidimensional construct, and that this complexity can be explained by the various current models and frameworks the literature presents.

Academic literature from different fields generally also conceptualises empathy (or achieving/growing empathy) as a linear or cyclical process (Barrett-Lennard, 1981; Nilsson, 2003; Kouprie & Visser, 2009; Stein, 2012). For example, Stein (2012) outlines the three-phase process of achieving empathy as: (1) the emergence of the experience focusing on the past experience of another; (2) ‘‘the fulfilling explication” immersing into the experience and (3) the ‘‘comprehensive objectification” when an empathiser steps out with increased understanding (Stein, 2012). From this description of the process of achieving empathy, the movement of ‘‘stepping” in and out of the other’s experiences can be outlined.

A similar understanding of empathy is also proposed by a range of psychotherapists, describing how an empathiser steps in and out of the other person’s experience (Reik, 1949; Rogers, 1975). Kouprie and Visser (2009) propose “a framework for empathy in design”, building on research from the field of psychotherapy and based on the idea of ‘‘stepping into and out of the user’s life”. The authors outline

four phases: (1) Discovery when an empathiser enters the world of users, (2) Immersion when an empathiser is ‘‘wandering around” trying to understand the world of users, (3) Connection creating an understanding based on one’s own experience and feelings and experience and feelings of others, and (4) Detachment when an empathiser leaves the world of users with increased understanding. Kouprie and Visser (2009) also outline the phases of immersion (stepping in) and leaving (stepping out of) the worlds of others with better understanding by forming a combined experience (considering own and others’ worlds). This process of immersion into and leaving the worlds of others occurs repeatedly.

It is challenging to state (as there are no explicit excerpts) that participants go through all phases linearly (phase by phase) when empathising. The order of these phases can be different, or they can be intertwined. This approach aligns with Smyth’s view (1996), which states that empathy can involve intertwined aspects (e.g., resonant or imaginative empathy) that play an equally important role, and people who empathise need to be able to use both aspects simultaneously. In this regard, the processual nature of empathy is noted in existing models and frameworks of empathy when scholars note the phases of immersion in the worlds of others and leave them with increased understanding. Similar phases have also been identified in this study (Immerse into the experiences of others, Relate to one’s own experience, Synthesise). However, the linearity of these phases has not been confirmed.

In addition to the process of immersion and leaving the others’ worlds through the formation of newly combined experience, the *Simulating experience* phase has emerged from the clarification of engineering students’ empathy experiences. This

phase arose in the students' description of their experience of empathy due to a common understanding of the role of empathy in entrepreneurship as a predictive phenomenon.

The essential practice in entrepreneurship and entrepreneurial activities is predicting clients' behaviour and reaction to opportunity recognition. According to Cohen et al. (2021), entrepreneurs must be able to ''read" the environment and predict trends to identify unmet clients' needs and validate opportunities for developing new products or services. McMullen (2015) claims empathy (empathic accuracy) is an operant between entrepreneurs' beliefs about opportunities and their responses. They add that empathy in an entrepreneurial context is also ''predictive" since entrepreneurs should focus on satisfying what potential customers will want. Packard and Burnham (2021) propose a *process model of simulated empathy* in entrepreneurship, drawing on McMullen's (2015) work, in which they outline *predictive empathy* as an important element. Authors define predictive empathy as a ''mental simulation of what another's experience will or would be like in a not yet experienced context" (p. 7). This study demonstrates that the Simulating experience phase is "predictive" when an empathiser simulates the combined experience in other contexts and with other people to spot an opportunity or satisfy customers' requests or needs. At the same time, this phase could have stood out due to specific characteristics of the entrepreneurial practice in which engineering students were immersed during this study.

Another phase that has emerged from the illumination of engineering students' experience of empathy is the phase of *Pause and be conscious*. Kossak (2021, xi) claims that empathy starts with ''being attuned to our own sensory presence and internal pulse". The author emphasises the important role of the process of attunement when empathising with others. They describe this process as ''an immersion in the present

moment and a sensory awareness of ourselves, others, and the space we inhabit" Kossak (2021, xi). Despite the author emphasising the critical role of attunement when empathising in expressive arts therapy, attunement is also considered an essential element of opportunity evaluation and entrepreneurial cognition in entrepreneurship (Bird, 1988).

In this study, it can be assumed that the phase *Pause and be conscious* is characterised precisely by the "attunement" as engineering students have emphasised that "pause", and "consciousness" help them gain some time to think about the context and conditions. According to Dreher and De Souza (2018), attunement may involve moments of silence and pause that prepare them to listen and focus their attention. In this regard, when interpreting students' descriptions of the phase *Pause and be present*, I rely on Kossak's term attunement when interpreting this phase. However, I also would like to emphasise the intentionality and practicality of this phase, in contrast to some claims that attunement cannot be controlled (Kossak, 2021).

In describing and interpreting the process and phases of empathy, it is also worth noting the important role of personal experience, subjectivity, and intentionality. Some of the engineering students in this study explicitly state that personal experience (e.g., "you may not always be able to efficiently relate events of other people's lives to your own. Because, obviously, if I have not experienced all there myself, then it is going to be hard [to understand]" (Participant 12)) and subjectivity (e.g., "I'd say it's very subjective... that guides how I empathise with people" (Participant 4)) affects how they understand other people's experiences and perspectives. At the same time, when describing the experience of empathy, engineering students emphasised that they used empathy to achieve specific goals ("I use empathy to…") or as a tool (e.g., "I use

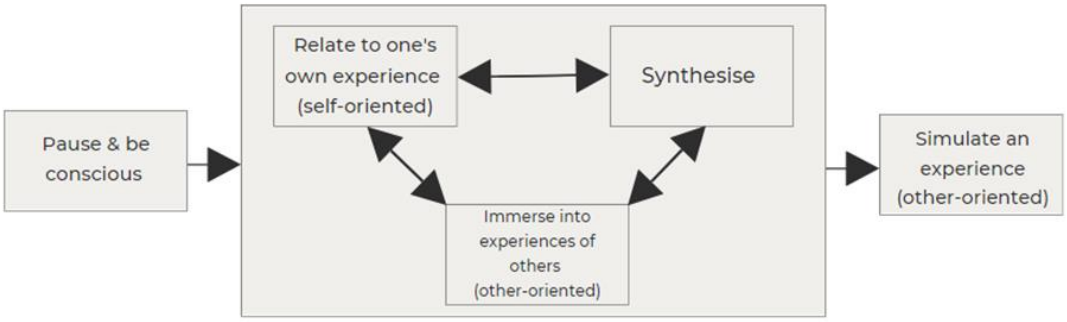
empathy as a tool" (Participant 15)). That is why it can be assumed that engineering students acknowledge the intentionality of this phenomenon.

Packard and Burnham (2021) connect the empathy process to entrepreneurship theory and state that empathy can be characterised as an intentional and knowledge-based process within the entrepreneurial context. In this regard, this emerging process of empathy (from students' descriptions of their experiences of empathy in entrepreneurial contexts) can be conceptualised as understanding and imagining other people's experiences and worlds from their own perspectives. Due to subjectivity (caused by using one's own mental models), the empathy process cannot be perfect, and an empathiser would be prejudiced (biased) in favour of their own interpretations, experiences and knowledge when forming combined experiences and simulating this experience in other conditions.

To summarise, engineering students experience empathy in an entrepreneurial context as a process that requires them to attune to themselves, others, and the context. Then they have to step in and step out from the other people's worlds with a combined experience considering their own perspective and mental models, and then simulate (predict) this experience in other circumstances and with other people (see Figure 6). The existing scholarly literature demonstrated above justifies these phases and their sequence.

Figure 6

Empathy as a multiphase process



Another dimension of empathy that demonstrates the complexity of this phenomenon is its multifaceted nature, and the idea that engineering students should have various attributes and orientations to empathise with others. In this study, I infer the multifaceted structure of empathy based on participants' words that outline different layers of this phenomenon (e.g., "I think that there's like definitely different layers to empathy" (Participant 4)) or based on engineering students' references to qualities and orientations when describing how they empathise with others (e.g., "empathy it's just having an open mindset" (Participant 2)). When experiencing empathy in an entrepreneurial context, engineering students related empathy to the four personal attributes: open-mindedness, being able to take a step back, reflectivity and thinking about consequences. Also, there are three orientations: orientation to grow and learn, problem-solving orientation, and a win-win orientation. This study did not aim to understand all the qualities an empathiser should have or to investigate the role and impact of particular attributes or orientations on each phase. It focused on interpreting the potential characteristics that determine and influence how engineering students in an entrepreneurial context experience empathy. This statement means that these attributes

and orientations were interpreted from student descriptions of their experience of empathy, which in turn may not reflect the actual number of facets of empathy, and potentially other attributes and orientations may also shape the experience of empathy that is not explicitly articulated in students' accounts.

Various authors believe that specific personal attributes relate to empathy or have an impact on this phenomenon. For example, several authors investigate the relationship between empathy and the big five personality traits such as openness, conscientiousness, extraversion, agreeableness, and neuroticism (e.g., Barrio et al., 2004; Song & Shi, 2017; Lermen et al., 2022). The authors emphasise that these traits may predict or determine the level of self-evaluated empathy in different groups of people. Additionally, some studies state that certain characteristics or internal processes of a person, such as analytical thinking, can negatively impact or suppress empathy (e.g., Small et al., 2007; Jack et al., 2013). In this regard, some studies aim to understand what attributes can potentially affect empathy. At the same time, these studies usually do not consider these attributes as part of empathy, but single them out as separate characteristics that can potentially influence empathy and how an empathiser interprets the experiences and perspectives of others.

In recent years, various models of empathy have been proposed that highlight different dimensions and facets of this phenomenon. One example is the model of empathy in engineering (Walther et al., 2016), which relies on the theoretical perspective from the fields of psychology, neurobiology, and social work. According to Walther et al. (2017), empathy can be conceptualised as a complex, multidimensional, and multifaceted phenomenon. The authors outline three dimensions that conceptualise empathy in engineering: empathy as a learnable skill, practice orientation, and a

professional way of being. They show that each dimension is underpinned by different facets (e.g., Affective sharing (skills dimension), Epistemological openness (practice orientation dimension) or Dignity and worth of all stakeholders (professional way of being dimension)). This study of engineering students relied on this model when illuminating the experience of empathy. Personal attributes are a foundation underpinning the process of empathy, while orientations inform engineering students on how to empathise by conceptualising and orienting the application of empathy and related personal attributes in entrepreneurial and engineering contexts. In this regard, it is worth noting that here, based on the Walther et al. (2016) model, I interpret personal attributes and orientations as facets of empathy that underpin the process of empathy and inform engineering students about the orientation of this process (See Figure 7).

