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Final Master Thesis

Nurture through Pedagogy: Can entrepreneurial education enhance students' creative idea generation?

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Abstract

In today's vulnerable, uncertain, complex, and ambiguous world, the need for entrepreneurial skills among workers has been highlighted. Universities have begun offering entrepreneurship education (EE) that to teach the students the cognitive skills, such as alertness, imaginativeness and creativity, needed to undertake the complex challenges. So far, EE has focused on business students, although these skills are relevant across disciplines, which has inspired this research to compare the cognitive processes of entrepreneurship and engineering students in the creative idea generation process. Prior research has found that engineers and entrepreneurs tend to think differently. These differences contribute to their pedagogies. On the one hand, the engineering students are taught mathematical structures and sequential problem-solving methods, while the entrepreneurship students are equipped with alternative methodologies and decision-making logics. Consequently, this study investigated *in what ways does the entrepreneurship education at the university master level affect the creative idea generation capacity of engineering and entrepreneurship students?* This research expected that entrepreneurship students will generate more ideas, in quantity and in creativity, than the engineering students, and that the students will use different idea generation patterns to arrive at the ideas. To test these hypotheses, data was collected through a problem case scenario experiment with verbal protocol analysis with entrepreneurship (*n*=10) and engineering students (*n*=10). The results of the data analysis found that entrepreneurship students generated more creative ideas and used more diverse cognitive patterns than engineering students. For the quantity of ideas generated, there was no difference between the groups. This research contributes to entrepreneurship and engineering pedagogy literatures by demonstrating how EE can teach students become more creative and accumulate cognitive strategies suited for complex problem-solving.

Key words: creative idea generation, creativity, cognition, opportunity recognition, business idea generation, entrepreneurship education, entrepreneurship students, engineering pedagogy, engineering students, verbal protocol analysis

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TABLE OF CONTENTS

Chapter 1. Introduction 5
Chapter 2. Theoretical Framework 9
2.1 Entrepreneurship as an individual level phenomenon 9
2.2 The role of cognition in creative idea generation 11
2.3 Entrepreneurship education and creative idea generation 12
2.4 Engineering and entrepreneurship education 13
2.5 Synthesis of key findings 15
2.6 Analytical framework 17
Chapter 3. Methodology 20
3.1 Data collection method 20
3.2 Population and sample 21
3.3 Data collection 23
3.4 Measures 25
Chapter 4. Results 29
4.1 Experiment sample characteristics 29
4.2 Quantitative data analysis 30
4.3 Qualitative data analysis 34
4.4 Synthesis of data analysis 48
Chapter 5. Discussion 49
5.1 Answer to the research question 49
5.2 Practical implications 52
5.3 Limitations and future research 53
Chapter 6. Conclusion 56
References 57
Appendix A. Experiment Instructions 64
Appendix B. Survey Questions 66
Appendix C. Experiment Participant Notes And Sketches 70

LIST OF TABLES

Table 1	*Synthesis of the Differences Between Entrepreneurship and Engineering Approaches*	Page 16
Table 2	*Measures, Definitions and Operationalisations*	Page 26–27
Table 3	*Entrepreneurship Student Participant Demographics*	Page 29
Table 4	*Engineering Student Participant Demographics*	Page 30
Table 5	*Quantity of Ideas Generated by Entrepreneurship Students*	Page 30
Table 6	*Quantity of Ideas Generated by Engineering Students*	Page 31
Table 7	*Creativity of Ideas Generated by Entrepreneurship Students*	Page 31
Table 8	*Creativity of Ideas Generated by Engineering Students*	Page 31
Table 9	*Overall Means, Standard Deviations, and Correlation of Research Variables*	Page 32
Table 10	*Themes of Ideas Generated*	Page 34
Table 11	*Count of Ideas Per Theme*	Page 35
Table 12	*Cognitive Patterns for Creative Idea Generation*	Page 38
Table 13	*Frequency of Cognitive Patterns*	Page 38
Table 14	*Participants' Self-Selected Most Creative Ideas and Their Reasoning*	Page 45–46
Table 15	*Participants' Most Creative Ideas Based on Scoring*	Page 46–47
Table 16	*Support for Hypotheses*	Page 49