Figure 7

Empathy as a phenomenon related to other attributes and orientations.

In conclusion, the claim that empathy is a complex construct has been made relying on the results of this study and descriptions of engineering students' empathy experiences. This is supported by the literature and research demonstrating that empathy can be conceptualised as a multiphase process underpinned by personal attributes and orientations representing facets of empathy. The process of empathy involves the attunement phase when engineering students attune to the context considering their state and characteristics of others, then immerse into and leave the worlds of other people with an increased understanding (combined experience), taking into consideration the personal experience and perspectives, as well as perspectives of others. They then

simulate (predict) this combined experience in specific situations and with a wider audience. This process is underpinned by four personal attributes: open-mindedness, being able to take a step back, reflectivity, and thinking about consequences. There are also three orientations, such as orientation to grow and learn, problem-solving orientation and win-win orientation, each of which informs how engineering students empathise and respond to situations in entrepreneurial and engineering practice.

Claim 2

Claim 2 - Engineering students in an entrepreneurial context believe that different experiences shape the experience of empathy and can be prefigured by elements of entrepreneurial programs.

The second claim based on the results of this study is that empathy can be shaped by different experiences and prefigured (create conditions for empathic manifestation) by elements of entrepreneurial programs. In this study, one of the aims is to understand what entrepreneurial experiences shape engineering students' empathy. Conclusions about the connections of the emerging (interpreted) experiences and empathy experiences were made based on the engineering students' descriptions of various experiences that were present (had an impact on) when discussing their empathy experiences. These connections are characterised by noticing experiences that impact empathy through connecting prepositions and phrases such as "*I am trying to empathise with…", "to empathise you need firstly…",* and *"I empathise after…".* At the same time, conclusions on the impact of elements of entrepreneurial pre-acceleration programs have been drawn based on the accounts of engineering students when they described particular situations when they empathised (were encouraged to empathise). In this regard, to interpret experiences that shape empathy, I focused on experiences that

emerged in connection with the experience of empathy and further interpreted the contextual elements of entrepreneurial programs that may create conditions for the manifestation of both types of experiences.

The claim that empathy can be facilitated or shaped under the influence of different elements and experiences within educational programs or different pedagogical approaches has been made by many researchers. Cuff et al. (2016) provide an example of one of the dichotomies inherent to empathy; this relates to whether it is a contextual or trait concept (stable). In this review, the authors conclude, relying on evidence from different studies, that empathy is influenced by both state (contextual) and trait characteristics. Despite recognising empathy as an inherent trait, the authors also recognise that this phenomenon's manifestation (fostering) or development can occur under the influence of various contextual elements or situations. Hess and Fila (2016b) state that empathy can be developed or nurtured within specific educational contexts and under the influence of specific techniques, such as Design Thinking, Service-Learning, Collaboration or Ethics Education. Yeaman (2020) identifies different elements of service-learning programs, such as Course design, Community encounters, Direct interaction, and Diversity, that could shape the development of empathy. Lunn et al. (2022) conducted a systematic literature review of different approaches and techniques that can be used to develop empathy in students from STEM fields. The author identified the following common approaches that can be used to foster empathy: Narrative and Creative Arts Techniques (e.g., poetry), Communication Skills Training or Interventions (e.g., role-playing), Problem-based Learning, Stakeholder Engagement or Interactions, and Experiential immersion. In this regard, it can be noted that empathy is a phenomenon that can be fostered or shaped by various elements of educational programs and external experiences.

The results of this study demonstrate that engineering students, when describing their experience of empathy, also highlighted specific contextual elements of pre-acceleration programs (e.g., design tasks, Communities of Practice (CoP)) within which various experiences can exist that shape the experiences of empathy. These elements are related to the educational component of pre-accelerators (workshops, group activities) and the entrepreneurial practice (pre-acceleration programs aimed at creating conditions for entrepreneurship). For example, in pre-acceleration programs, students, apart from identifying the problem or market needs (Market), should form teams of same-minded people (CoP) to come up with a prototype (Design task) and communicate with other startups and stakeholders (Diversity). Within each element, students can live through experiences that form empathy. For example, the pre-acceleration programs provide engineering students with the opportunity to talk to different people (Talking to others), hear different stories (Being touched through listening stories), observe different situations (Observing ‘‘clicking” situations), or work on tasks or problems that may raise questions (Starting with a broad question). These can, in turn, shape an empathic response (experience of empathy). Engineering students relate these experiences with specific program elements, and different experiences that may exist within these elements and help to shape their empathic response.

In this study, four experiences that shape empathy emerged from the accounts of engineering students. The first experience is “Starting with a broad question”. The connection between empathy and the process of asking questions is given in the work of Huang et al. (2017). The authors state that asking questions may indicate empathy and positive attitudes towards others. However, in this study, a broad question arises not from conversations with others but from the necessity of understanding the context for solving an entrepreneurial problem. According to Rasoal and Ragnemalm (2011), when

students engage with a problem within problem-based learning, it encourages them to empathise with others. To solve a problem, in most cases, it is necessary to understand the causes of this problem, considering the main stakeholders. One of the first phases of identifying a problem's causes may be forming a broad question to direct the research process. Since, in the entrepreneurial context, the research process involves the consideration of stakeholders' perspectives, it can potentially encourage engineering students to empathise.

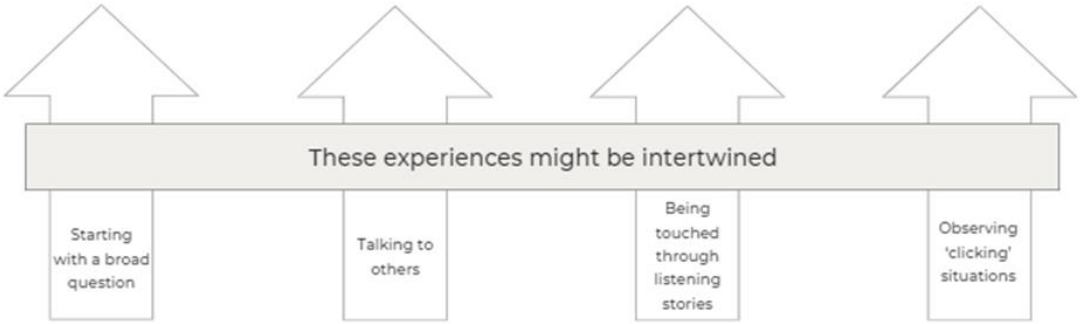
The second experience is "Talking to others". According to Harlynking (2019), conversations are a powerful tool for fostering empathy. In their study, participants were involved in two types of conversations (emotional and factual), and all the participants demonstrated increased empathy at the end. That is why when talking to others, engineering students have a chance to empathise with others.

The third experience is "Being touched through listening to stories". The relationship between empathy and the process of listening is noted in studies from various industries, for example, medicine (Halpern, 2003) or sales (Aggarwal et al., 2005). Empathy can be shaped during listening if an empathiser forms an emotional connection with the person they talk to. This connection (and, therefore, an empathic response) can emerge when an empathiser listens to not just routine dialogues but also when it takes the form of a story (Baker-Graham, 2016) or narrative (Walkington et al., 2020). Based on the existing scholarly literature, this study highlights that empathy can be shaped by "touching stories" and not just through listening since empathy manifests itself when there is an emotional connection. So, various researchers state that listening can influence empathy if an emotional connection is formed (which may occur through stories or narratives).

The fourth experience that may shape empathy is *Observing ‘‘clicking” situations*. According to Lamm et al. (2007a, 2007b), empathy can be activated through observations if the first-hand experience of the empathiser involves similar neural representations, meaning that if an empathiser has previously experienced a similar ‘‘clicking” situation that caused sensory or affective responses (e.g., through emotional and bodily awareness), then it is likely that empathy may be activated during observations. Lamm et al. (2007a, 2007b) made this statement after researching how empathy is activated when observing pain. Engineering students have the opportunity to observe various situations in entrepreneurial pre-accelerators. For example, Skaggs (2018) states that empathy might be experienced through observation in the context of design thinking. Empathy can be activated as engineering students are usually asked to observe potential clients’ behaviour to understand their problems in the context of design thinking (which is commonly used as a theoretical foundation in entrepreneurial programs). This can elicit specific reactions and empathy if they have experienced similar feelings or body patterns or when observed experiences “click” (ignite) some other feelings such as interest or curiosity. In this regard, relying on the existing literature and the results of this study, it can be concluded that empathy may be formed (be activated, manifested, or fostered) under the influence of various experiences, such as when asking a broad question when talking to others and when hearing stories or observing situations (See Figure 8). This figure demonstrates the intertwined nature of the experiences that may shape empathy in pre-acceleration programs. This was proposed relying on the results of this study and discussed literature as several experiences simultaneously can encourage engineering students to empathise. At the same time, the "arrows" demonstrate that other experiences can influence and shape the experience of empathy, which is also supported by literature.

Figure 8

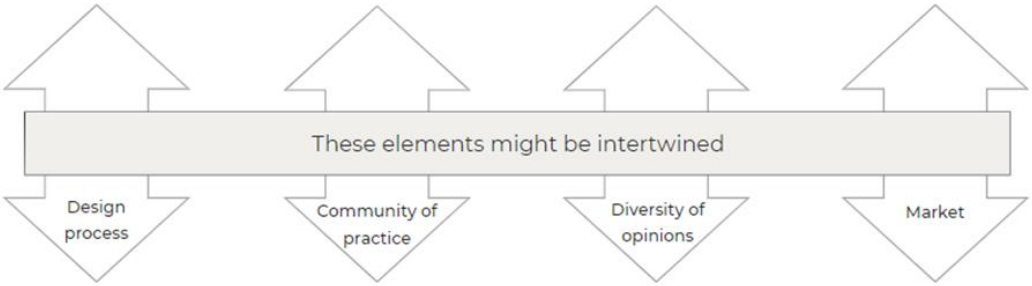
Experiences that may shape empathy in pre-acceleration programs.



At the same time, the results of this study, based on the engineering students' descriptions of their experience of empathy, demonstrate that this phenomenon can be shaped under certain conditions within specific elements of entrepreneurial pre-acceleration programs. This means that these elements can form conditions (prefigure) both for the manifestation of the experience of empathy and for the experiences that shape this phenomenon (See Figure 9). This figure demonstrates the intertwined nature of elements that may prefigure empathy in pre-acceleration programs as these elements can be connected to each other. This claim is made relying on the results of this study and the literature discussed in this section.

Figure 9

Elements of pre-acceleration (entrepreneurial) programs that prefigure conditions for both types of experiences.



The first element that engineering students have associated with their experience of empathy is *design*. According to James et al. (2018), design tasks and problems may encourage engineering students to consider the perspectives of others and, therefore, create conditions for empathy by caring about the needs of different project stakeholders. Hess and Fila (2016b, p. 8) state that "any projects where designers interact with or design for others (which, we would argue, is most design projects) are suitable for empathic utilization and, thereby, empathic growth" and that "design tasks where the user is highly visible are likely to manifest in a greater utilization of empathic techniques among designers". In this regard, the "design" element that is an essential part of entrepreneurial pre-accelerators and entrepreneurship can potentially represent an environment (taking into consideration the existing practice and the aims of the processes that make up this element) in which empathy and other experiences shaping this phenomenon would be manifested.

The second element of entrepreneurial pre-accelerators that may prefigure empathy is "diversity". The entrepreneurial process involves diverse stakeholders who

can benefit entrepreneurs, such as resources, knowledge, insights, or ideas (Witt, 2004). An entrepreneur must clearly understand the needs of stakeholders to achieve business success and receive benefits from them, and Holt et al. (2017) state that it is difficult to understand their wants and situations without empathy. Since entrepreneurial pre-accelerators involve engagement with various stakeholders, engineering students may potentially need to use empathy to identify the needs of stakeholders. That is why diversity can create conditions for the manifestation of empathy. The relationship between empathy and diversity of opinions is also highlighted in the following studies. Yeaman's (2020) study shows that diversity and different kinds of direct communication within service-learning programs may shape the development of empathy in engineering students. Kasl and Yorks (2016) also highlight the important role of empathy in diverse groups.

The third element is CoPs. In pre-accelerators, participants work in groups to solve different entrepreneurial problems, which can be considered CoPs. Van Weele et al. (2018, p.185) state that a startup community resembles a CoP due to "their strong shared identity, tight social relationships and sharing of practices." Empathy is an essential component of CoPs as it helps maintain group dynamics. Hemmig (2009) investigated the CoPs of artists and concluded that empathy and emotional support from other artists (like-minded) are key elements of these practices. Like artists, engineering students may use empathy to maintain good group dynamics, implying that this element (CoP) may prefigure conditions for empathic experiences. However, this assumption certainly needs to be verified.

The final element that has emerged from this study is the market. Market and collaborations with potential clients are the key differential factors of entrepreneurial

pre-accelerators compared to classic entrepreneurial subjects. As part of these programs, students can interact with potential customers who form a market to receive feedback on their ideas or identify their problems and needs. In this situation, offering a more appealing product to customers is important. According to McMullen (2015), empathy is a necessary component of an entrepreneurial value proposition that allows entrepreneurs to determine whether their idea is competitive enough. The necessity to offer more effective propositions (against competitors) may encourage engineering students to use empathy toward stakeholders or competitors and go through the experiences that shape this phenomenon.

The literature demonstrates the relationship between all four identified elements and empathy, which in turn means that the following elements may potentially prefigure conditions for engineering students to experience empathy and form specific notions and descriptions of this phenomenon.

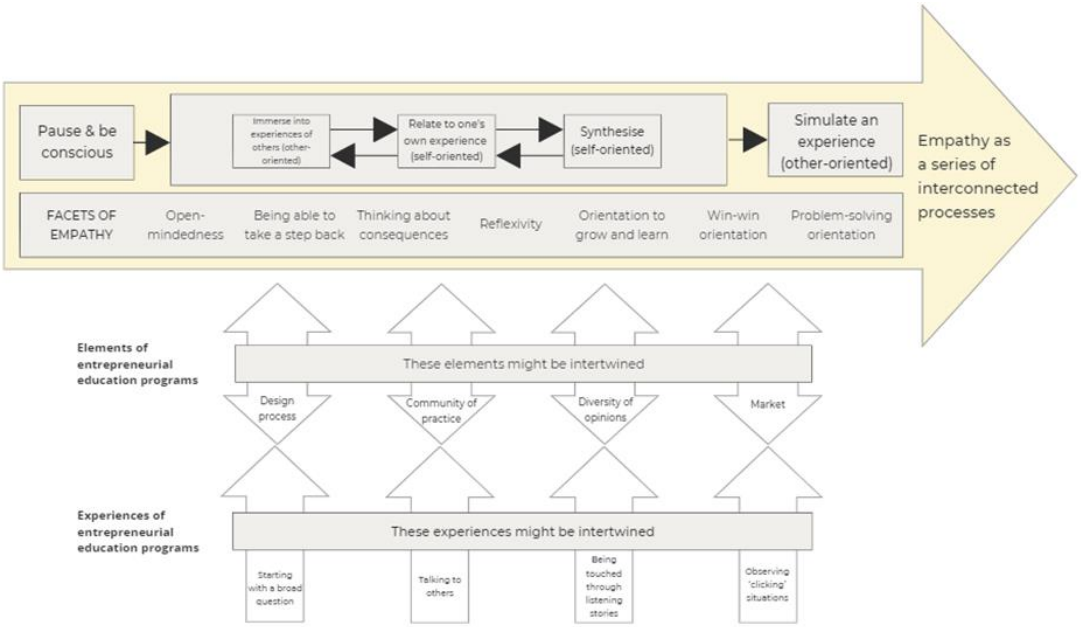
This chapter provides theoretical justifications for the research results that engineering students can experience empathy as a multiphase process. That involves the attunement phase, or immersion into and leaving the worlds of others with a combined experience of considering the personal and others' perspectives and simulating the combined experience in other situations and contexts. Empathy in entrepreneurial pre-accelerators can also be represented as a multifaceted phenomenon (underpinned by four personal attributes and three types of orientations). The current scientific literature also demonstrates that different experiences may shape empathy (e.g., Starting with a broad question, Talking with a purpose, Being touched through listening to stories, and Observing ‘‘clicking" situations) and that this phenomenon can be prefigured

(manifested in) by specific contextual elements of educational programs (e.g., design, the community of practice, diversity of opinions and market).

Based on the results of this study and the existing literature, I propose a model of empathy (See Figure 10). It is worth recalling that this model has emerged from engineering students' subjective descriptions of their experiences of empathy and my interpretations. This model demonstrates that empathy is experienced by engineering students in entrepreneurial pre-accelerators as a five-phase process (Pause and be conscious, Immerse into the experiences of others, Relate to one's own experience, Synthesise, and Simulate an experience). The process is linear and cyclical and underpinned by personal attributes and orientations. At the same time, this model demonstrates four intertwined experiences that shape the experience of empathy and four elements of pre-acceleration programs that may prefigure empathy. The connections between elements are made relying on existing scholars. However, this model requires empirical evidence that confirms the existence and connection of all the elements of this model. This model can encourage educators to rethink the traditional understanding of empathy and can help to understand the complexity and necessity of empathy in engineering and entrepreneurial practices.

Figure 10

The model of empathy experienced by engineering students in entrepreneurial pre-accelerators.



Reflection on the Findings

While this research did not aim to make statements about changes in empathic experiences and abilities or identify the connections between empathy and morality, I believe it is important to share several insights. The study insights can help future researchers clarify the phenomenon of empathy in entrepreneurial engineering and how entrepreneurial educational programs such as pre-accelerators support the development of empathy.

Empathy and Morality of Engineering Students in Entrepreneurial Pre-accelerators

Previously, it was mentioned that one of the facets of empathy is the win-win orientation (which emerged from the results). To describe this facet, engineering

students state that when they empathise, they usually want to benefit from these interactions (e.g., understanding customers' needs) and help their customers/other stakeholders (usually by proposing more customised solutions). However, when mentioning that they empathise in order to understand others better (which in turn can help engineering students design and develop customised products), many participants stress the words "care" and "help" in the context of empathy, and as an outcome of this process notice "making lives of others better". This fact makes one consider whether engineering students characterise empathy as a moral value and what role entrepreneurial activity (if any) plays in understanding empathy as a moral value. When answering the questions about empathic engineers and outcomes of empathic experience Participant 20 states, "it makes the lives of other people better. When you are considerate about that situation or when you're caring about that situation, we can help people."

The engineering codes of ethics in various countries state that engineering activity itself should focus on bringing benefit (duty) to society and public welfare (e.g., National Society of Professional Engineers, 2019). In the early stages of research on empathy in engineering, different researchers suggested that integrating empathy into engineering programs should be done in conjunction with developing students' morality (Rest & Narvaez, 1994; Baxter, 2014) as both these phenomena can help in developing ethical obligations placed on modern engineering professionals (Howcroft et al., 2021). The link between empathy and moral development has been noted and established in existing literature (Hoffman, 2001). The requirements for engineering practice and the initial goal of integrating empathy as a moral value into the engineering process could potentially influence the engineering students' understanding of empathy as a moral value or from mental connections between empathy and morality.

The entrepreneurial practice may also encourage practitioners to pay special attention to moral aspects. Landowska et al. (2020) state (relying on Tomasello's (2009) work) that entrepreneurs, like other human beings, are required to cooperate to achieve success. Curry (2016) also adds that for successful cooperation, sharing universally accepted moral values is important. According to Hannafey (2003), entrepreneurs face different problems related to moral dilemmas. In this regard, when researching and solving entrepreneurial problems (to propose successful customer-oriented solutions) and when interacting with stakeholders, entrepreneurs should make decisions considering moral aspects. The entrepreneurial practice itself may potentially encourage practising entrepreneurs to see all "learned concepts and models" (e.g., empathy) through the lens of morality.

This study was not designed to investigate whether engineering students in an entrepreneurial context consider empathy as a moral value. However, analysing students' accounts, when describing empathy, some students associate this phenomenon with moral values, clarifying that empathy is necessary to help people and improve their lives. The above-mentioned reflective notes require further validation and empirical evidence. Future empathy researchers may want to more closely examine whether there is any relationship between empathy and morality.

Changes in Engineering Students' Understanding of Empathy

Another insight that emerged from analysing, interpreting, and clarifying the experience of empathy in the data collected is that some students stated that their understanding of empathy changed during their participation in pre-acceleration programs.

> I always thought of empathy as being very tied to caring for someone. For me, after the pre-acceleration program, after working in the startup space. My definition of empathy changed in the context of entrepreneurship, being that to be a good entrepreneur, you need to empathise with the problem being solved. Prior to that, it might have just been to be an entrepreneur; you need to empathise with the team. My definition of what empathy meant was just restricted to the ability to understand someone's perspective, whereas now it's being able to understand a societal issue and empathise with it. (Participant 14)

It is important to highlight that this study was not aimed at comparing engineering students' interpretations of their empathy experiences before and after the programs. However, I consider it valuable to pay attention to the change and propose future researchers investigate this topic in more detail.