CHAPTER 1. INTRODUCTION

Since the Covid-19 pandemic erupted, the business world has changed on a rapid pace and this has resulted in a need for new skills, especially tolerance for ambiguity and uncertainty (Peschl, Deng & Larson, 2021). In the current unpredictable environment, the demand for employees with creative and cognitive capacities needed to tackle the future challenges has skyrocketed (Dondi, Klier, Panier & Schubert, 2021). This goes to say that entrepreneurial skills are vital not just for workers, but also for students. In their future careers, they will be confronted with a growing number of open, dynamic, and complex problems that require a flexible and adaptive mindset to tackle (Peschl et al., 2021). Thus, in today's vulnerable, uncertain, complex, and ambiguous world, new graduates need to do more than simply possess explicit and procedural types of knowledge to be successful. Instead, they must possess higher cognitive capabilities to use this knowledge in problem-solving, creativity, imagination, and adaptability to adjust to the dynamic working environment and its demands (Dondi et al., 2021; Beckford, 2020). As a response to the Covid-19 pandemic, the ways of working shifted quickly from the traditional office-based work to remote working in the digital environments, which created a demand for new employee skills (Pataki-Bittó & Kapusy, 2021). As organizations are continually evolving and changing, leaders and employees need to be innovative, risk-taking, and tolerant to change to tackle the difficult challenges they are facing (Dondi et al., 2021). Further, they are expected to identify, develop, and commercialize new opportunities and to use creativity in their day-to-day work, which the entrepreneurial skills of imaginativeness, successful idea generation and opportunity recognition enhance (e.g., Chen, Chan, Hung & Lin, 2019; Camelo-Ordaz, Diánez-González, Franco-Leal & Ruiz-Navarro, 2020; Kier & McMullen, 2018; Weinberger, Wach, Stephan & Wegge, 2018). Hence, it is crucial to acknowledge the importance of these abilities for students across the board, not just those interested in entrepreneurship.

According to Ward (2004), entrepreneurship thrives on new and beneficial ideas. Successful ideas typically require a balance of novelty and familiarity in that they must be fresh and distinctive enough to pique customers' interest, yet familiar enough to not be misinterpreted or dismissed as too radical (Ward, 2004). The process for generating new business ideas rests on opportunity recognition, which Baron (2006, p.107) defines as "the cognitive process (or processes) through which individuals conclude that they have identified an opportunity". Being alert to and actively seeking for new opportunities and having relevant prior knowledge and experiences matter for discovering successful business opportunities (Baron, 2006; Chen et al., 2020; Camelo-Ordaz et al., 2020). More significantly, the cognitive capabilities of individuals explain why one finds new solutions for the market and consumers needs while others cannot. Essentially, everything in an individual's head can be seen as a thought, which vary from person to person. The same can be said about the cognitive techniques and processes that individuals use to ‘connect the dots’ to recognize patterns of business opportunities and to generate creative ideas (Ward, 2004; Baron, 2006). After reviewing prior literature, the question remains if these cognitive frameworks for creative idea generation can be taught, or are they innate capabilities that individuals are born with?

Individuals do not come into this world knowing how to draft a business strategy or spot possibilities. Education can be used to teach and improve these abilities (Kyndt & Baert, 2015; Man, Lau & Chan, 2002). Entrepreneurship education (EE) has emerged as a distinct educational field with a curriculum that significantly differs from the standard management education (Mwasalwiba, 2010). EE can be defined as the education to develop entrepreneurial attitudes and skills among students (Holzmann, Hartlieb & Roth, 2018). It mainly focuses on the specific setting of venture formation and the broader term *entrepreneurial* education, which encompasses both business and non-business contexts, focuses on the development of attitudes, competencies, and enterprising behaviours among individuals (Gabrielsson, Hägg, Landström & Politis, 2020). Entrepreneurial knowledge can thus be thought of as a combination of primary and secondary entrepreneurial experiences with the primary being entrepreneurship and the secondary being a reflection on those experiences (Hägg & Kurczewska, 2020). According to Lindberg, Bohman, Hulten and Wilson (2017), having a deeper knowledge of the relationship between pedagogical interventions and entrepreneurship pedagogy, that accumulates students self-directed learning skills, allows for training graduates who are ready and competent for the global competition.