As mentioned above, many researchers believe that empathy can be facilitated (Walther et al., 2016), and controlled (Hodges & Wegner, 1997), and the way people empathise and, therefore, understand this phenomenon can change under various conditions and within specific contexts. Yeaman (2020) notices that engineering students might change their perspectives on empathy within the context of service-learning programs. Therefore, engineering students' empathy and understanding are not static, and there is a possibility that, under the influence of various contexts, they may change their understanding of empathy and its role.

It was also mentioned above that the entrepreneurial programs and elements included in these programs and the entrepreneurship experience could encourage engineering students to apply empathy or begin to study related tools and information. So, in most pre-accelerators, engineering students can become familiar with the theories

and definitions of empathy as part of design thinking, market validation workshops or when applying empathy-related tools such as an empathy map, customer journey map, and personas. In this regard, pre-acceleration programs provide many opportunities for engineering students to change their understanding of empathy. However, since pre-accelerators include many educational and entrepreneurial experiences, it is important to have empirical data confirming the role of certain elements in changing the understanding of empathy of engineering students.

This section provided some reflective notes that have emerged from this study but are not directly related to this project's aims. These notes represent the assumptions that were made during the analysis of the acquired data. These notes should be verified by demonstrating some empirical data in future studies to draw conclusions about the validity of these assumptions. Students' descriptions of their empathy experience raise questions about the relationship between empathy and morality and whether pre-acceleration programs are causing the change in engineering students' understanding of the role of empathy and empathy itself.

Implications for Engineering Education

This research provides implications for diverse groups of stakeholders, including engineering researchers, educators and practitioners, startup founders and investors, engineering students and entrepreneurs, as well as the general public. The primary outcome of this study is a model of empathy experienced by engineering students in entrepreneurial pre-accelerators, which is formed based on the clarification and interpretations of engineering students' descriptions of their experiences of empathy in pre-accelerators (entrepreneurial education). It is important to note that this model has

been formed based on the results of a hermeneutic phenomenological study that did not attempt to understand the object but sought to understand its meaning (Levinas, 1987). Therefore, this model represents how engineering students make meaning out of their empathy experience, which is lived through their eyes. In this regard, when reading a further discussion on implications and practical recommendations, it is essential to keep in mind that when illuminating and interpreting engineering students' experiences of empathy, I did not aim to investigate empathy objectively but to explore some "invisible" contextual elements and contribute to changing understanding of the phenomenon of empathy. That is why the following implications and recommendations are made to encourage researchers and educators to look at the phenomenon of empathy in entrepreneurial engineering from a new perspective.

For Engineering Educators

The model of empathy experienced by engineering students in entrepreneurial pre-accelerators conceptualises empathy as a process sustained by specific personal attributes and orientations considered empathy facets (e.g., being open-minded, adaptable, reflective). This process can be shaped by different experiences (questioning, observing, talking, listening) within specific contexts such as design, CoP, market, and diversity. The experiences that shape empathy and the elements that prefigure conditions for both types of experiences represent complex structures. Therefore, it is difficult to single out the role of a specific element, as they are intertwined with each other and usually work together. This model can encourage educators to consider this phenomenon's complexity and pay greater attention to factors and elements that can shape it.

Firstly, engineering educators should consider that empathy potentially is not only a procedural phenomenon accompanied by mental and behavioural processes, but it also requires various facets that support this process. The study results demonstrate that when students describe empathy, they not only describe phases but also mention facets that support this process. This means that students should understand not only all the phases of the process but also possess or develop specific attributes and orientations to be able to experience all its phases. In this regard, educators are required to explicitly articulate and explain to students the role of each phase and potential outcomes to help them go through all the phases of a process. Educators should also pay attention to attributes that can support the process of empathy as the study results demonstrate the important role of facets when experiencing empathy. This understanding follows Stein's (2012) interpretation of the nature of the empathic response. Stein (2012) claims that empathy can be facilitated by focusing on developing specific attitudes, qualities, or behaviours rather than focusing on developing this phenomenon. Thus, when integrating empathy into engineering programs, it is vital to consider the procedural features of this phenomenon and the attributes/orientations that support this process.

Recommendation 1 - To consider not only processual characteristics of empathy but also attributes and orientations that support this process.

The development of attributes and orientations can be achieved in many different ways. Next, some examples of approaches that can help achieve this goal are presented. It is worth recalling that these examples need further validation. However, engineering educators may consider these examples as potential interventions to be tested in practice. For example, firstly, within the framework of entrepreneurial educational interventions, educators (who set the goals to facilitate empathy in

engineering students) may have modules (e.g., case studies) aimed at prompting students to practise epistemological openness (open-mindedness) by evaluating different experiences and values that are different from their own. This should be done in a safe environment (with humility and guiding questions) to ensure students can fight confirmation bias, which may lead to closed-mindedness (Kruglanski, 2004).

Secondly, according to Dohrenwend (2018), reflection is a foundation for empathy, as thoughts and feelings that are not acknowledged and accepted may ‘‘contaminate” or ‘‘block” empathic reasoning. That is why engineering students should have a chance within engineering programs to reflect on the acquired experience or perspective. Reflection may nurture the combined experience by outlining the connections between one’s own and others’ experiences. Educators may also use different reflection prompts to guide students’ reflective sense-making of other people’s experiences to foster their reflexivity quality.

Thirdly, empathic people are considerate of one another (Kuhmerker, 1975). Attention to detail can help engineering students form a more holistic image of the experiences of others. Educators may encourage engineering students to share the details of their own experience and discuss the details of the experience of others, followed by a paraphrasing activity to ensure an empathiser and an empathisee understand details properly.

Fourthly, it is also important to consider giving students a chance to understand their goals and values to follow the win-win approach. Within the framework of entrepreneurial pre-accelerators, engineering students not only declared their desire to help others but were also aware of why they do it and how it can help them in their projects. Finally, the program can follow an iterative approach, stimulating various

changes and allowing students to pivot their perspectives and let go of some of their ideas. These approaches demonstrate how attributes and orientations can be fostered to support empathy.

In addition to the personal qualities of an empathiser, engineering educators who want to incorporate empathy in a curriculum may consider contextual features, such as social and cultural characteristics and environmental factors, as important elements in facilitating the facilitation of empathy as well. As revealed in this study, different experiences can form empathy. At the same time this study demonstrates that elements of entrepreneurial programs may prefigure these experiences and the experience of empathy itself. In this regard, engineering educators should pay attention to the environment and settings and the fact that students understand all the phases of the empathy process and possess the necessary attributes and orientations.

Recommendation 2 - To consider environment and learning settings as elements that may prefigure empathy.

Another element of entrepreneurial programs (pre-accelerators) that may prefigure empathy experience is design. Design as context can also be a source of experiences that shape empathy. The context of design, customer needs, and problems and product orientation can prefigure different experiences that shape empathy, such as talking to others, starting with a broad question, creating conditions for forming personal attributes and fostering empathy. Considering the findings and the results of existing studies demonstrating the connection between empathy and design practices, it can be assumed that design-oriented entrepreneurial educational interventions that include customer-oriented projects can create conditions for empathy manifestation. An example of such approaches can be design-oriented projects or activities that encourage

the creation of client-oriented prototypes. However, it is worth remembering that even in a suitable environment and setting, such as design tasks or projects, students must have attributes and understand all the phases to foster empathy.

The other identified contextual aspects that can prefigure the process of empathy are CoP and diversity. Trust, empathy and reciprocity are the building blocks for relationships that unite members of CoP (Preece, 2004). To promote empathy, educators can integrate elements of CoP into their programs and educational activities. In their study, Buysse et al. (2003) present different examples of applying the CoP approach from the education literature. Although the projects presented in this study have different goals and conditions, there are some commonalities in these projects that engineering educators should consider when trying to apply the CoP approach to create conditions for empathy, such as regularity, opportunities to share their own perspective in a safe environment and opportunities for self-development. Barab and Duffy (2000, p. 35) state that the essential element of CoPs is the "development of self through participation in a community". In this regard, when creating conditions for CoP, it is also necessary to allow students to set their own goals and expectations. At the same time, within the framework of these communications, it is important to give students the freedom to share any thoughts to promote the diversity of opinions that can prefigure empathy.

The final contextual element is the market. As mentioned, the desire to propose more effective and commercialised solutions than competitors may foster engineering students' empathy towards stakeholders and customers. The process of interaction with stakeholders should take place in real conditions. Therefore, when integrating empathy, engineering educators can involve real stakeholders in educational activities to give

students a chance to understand their needs and receive feedback on their ideas. In this context, there should be a focus on creating opportunities for students to offer practical solutions to real problems rather than simulating competition since it can motivate people to avoid empathy (Zaki, 2014).

For Engineering Education Researchers

As mentioned above, one of the outcomes of this study is the model of empathy experienced by engineering students in entrepreneurial pre-accelerators, which was obtained using a hermeneutic phenomenological study. This model includes various phases, orientations, attributes, experiences, and contextual elements that shape empathy. Engineering researchers can use this model to develop new hypotheses and studies related to empathy in engineering and entrepreneurial contexts. These studies can focus on verifying the identified elements and phases of empathy in this study and identifying new elements of this phenomenon. Also, this model can serve as a starting point for further research to explore in detail the contextual elements of the pre-acceleration program that can encourage engineering students to empathise or develop empathy.

Another important implication for engineering education researchers is that this study demonstrates the first attempt to understand how complex constructs (empathy) are experienced and shaped in transdisciplinary fields such as entrepreneurial engineering. This study indicates that both types of practices (elements of entrepreneurial and engineering activity) impact how empathy is experienced. New emerging technologies and the increasing importance of human-oriented approaches are shaping new types of engineers. In this regard, engineering education researchers can

use the findings to design future research to study empathy in other transdisciplinary engineering contexts.

For Startups and the Business Community

In addition to benefits for the engineering education and research community, there are also implications for the startups and business stakeholders. Currently, the business community pays serious attention to the creation of various types of programs aimed at developing entrepreneurial and social skills in technical specialists. Examples of these programs are accelerators, incubators, pre-accelerators and others. According to Merguei (2022), pre-acceleration programs are a relatively new element of the entrepreneurship support ecosystem. In this area, a dialogue is currently underway on what educational activities and environmental elements should be included in these programs. Since empathy (given the benefits that it can bring to entrepreneurial and engineering practices) is an essential competency for both engineers and entrepreneurs, it should be included in entrepreneurial education and support programs. Startup community stakeholders can use the results of this study when creating entrepreneurial programs or funding for the creation of similar programs aimed at training future entrepreneurial engineers with well-developed empathic abilities. The results of this study can also be used to design checklists or outline key performance indicators that can be used to evaluate the effectiveness of pre-acceleration programs in terms of developing empathy in entrepreneurial engineers.

For Engineering Students Who Want to Pursue Entrepreneurship

Engineering students who want to pursue entrepreneurship and learn more about empathy can use the study results and the stories of other engineering students that show

how they (other students) experienced this phenomenon and what factors influence it. This can help future entrepreneurial engineers form their strategies, techniques and understanding of how to develop their empathy and the challenges they may encounter when developing their empathy (or its facets) or using it in the context of entrepreneurial engineering.

The peer-to-peer component is an essential element of different structured entrepreneurial programs, including pre-accelerators, as students have an opportunity to work together when shaping their business ideas, and creating and developing products. Peer-to-peer interactions encourage pre-accelerator participants to act as a team and help others. This is crucial for improving their competencies. Engineering students already involved in an entrepreneurial context can use this model to form group strategies or approaches to develop their empathy or use this model to raise awareness among startup participants about this phenomenon. These strategies can allow them to understand this phenomenon, what attributes and orientations they need to develop to improve their abilities, when empathy is essential, and what benefits it can bring to their entrepreneurial practice.

For the General Public

In addition to entrepreneurship and engineering, empathy, in general, is an essential component of human relationships. According to Gentry et al. (2015, p. 643), “research indicates that people with empathic concern do tend to behave in observable ways that show concern for others and are focused on others”. Considering the role of empathy in relationships with others, more and more people and professionals from various industries demonstrate a particular interest in developing and studying this phenomenon to improve the quality of relationships with others and improve their own

emotional intelligence and communication skills. Although this model was derived from the descriptions of empathy experiences by engineering students in entrepreneurial accelerators, the general public can also use the results of this study to understand the complexity of this phenomenon, understand the role of specific environmental elements in the formation of empathy, and develop their strategies for enhancing their own empathy.

Empathy is also an important component of leadership. According to Hopkins et al. (2015) and Marques (2015), empathic leaders are able to receive respect and build loyalty and commitment from others. At the same time, empathy can help leaders predict other people's actions (Badea & Pană, 2010; Wang & Seibert, 2015). Considering these benefits, senior specialists at various levels, educational departments, and other individuals in the workplace are considering various initiatives to create environments and activities to develop leaders in the workplace. Since empathy is an essential element of leadership, the general public can use this model to shape culture or develop approaches to enhance empathy in future leaders.

Some academics and researchers investigate the relationship between empathic skills and personal well-being. For example, Mehrabian (1996) states that empathy may positively impact people's emotional well-being. People with well-developed empathy feel that their actions positively impact others, and their understanding of that may bring more good feelings and a sense of happiness into their lives. Wei et al. (2011) also find a positive correlation between empathy and subjective well-being. In this regard, entrepreneurial engineers and the general public interested in improving their own well-being can get acquainted with the results of this study to create personal strategies to improve their understanding of empathy and improve their well-being.

In addition to those interested in improving the quality of relationships with other people, the formation of leadership skills in the workplace or the improvement of one's own well-being, the results of this study can be used to form professionals for whom social contribution to society plays an important role. This study has been based on requests from academics, researchers, and other stakeholders focusing on the preparation of more empathetic engineers and entrepreneurs. If educators, researchers, and other stakeholders take seriously the recommendations for integrating empathy into programs and subjects aimed at preparing entrepreneurial engineers and other socially oriented specialists, the general public can be the beneficiaries of this study. Empathic engineers, entrepreneurs, and other socially oriented professionals are expected to be able not only to create more customised and human-oriented products, solutions and ventures but also to consider moral obligations and social awareness as essential elements of their practices.

Limitations of the Study

Every research has certain limitations based on its characteristics. This study's main limitations are associated with using the phenomenological approach. The underlying nature of this approach lies in the investigation, illumination and interpretations of descriptions and accounts of participants who had the opportunity to experience a similar phenomenon. The sample of participants within the phenomenological inquiry should not be large, and it does not allow for transferring the study's results to wider cohorts and program types. That is why this study shed light and provided a general understanding of how empathy is experienced by the twenty engineering students who took part in four Australian entrepreneurial pre-acceleration programs. It is important to consider more pre-accelerators as each entrepreneurial program can include many unique approaches, speakers, or events that may impact the

experience of a phenomenon. Also, some types of engineers, for example, Civil or Humanitarian engineers, were not represented in this study, which is also a sample-related limitation. It is necessary to further investigate this phenomenon with phenomenological studies to reach a saturation point where different accounts and descriptions emerge from various research sites and participants. As a result, this will allow researchers to draw further conclusions about empathy in entrepreneurial engineering.

The second limitation of this study is that engineering students' descriptions of empathy are self-reported, and the students rely on their memory and personal beliefs about empathy. Memory is not an ideal source of information. Participants cannot always remember their own experience of the phenomenon and describe all its elements and details. In addition, participants may choose not to disclose some aspects of their experiences that do not fit into their preferred model of values and beliefs. In phenomenological research, this problem is usually mitigated by interviewing several people and analysing the resulting descriptions separately and then together to identify common patterns (Zeivots, 2015). However, due to the small sample, finding out what is hidden is not always possible. Also, for this study, I recruited a few participants who had completed the program a few months previously. This may have influenced the recall of their program experience and therefore, their descriptions of empathy. Some participants participated in other entrepreneurial programs (e.g., incubation programs), which could also have influenced how they described factors that affect empathy. This study did not attempt to understand the role the participants' values and beliefs played in their empathy descriptions. The lack of any understanding of this could also influence an interpretation and illumination of empathy because the students described their experience of empathy based on their memories and personal beliefs.

The COVID-19 pandemic and related restrictions triggered another group of limitations. Firstly, as mentioned above, most interviews were conducted online due to social-distancing restrictions. In a few cases, some participants' words or phrases were inaudible, and the internet connection was occasionally interrupted during an interview. While it is important to highlight how these limitations might affect some excerpts, the actual numbers of misheard words and the frequency of internet connection interruptions were relatively limited. In addition, I aimed to overcome these issues by repeating questions and following up with some students after the interview. That is why these limitations provided a limited impact on the quality of data.

Secondly, due to pandemic restrictions, engineering students were encouraged to undertake most pre-accelerator events and activities online. As mentioned above, in pre-acceleration programs, students usually attend various educational events (for example, workshops), interact with peers when discussing ideas or products, and participate in discussions with different stakeholders. However, due to social-distancing restrictions, they did not have a chance to experience these program elements and activities offline. This could impact engineering students' experiences of empathy since empathy is primarily an interpersonal phenomenon enriched by physical presence.

Future Research

As mentioned above, the main result of this study is a model of empathy for engineering students in pre-acceleration entrepreneurial programs. This study represents the first step (starting point) towards building validated models of empathy in entrepreneurial engineering that can be used to incorporate empathy into the engineering curriculum focused on preparing empathic entrepreneurial engineers. Therefore, discourse on specific competencies in entrepreneurial contexts should

continue. The findings of this study demonstrating the complexity of empathy and the contextual nature of this phenomenon are open for further investigation, critique, and clarification. in the future, researchers can conduct some empirical studies to test the components of the proposed empathy model or explore empathy phenomena in other entrepreneurial education and support programs, such as entrepreneurial incubators, accelerators, and boot camps in various geographic locations. It can also include a wider and more diverse engineering audience using the current understanding of empathy that has emerged from this study.

The other recommendation for future research is to keep researching components/facets of empathy. The results of this study demonstrate that different attributes and orientations can play an important role when empathising with others. However, this study does not aim to understand all the elements/facets of empathy. Instead, it focuses on understanding how the empathy process undergoes and what dimensions (e.g., processual, affective, cognitive) are involved in a given experience.

To integrate empathy into engineering programs focused on preparing empathic entrepreneurial engineers, it is essential to understand all facets that form empathy and the factors that influence each facet. Future studies may capture all aspects of empathy and investigate how different elements of educational and entrepreneurial support programs support the development of empathy elements.

Since this study adopted hermeneutic phenomenology as a methodological and philosophical inquiry, I captured the “snippets” of how engineering students empathise with others. However, to create models that will be used as a theoretical foundation and propose specific recommendations for incorporating certain activities in the engineering curriculum, it is essential to explore how each element of educational (entrepreneurial)

programs contribute to developing empathy. That is why it is necessary to conduct research to understand how this phenomenon changes over time under the influence of certain events/activities and elements of the environment. This understanding will allow drawing specific conclusions about how specific elements presented in educational programs play a role in developing empathy among engineering students.

Reflection on the Research Journey

In this section, I will provide my own reflection on my research journey. As part of this study, two conference papers were produced and presented, and a literature review was written, which was subsequently published in a journal. However, in addition to these works, I also wrote several other papers related to empathy, and presented a workshop during the 2022 Australasian Association for Engineering Education (AAEE) Conference in which this model was demonstrated. Also, in this section, I will demonstrate an evolution of my understanding of empathy, considering all the comments received from various academics and reviewers.

My interest in empathy started forming after I became acquainted with the design thinking methodology during one of the entrepreneurial workshops for STEM students. Over the past decades, design thinking has become popular in entrepreneurship education (Lahn & Erikson, 2016; Huq & Gilbert, 2017; Henriksen et al., 2017; Bauters & Vesikivi, 2021) and nowadays, a growing number of entrepreneurial educational events for various groups of learners use this methodology to immerse themselves in the process of creating human-oriented products and solutions. Empathy is an essential element of design thinking and human and user-centred approaches. It should be used during the "empathise" (divergence) phase to understand peoples' problems and identify their inherent desires and needs (Dam &

Siang, 2020). After going through an entrepreneurial educational program, and as an engineering graduate, I realised empathy's benefits for various industries, such as entrepreneurship for engineering, and processes such as design, team management. At the same time, in addition to the obvious benefits of empathy, I also realised that it is not always easy to immerse yourself in the lives of others and put human problems and needs at the forefront of entrepreneurial and engineering decisions. However, despite the difficulties, the peers, coordinates, and detailed guides within this entrepreneurial program helped me to understand the critical role of the perspectives of others and empathy.

After analysing the experience in an entrepreneurship program within which I understood the benefits of empathy, I began to think back to my own experience when I was doing an engineering course in which I did not have many opportunities to learn about the benefits of empathy. Further, after reading the work of Cech (2014), I learned that many engineering programs do not contribute to developing other-oriented qualities in engineering students, such as public welfare commitment or concern due to the orientation towards analytical thinking. At that moment, I immediately thought that because I had a chance to learn the benefits of empathy and immerse myself in the experience of others within an entrepreneurial education program, other engineering students might experience a similar experience.

Before studying the challenges associated with the development of empathy in technical students, it was essential to analyse the existing literature and understand whether entrepreneurial educational programs or interventions affect the empathy of engineering students. As mentioned above, empathy is a crucial element in an entrepreneurial mindset (Korte et al., 2018). Also, because empathy is necessary for

human-centred design and interaction with diverse stakeholders, some educators in their entrepreneurial educational programs use activities, practices, or tools that encourage students to empathise. However, despite the current understanding of the importance of empathy in entrepreneurial education (for example, Neck et al. (2014) propose teaching entrepreneurship using a portfolio of different practices, including empathy), I decided to analyse how empathy is represented in Australian entrepreneurial educational interventions for engineering students. Later, my supervisory team and I analysed the entrepreneurial subjects available to engineering students across the University of Technology Sydney faculties for any indicators of empathy. Results of this study demonstrated that 73% of the Faculty of Transdisciplinary Innovation (FTDI) entrepreneurial subjects have different empathy indicators, 26% of the Business School, and 44% of the Faculty of Engineering and Information Technology (Litvinov et al., 2020) (See the results of the study in Table 13).

Table 13

Presence of empathy indicators in engineering subjects available for engineering students at UTS (Litvinov et al., 2020)

	Empathy for team managing	Empathy for opportunity recognition	Empathy for communication	Empathy for design	Empathy for ethical decision-making	Total empathy presence
FTDI	6	9	13	18	12	29
%	15%	23%	33%	45%	30%	73%
BS	0	3	1	6	0	7

%	0%	11%	4%	22%	0%	26%
FEIT	2	1	0	3	0	4
%	22%	11%	0%	33%	0%	44%
Total	8	13	14	27	12	40
%	11%	17%	18%	36%	16%	53%

Further, in our next study, we found that engineering students who completed one of the Australian entrepreneurial acceleration programs mentioned empathy in their description of their experiences as one of the competencies they developed within this program's framework (Litvinov et al., 2021). In this regard, it can be concluded that engineering students have a chance to develop and manifest empathy within the framework of entrepreneurial programs. However, the question of whether entrepreneurial programs impacted empathy and which elements of the programs had an effect should be explored in more detail in future studies. These preliminary results obtained as a result of these studies regarding the role of entrepreneurial education programs in developing engineering students' empathy have become only the starting point in my developing research journey.

In the next phase of my research, we decided to analyse the existing literature to understand what empathy is, whether there are any models of empathy proposed by scholars that can be used to develop it in engineering students in an entrepreneurial context, and what are the challenges in researching and teaching it for engineering

students. Understanding the answers to the above questions can help design and implement approaches to empathy development among engineers or evaluate the effectiveness of existing programs for developing empathy. In this literature study, we conclude that there are currently a limited number of models that consider the complexity of this phenomenon, and we also emphasise that there are no models of empathy at the moment that consider the contextual features of entrepreneurial and engineering practice (Litvinov et al., 2023). So how can we teach something if we do not fully understand empathy in the context of entrepreneurship and engineering? How can we effectively teach empathy if we don't understand in what processes and practices this phenomenon has been involved? Having not found answers to these questions in the literature, I decided to focus my research on understanding empathy in the context of entrepreneurial programs aimed at preparing entrepreneurial engineers and experiences within entrepreneurial programs that shape empathy.

As mentioned above, I used an iterative approach in this study when analysing student descriptions of empathy. The results of the first iterations of the analysis were presented at the Frontiers in Education 2022 conference (Litvinov et al., 2022). During this conference, I received a series of comments from various academics who emphasised the need to demonstrate the relationship between the elements and the facets of empathy, as well as the importance of using existing models of empathy from other areas in creating the final concept of an empathy model in engineering entrepreneurship. These comments were used in subsequent iterations and seriously impacted the final image of the empathy model presented in this thesis.

The final phase of this study included finalising the empathy model, considering all the comments received during the conferences and on published papers. Due to the

fact that this research takes place in the field of engineering education, it was important not only to demonstrate this model but also to give practical recommendations on how this model can help researchers and educators. This model was presented at the AAEE2022: Future of Engineering Education conference as part of a workshop program where various academics and educators discussed potential ways to apply this model in entrepreneurial programs and subjects within the framework of engineering curricula. During the workshop, the participants (academics, researchers, and educators) stressed the importance of considering the contextual elements of educational programs and empathised that engineering students should be aware of the complexity of empathy, which can include both processual and multifaceted features. These comments were considered when finalising the recommendations presented in Chapter Five of this thesis.

To summarise, this section demonstrates my reflection on the research journey. During this study, my understanding of empathy has changed dramatically from understanding this phenomenon as a utilitarian tool to being complex and multifaceted. It is worth noting the important role of comments from various academics, researchers, and educators received at conferences, and in the publication of work that helped me form both the final look of this model and practical recommendations.

Conclusion

In this chapter, the model of empathy experienced by engineering students in entrepreneurial pre-accelerators was proposed based on the research results, claims made relying on research results and scholarly materials. This model demonstrates how engineering students experience empathy within entrepreneurial pre-accelerators, what experiences shape the experience of empathy, and what elements of pre-accelerators

may prefigure this phenomenon. The recommendations made relying on this model can be used for different stakeholders who want to learn more about empathy or incorporate this phenomenon into educational activities. At the same time, it should be mentioned that this model requires further empirical investigation due to the limitations of this study.

Chapter 6. Conclusion

Introduction

The final chapter of this thesis presents the significance and theoretical and methodological contributions of this research. This research was guided by the following research questions and aims:

Aim 1: to illuminate the engineering students' lived experience of empathy in entrepreneurial pre-acceleration programs.

Aim 2: to understand what specific experiences of entrepreneurial processes shape engineering students' empathy.

RQ 1. How is empathy experienced by engineering students in pre-acceleration entrepreneurial programs?

RQ 2. What are the experiences that shape empathy in pre-acceleration programs?

First, the chapter justifies why the results of this study are important theoretical contributions towards understanding empathy. This study reveals that participants of pre-accelerators experience empathy as a multiphase process underpinned by different attributes and orientations. At the same time, the study results demonstrate the important role of contextual elements and experiences in shaping empathy and clarify which experiences and elements shape this phenomenon. The significance of the revealed intertwined structure of these elements for future studies of empathy was also noted. This chapter ends with a summary of the entire study to demonstrate the research steps and outcomes.

Significance of the Research Findings and Theoretical Contributions to the Research of Empathy

This research has provided an opportunity to develop a holistic understanding of empathy among engineering students in the context of entrepreneurial pre-acceleration programs. The model of empathy obtained in this study demonstrates that the empathy experiences of engineering students include processual characteristics (multiphase).

Five phases were identified: Pause and be conscious, Immerse into the experiences of others, Relate to one's own experience, Synthesise, and Simulate an experience have been identified in this study. These phases have a linear and cyclical sequence. At the same time, it was found that various multifaceted attributes and orientations play an important role in shaping an individual's empathy process. Seven personal attributes and orientations have been identified and interpreted in this study: open-mindedness, taking a step back, reflectivity and thinking about consequences, orientation to grow and learn, a win-win orientation, and problem orientation. In this study, attributes and orientations represent facets of empathy that underpin the experience of empathy and give students a chance to experience all five phases of empathy. Most existing models of empathy in different fields, such as engineering or design, emphasise empathy's multi-phased and multifaceted nature. In line with existing research, this study has identified the relationship between these elements of empathy and also explained how these elements are related, which is a theoretical contribution to the study of empathy.

This study also made some theoretical contributions toward understanding empathy phases. Some existing processual models of empathy outline the stages of stepping in and stepping out of other people's worlds with an increased understanding of

their experiences, such as Kouprie and Visser's (2009) model. This study revealed that in addition to immersing and leaving the worlds of others (immersing into the experiences of others, relating to one's own experience and synthesising the combined experience), engineering students also believe that the phase of immersion in the present moment (Pause and be conscious) paying attention to contextual features as well as the predicative phase (simulating experience) are also essential parts of the empathy process. The identification of these two phases as part of empathy can also be considered a theoretical contribution to the study of empathy of engineering entrepreneurs since these phases do not occur together in existing models in this field.

Another important theoretical contribution relates to empathy-related orientations and the fact that engineering students within entrepreneurial pre-acceleration programs, when describing their experience of empathy, pay serious attention to the benefits for other people. This is reflected in the “win-win” orientation and the importance of considering the consequences of their activities at the social level, which is reflected in the “thinking about consequences” orientation. Cech (2010) found a lack of focus on the ethical component in engineering programs, which causes a decrease in engineering students' public awareness and engagement. Based on the conclusions of Cech’s study (2010), the author concludes that a lot needs to be done to change engineering education programs so that engineers begin to consider the importance of interaction with society. Since the experience of empathy includes an orientation towards benefiting others, entrepreneurial engineering empathy can become a “bridge” between engineering and society that needs to be built in engineering programs.

The third theoretical contribution of this study is that engineering students notice in their descriptions of empathy experiences that it is shaped not only by certain contextual elements, such as design, Communities of Practice, diversity of opinions and market, but also by various experiences that also occur during entrepreneurial programs such as starting with a broad question, talking with a purpose, being touched through listening to stories and observing "clicking" situations. Currently, there is a discussion about the role of certain contexts in forming empathic tendencies or the manifestation of empathy in the fields of study of empathy or engineering education. The theoretical contribution of this study is not only that students note the importance of certain contextual elements in empathy, but also provide examples of specific elements. They also add that within these elements, specific experiences may encourage engineering students to empathise. The results of this study contribute to the study of empathy, as it encourages future researchers to pay attention not only to contextual elements but also to explore in detail which experiences within these elements impact the empathy of engineering students and the extent of this impact.

This study reveals that the challenges of studying empathy relate to the intertwined structure of contextual elements that form empathy experiences. Therefore, it may be difficult to identify and extract them. So, during one project or activity, students can be immersed in several elements that all similarly impact empathy.

The experiences that shape empathy within the elements of entrepreneurial pre-acceleration programs also have an intertwined structure. This intertwined structure means that to create holistic, contextual models of empathy, researchers need to draw conceptual boundaries between elements while noting the complexity of the context. Therefore, further studies of empathy in various contexts should consider the

complexity of the formation and induction of this phenomenon. It is also important to use research approaches and theoretical frameworks that consider the fragility and uncertain structure of contextual elements to obtain results that can be used to give clear recommendations for integrating empathy into different educational programs and curricula.

Methodological Contributions in the Field of Engineering Education

The qualitative research strategy adopted for this study is not commonly used in engineering education. The implications associated with using qualitative methodologies in engineering education can benefit researchers and educators and encourage further exploration of the interpersonal skills of holistic engineers. This study uses a hermeneutic phenomenological inquiry that is not a common methodological approach to studying educational interventions, contexts, and competencies in engineering education. This is an attempt to understand how complex, multifaceted, and contextual competence, such as empathy, is experienced by engineering students when participating in pre-accelerator programs. The phenomenological approach allowed the researcher to find that engineering students are aware of the complexity and importance of empathy and also notice (make sense of) various experiences and elements of entrepreneurial programs that affect how they experience empathy. As future engineers will require a broad spectrum of technological and interdisciplinary competencies, this request can potentially drive qualitative research within engineering education. Therefore, researchers can use the previous chapters' insights on hermeneutic phenomenology to address these requests and explore other important competencies that future engineers should possess, including creativity, leadership, and sustainability. Also, researchers would benefit from the analysis of how hermeneutic phenomenology

can help understand the role of context and different experiences in forming various constructs.

The iterative approach employed during this study has contributed to forming interpretations and illuminating the elements of empathy. This approach first helped the researcher enhance the quality and credibility of this qualitative study by incorporating feedback from different scholars at different phases. This includes comments from a supervisory panel, comments from conference participants, and comments from journal reviewers. The iterative approach helped me understand that empathy is a multiphase phenomenon, and that attributes and orientations are important elements of the experience of empathy that also need to be considered when studying this phenomenon. At the same time, this approach helped me to start noticing some connections between phases, attributes, and orientations, which further formed the model of empathy, and the existing literature confirmed these connections. Engineering education researchers can use the insights from this study when integrating interactive approaches into their own research.

Semi-structured interviews were used as a data collection method in this study. When designing the interview guide, I created grouped questions based on the research questions, as this research had several aims and questions. The semi-structured nature of the questionnaire allowed flexibility during an interview, unlike unstructured or structured interviews. At the same time, acknowledging the complexity of empathy and that some elements might be “hidden”, semi-structured interviews encouraged engineering students to share their stories, feelings, and thoughts. This data collection method helped to uncover some elements of empathy that are usually hidden, such as attributes and orientations.

In addition to the methodological approach and data collection method, the structure of the interview guide and the choice of questions also played an important role in shaping the understanding of empathy. In this study, I first gave engineering students a chance to think about their understanding of empathy (e.g., Q3 - What does empathy mean to you? How would you define empathy?). Then they were asked to give examples of situations in which they had experienced empathy (e.g., Q4 - Tell me what empathic experiences you think may exist in a pre-accelerator? and Q5 - Tell me about empathy, if any, you had in the experiences you described?) and then engineering students were asked what was going on in their head, what they were doing and feeling at that moment (e.g., Q9 - What would you say if someone asks you what is going on in your mind when you empathise?). This approach encouraged engineering students who took part in an entrepreneurial pre-acceleration program to share detailed descriptions of their empathic experiences. These insights can encourage engineering education researchers to consider using hermeneutic phenomenological inquiry and semi-structured interviews for their research projects when they need to explore a new aspect of engineering practice or uncover a complex phenomenon by obtaining its detailed descriptions.

Since this study was conducted during the COVID-19 pandemic, various online tools were employed to conduct interviews. Qualitative semi-structured interviews need to be conducted in a comfortable atmosphere for participants to think about their own experiences and recall specific situations in which they might experience different emotions or thoughts. To create a relaxed and comfortable environment, engineering students were provided with explanations of all the features of conducting interviews online, and I allowed them to ask any questions related to format or technology (e.g., Zoom platform). I also always allowed participants to do interviews with the camera off

(when they preferred this format) to make them feel more comfortable. However, despite these measures, I still encountered problems related to the online format, such as connection interruptions or audio or video equipment quality. Therefore, engineering education researchers can get acquainted with my experience conducting interviews online to minimise potential difficulties in their research.

To summarise, engineering education researchers who plan to use a qualitative approach in their studies focused on exploring complex constructs can familiarise themselves with the design of this study. This study applied hermeneutic phenomenological inquiry, an iterative approach to data analysis and results interpretation, semi-structured interview data collection methods and a specific sequence of questions. Researchers can analyse the research design of this study to analyse and minimise potential challenges and consider the positive aspects of this study.

Conclusion

This section examined the extent to which the results of this study address the research questions and aims. This study aimed to form a holistic understanding of the phenomenon of empathy in the field of entrepreneurial engineering. Since empathy is an essential competency for both fields (entrepreneurship and engineering), various academics have expressed the need to investigate this phenomenon within entrepreneurial and engineering research sites in order to form conceptual models that reflect the contextual features of this phenomenon. It is assumed that the newly formed understanding of empathy in entrepreneurial engineering can be used as a theoretical foundation for developing empathy in future entrepreneurial engineers. So, to start creating (make a first step towards creating) contextual models of empathy, it is

important not only to examine the relationship between empathy and various contexts such as social work, psychology, and nursing, but also to understand how different practitioners experience this phenomenon, and also how the specific experiences and elements within entrepreneurial engineering context work to shape empathy.

This study approached empathy as an experience that is situated in the context of entrepreneurial pre-accelerators. The choice fell on pre-accelerators, as this type of program includes educational competence and encourages engineering students to immerse themselves in entrepreneurship. The following research questions were shaped, focusing on engineering students' lived experience of empathy within the context of entrepreneurial pre-accelerators.

RQ 1. How is empathy experienced by engineering students in pre-acceleration entrepreneurial programs?

RQ 2. What are the experiences that shape empathy in pre-acceleration programs?

In this study, hermeneutic phenomenology was selected as a methodological and philosophical inquiry as it enables researchers to record the experience of a phenomenon (by focusing on students' lived experiences) that can be interpreted or illuminated through analysing their accounts and descriptions of the phenomenon. The emerging themes and sub-themes demonstrated that engineering students experience empathy in an entrepreneurial context as a process that involves five phases: Pause and be conscious, Immerse into the experiences of others, Relate to one's own experience, Synthesise, and Simulate an experience.

At the same time, empathy is experienced as a phenomenon related to four attributes: open-mindedness, being able to take a step back, thinking about consequences, and reflexivity, as well as three orientations: orientation to grow and learn, win-win, and problem-solving orientations. The second research question focuses on interpreting the experiences and contextual elements that may shape and prefigure empathy. Four themes are related to experiences that shape empathy (starting with a broad question, talking with a purpose, being touched through listening to stories, and observing ‘‘clicking” situations), and four themes are related to contextual elements (design, CoP, diversity of opinions and market) of pre-acceleration (entrepreneurial) programs that prefigure conditions for both types of experiences. It is important to mention that both experiences that shape empathy and elements that may prefigure both types of experiences might be interconnected and intertwined.

Considering the results of this study and relying on existing research, a model of empathy in entrepreneurial pre-acceleration programs has been created (See Figure 10). This model, which is presented in Chapter Five, was used to provide practical recommendations for incorporating empathy into the entrepreneurial engineering curriculum.

Another intention of this research was to contribute to the area of empathy in entrepreneurial engineering education. Based on the results of this study, I propose future researchers, academics, educators, and other stakeholders consider the following contributions to knowledge:

- Engineering students describe empathy as a complex, multiphase, and multifaceted process.

- As part of the empathy process, engineering students highlight not only the phases aimed at understanding the perspectives and emotions of others but also outline the predictive phase.
- Within pre-accelerators, conditions (elements) can prefigure the experiences that shape (or lead to) empathy and the experience of empathy itself.
- Elements and experiences that affect empathy can represent a complex intertwined structure within which it is difficult to make a conclusion about the direct role of a particular experience or element in the formation of empathy or prefiguring the conditions for both types of experiences.

In this thesis, I advanced the understanding of empathy in the entrepreneurial engineering context and provided some recommendations on how to incorporate empathy into the entrepreneurial engineering curriculum. This study also aimed to understand how empathy is experienced and what factors shape this phenomenon. However, to design effective educational interventions, it is important to understand how empathy is experienced and explore this phenomenon's development process in detail. Future researchers can use the model demonstrated in this study to investigate the role of specific activities in developing the empathy phenomenon.

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List of Appendices

Appendix A. Participant Information Sheet

PARTICIPANT INFORMATION SHEET FOR INTERVIEWS
Educating Entrepreneurs in Empathy in the IT and Software Engineering Fields / ETH22-7166

WHO IS DOING THE RESEARCH?

My name is Aleksandr Litvinov, and I am a PhD student at UTS, FEIT. My supervisor is Anne Gardner (anne.gardner@uts.edu.au)

WHAT IS THIS RESEARCH ABOUT?

This research is to find out about students' empathic experiences during the accelerator program.

WHY HAVE I BEEN ASKED?

You have been invited to participate in this study because you participated in the accelerator program. Your contact details were obtained from the program Coordinator or obtained from the official website of the program you participated in.

IF I SAY YES, WHAT WILL IT INVOLVE?

If you decide to participate, I will ask you to participate in a 90-min semi-structured interview that will be audio-recorded and transcribed. You will receive a $50 electronic gift voucher as compensation for your time.

ARE THERE ANY RISKS/INCONVENIENCE?

No harm is intended, but we realise that invasion of privacy, embarrassment, or distress may result in unforeseen ways. You will be asked about your own experiences, so it is possible that this will involve some level of personal disclosure. Experience can involve emotions, and it is possible (although unlikely in a study context) that retelling your experiences may embarrass you.

DO I HAVE TO SAY YES?

Participation in this study is voluntary. It is completely up to you whether you decide to participate.

WHAT WILL HAPPEN IF I SAY NO?

If you decide not to participate, it will not affect your relationship with the researchers or the University of Technology Sydney. If you wish to withdraw from the study once it has started, you can do so at any time without having to give a reason by contacting Aleksandr Litvinov via aleksandr.litvinov@student.uts.edu.au.

If you decide to leave the research project, we will not collect additional personal information from you, although personal information already collected will be retained to ensure that the results of the research project can be measured properly and comply with the law. You should be aware that data collected up to the time you withdraw will form part of the research project results. If you do not want us to do this, you must tell us before you join the research project.

CONFIDENTIALITY

By signing the consent form, you consent to the research team collecting and using personal information about you for the research project. All this information will be treated confidentially. The security of the data will be ensured through ethical storage practices. Hard copies of transcripts will be stored in a secure locker in the FEIT building at UTS in an area requiring swipe card access. Only researchers involved in the project will have access to the data. Electronic copies of the transcript, recordings and other files will be stored in a folder on the UTS server in a file requiring pin access. Your information will only be used for the purpose of this research project, and it will only be disclosed with your permission, except as required by law. In any publication, information will be provided in such a way that you cannot be identified.

WHAT IF I HAVE CONCERNS OR A COMPLAINT?

If you have concerns about the research that you think my supervisor or I can help you with, please feel free to contact me at aleksandr.litvinov@student.uts.edu.au or Anne Gardner at anne.gardner@uts.edu.au You will be given a copy of this form to keep.

NOTE:

This study has been approved in line with the University of Technology Sydney Human Research Ethics Committee [UTS HREC] guidelines. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au], and quote the UTS HREC reference number. Any matter raised will be treated confidentially, and investigated and you will be informed of the outcome.

Appendix B. Consent Form

CONSENT FORM FOR PARTICIPATION IN INTERVIEW
Educating Entrepreneurs in Empathy in the Information Technology and Software Engineering Fields / ETH22-7166

I _____ agree to participate in an interview as a part of the research project Educating Entrepreneurs in Empathy in the Information Technology and Software Engineering Fields being conducted by Aleksandr Litvinov (aleksandr.litvinov@student.uts.edu.au).

I have read the Participant Information Sheet or someone has read it to me in a language that I understand.

I understand the purposes, procedures and risks of the research as described in the Participant Information Sheet.

I have had an opportunity to ask questions and I am satisfied with the answers I have received.

I freely agree to participate in this research project as described and understand that I am free to withdraw at any time without affecting my relationship with the researchers or the University of Technology Sydney.

I understand that I will be given a signed copy of this document to keep.

I agree to be:
☐ Audio recorded

I agree that the research data gathered from this project may be published in a form that does not identify me in any way

I am aware that I can contact Aleksandr Litvinov (aleksandr.litvinov@student.uts.edu.au) or Anne Gardner (anne.gardner@uts.edu.au) if I have any concerns about the research.

_____ ____/____/____
Name and Signature [participant] Date

_____ ____/____/____
Name and Signature [researcher or delegate] Date

NOTE:
This study has been approved in line with the University of Technology Sydney Human Research Ethics Committee [UTS HREC] guidelines. If you have any concerns or complaints about any aspect of the conduct of this research, please contact the Ethics Secretariat on ph.: +61 2 9514 2478 or email: Research.Ethics@uts.edu.au], and quote the UTS HREC reference number. Any matter raised will be treated confidentially, and investigated and you will be informed of the outcome.

Appendix C. Research Data Management Plan

UTS Stash

Engineering Students' Experiences of Empathy in Entrepreneurial Pre-accelerators: A Hermeneutic Phenomenological Study

Description

This thesis is a hermeneutic phenomenological study of engineering students' lived experiences of empathy within entrepreneurial pre-acceleration programs. The trend towards preparing holistic engineers with developed entrepreneurial and interpersonal skills has been formed in recent years. This trend has encouraged educational institutions to introduce various entrepreneurial educational interventions into engineering curricula to foster entrepreneurial skills and mindset in engineers. Empathy is one of the essential competencies for both engineering and entrepreneurship fields. Considering the importance of empathy for engineers and entrepreneurs, it is expected that entrepreneurial interventions in the engineering curriculum would also contribute to developing empathy of future entrepreneurial engineers. These expectations are due to applying empathy-related approaches such as design thinking, human-centred design, or tools such as persona that are actively used in entrepreneurial educational activities. However, despite the importance of empathy, as well as its representation in entrepreneurship and entrepreneurial education, it is not entirely clear how entrepreneurial engineers experience this phenomenon, as well as which experiences and environmental elements prefigure empathy. This hermeneutic phenomenology study was conducted to develop a sophisticated understanding of empathy by focusing on how engineering students experience empathy within entrepreneurial programs and what specific experiences or elements within entrepreneurial programs shape engineering students' empathy by illuminating the lived experience of empathy from the student's accounts. The lived experiences of 20 engineering students who participated in four different Australian pre-acceleration entrepreneurial programs were examined. Pre-accelerators are an example of entrepreneurial programs that are focused on introducing students to the entrepreneurial process and usually involve both entrepreneurial and educational components. As a result, a visual contextual model of empathy has been proposed that demonstrates that empathy is experienced as a multi-phase process that is related to different attributes and orientations and which is shaped by four experiences (starting with a broad question, talking with a purpose, being touched through listening to stories and observing 'clicking' situations) and may be prefigured by four different program elements (design process, the community of practice, diversity of opinions and market).

Expand/Collapse all

– Project

Project overview

Project name

Engineering Students' Experiences of Empathy in Entrepreneurial Pre-accelerators: A Hermeneutic Phenomenological Study

Research Master Project Code / Student ID

HDR student project

Project description

This thesis is a hermeneutic phenomenological study of engineering students' lived experiences of empathy within entrepreneurial pre-acceleration programs. The trend towards preparing holistic engineers with developed entrepreneurial and interpersonal skills has been formed in recent years. This trend has encouraged educational institutions to introduce various entrepreneurial educational interventions into engineering curricula to foster entrepreneurial skills and mindset in engineers. Empathy is one of the essential competencies for both engineering and entrepreneurship fields. Considering the importance of empathy for engineers and entrepreneurs, it is expected that entrepreneurial interventions in the engineering curriculum would also contribute to developing empathy of future entrepreneurial engineers. These expectations are due to applying empathy-related approaches such as design thinking, human-centred design, or tools such as persona that are actively used in entrepreneurial educational activities. However, despite the importance of empathy, as well as its representation in entrepreneurship and entrepreneurial education, it is not entirely clear how entrepreneurial engineers experience this phenomenon, as well as which experiences and environmental elements prefigure empathy. This hermeneutic phenomenology study was conducted to develop a sophisticated understanding of empathy by focusing on how engineering students experience empathy within entrepreneurial programs and what specific experiences or elements within entrepreneurial programs shape engineering students' empathy by illuminating the lived experience of empathy from the student's accounts. The lived experiences of 20 engineering students who participated in four different Australian pre-acceleration entrepreneurial programs were examined. Pre-accelerators are an example of entrepreneurial programs that are focused on introducing students to the entrepreneurial process and usually involve both entrepreneurial and educational components. As a result, a visual contextual model of empathy has been proposed that demonstrates that empathy is experienced as a multi-phase process that is related to different attributes and orientations and which is shaped by four experiences (starting with a broad question, talking with a purpose, being touched through listening to stories and observing 'clicking' situations) and may be prefigured by four different program elements (design process, the community of practice, diversity of opinions and market).

Keywords

empathy

pre-accelerator

engineering education

entrepreneurship

Start date

31/01/2020

End date
30/06/2023

Funders

International Research Scholarship

UTS President's Scholarship

Grant ID

– People

People

First-named chief investigator / UTS supervisor

Name	Email	Project Role	ORCID
Anne Gardner	Anne.Gardner@uts.edu.au	Chief Investigator	

Data manager

Name	Email	ORCID
Aleksandr Litvinov	aleksandr.litvinov@student.uts.edu.au	

Contributors

Name	Email	ORCID

Additional supervisors

Name	Email	ORCID
Sojendra Pradhan	Sojen.Pradhan@uts.edu.au	
Jeri Childers	Jeri.Childers@uts.edu.au	

- Ethics and security

Ethics and Security

Initially your research data is classifed as UTS Internal. To improve the accuracy of this classification, please answer the following

Information Security Classification
UTS: Confidential

Does the research involve:
Human participant data

Will the data you collect from individuals include personal information?
No

Will the data you collect from individuals include sensitive personal information other than health information?
No

Will the data you collect from individuals include health information?
No

Will any data or information be individually identifiable or potentially re-identifiable (i.e. include codes) at any stage of the research?
No

Is Ethics approval required for your project?
Yes

- Data collection and storage

Data collection and storage

Please provide a brief description of your data collection methodology
Semi-structured interviews will be conducted either online via Zoom or face- to- face on the UTS campus strictly following social distancing guidelines.

Predominant file type(s), e.g. textual, tabular, image or recording. Give file format if known
The author will document interviews with an audio recorder (after obtaining permission from a participant) and also by taking handwritten notes.
file formats: xls, pdf, mp3

Data storage location
UTS provided collaboration space (e.g. CloudStor, OneDrive etc)

If other, provide further details: (Including access arrangements for the minimum retention period)

- Data retention and disposal

Data retention and disposal

Minimum retention period
5 years (general research)

The data steward is:
Anne Gardner

Have you made commitments to destroy part of the data prior to end of retention period (e.g original recordings, linking/code files)?
No

When should it be destroyed?

- Access and rights

Access and rights

Copyright and intellectual property owners of data created in project
University of Technology Sydney

Please list any other owners:

Access after the project will be
Mediated, by permission from the data manager

Are you using any secondary or third-party data?
No

Licences or Agreements:

Files asociated with this plan	Notes
Litvinov A Ethics Application.pdf	

- Research Workspace

Research Workspace

Associated workspaces

Name	Description	Location	Type

Appendix D. Participation Invitation

Hello [NAME],

I hope you are doing well!

My name is Aleksandr Litvinov, and I am a PhD student from UTS conducting research with entrepreneurs who participated in entrepreneurial development programs. I found your contact through the [PRE-ACCELERATOR NAME] program website.

For my research, I am looking for entrepreneurs who study engineering or IT and who participated in an entrepreneurial program. I would like to conduct an interview to learn about your entrepreneurial journey and empathic experiences during the program when collaborating with the team, stakeholders, mentors, customers. I also attached the Participant Information sheet with more details about my research project.

Might you be available for an interview?

I will also provide a $50 gift voucher as thank you for your time! Please, feel free to ask me if you have any questions.

Appendix E. Interview Guide

Intro questions & context	1. Could you please tell me about yourself (professional, academic background)? What gender do you identify with? 2. Please, tell me about your startup. What have you done already to develop your startup?
Empathy	3. What does empathy mean to you? How would you define empathy? 4. Tell me what empathic experiences you think may exist in a pre-accelerator? 5. Tell me about empathy that you had during the described experiences (e.g., decision-making, customer validation, opportunity recognition). 6. What role do empathic interactions play for a technology entrepreneur? 7. What positive or negative outcomes can empathy bring to both entrepreneurial activity and your professional career? 8. How do you use empathy in your entrepreneurial activities? 9. What would you say if someone asks you what is going on in your mind when you empathise? 10. How do you empathise with others? 11. Describe your empathy experience during the program? 12. In what situations did you have the opportunity to use empathy? 13. What activities of the pre-accelerator encouraged you to use empathy? 14. If you had a chance to change something in the program structure, what would you change to encourage empathy? 15. Is there anything else that you would like to add?