Currently, engineering students are being exposed to entrepreneurial curriculum and practical learning opportunities at a higher rate than ever before, both inside and outside of their degrees (Duval-Couetil, Shartrand & Reed, 2016). Prior studies highlight the possibility of incorporating EE into the engineering discipline, which has resulted in the development of specialized designs and methods aimed at engineer students (Duval-Couetil et al., 2016; Eager & Cook, 2020; Chau, 2005; Creed, Suuberg & Crawford, 2002). Along with that, EE outside the traditional business disciplines is on the rise (Bosman & Fernhaber, 2017; Morris, Kuratko & Pryor, 2014; Winkler, Troudt, Schweikert & Schulman, 2015), and entrepreneurial capacity (i.e., the ability to do something) and capability (i.e., the ability to do it well) are being linked to increased employability (Greene & Saridakis, 2008).

However, due to the differences between the disciplines, the cognitive processes used in engineering and entrepreneurship tend to differ. On the one hand, engineers think in a sequential manner according to Horváth and Rudas (2008). First, they observe phenomena and perceive and retrieve information about them. Second, they think about the problems and once they understand them, they consider the circumstances and create solutions. Third, they verify these solutions through experimentation, which is a typical step in natural sciences (Czocher, 2013). Overall, the engineering way of thinking can be described as a problem-solving method, which follows a logical and sequential thinking process (Horváth & Rudas, 2008). On the other hand, entrepreneurs primarily rely on two decision-making logics; causation and effectuation (Sarasvathy, 2001). Causation logic has a predetermined goal and focuses on choosing between the alternative means to achieve that effect, which essentially is a process based on the logic of prediction (Sarasvathy, 2001). Against this, effectuation logic takes a set of means given and focuses on selecting between the possible ends, which makes it a process resting on the logic of control (Sarasvathy, 2001). This shows that entrepreneurs use an iterative process, where they take steps back and forth between the means and ends to create desired effects. These differences are also reflected on the pedagogy in these fields. While the engineering students are taught mathematical structures and frameworks to apply in problem-solving, the entrepreneurship students are provided with alternative methodologies, such as the lean start-up method and design thinking methodology, that assist in discovering innovative solutions (Czocher, 2013; Peschl et al., 2021). Considering that cognitive capabilities stimulate problem-solving, opportunity recognition and idea generation, the question remains if EE with the alternative methodologies can make students better at generating creative ideas.

As shown above, the cognitive processes of engineers and entrepreneurs tend to differ due the nature of the disciplines, which is also relevant for students of these disciplines. For this reason, it is interesting to study if, and how, EE can impact university students' ability to think entrepreneurially and to spot opportunities. As the entrepreneurial thinking process is iterative in nature and EE equips students with various cognitive strategies, it can be assumed that they are more competent at thinking outside the box and producing creative ideas to solve complex challenges. Yet, the question remains if it is necessary for the engineering students to be exposed to EE to learn to think entrepreneurially, or if they can do so without EE. Especially, noting the relevance of the entrepreneurial skills for their future careers, the question remains whether, and how, EE can provide graduates with these desired skills and enhance their ability to generate new creative ideas. This topic, whether the entrepreneurial (cognitive) abilities can be taught in a pedagogical manner, is addressed through the following research question: *in what ways does the entrepreneurship education at the university master level affect the creative idea generation capacity of engineering and entrepreneurship students?*

To answer this question, this study will identify the differences in the cognitive processes used for creative idea generation between engineering and entrepreneurship students. The nature of the disciplines and their different cognitive processes are of special interest in assessing how these students identify new business opportunities. The further explanation for the choice of these disciplines is provided in the theoretical framework. The aim of this research is to assess the impact of EE on students' ability to generate creative ideas, which addresses the nature versus nurture debate in entrepreneurship as well. In essence, this study will research to what extent students from disciplines other than entrepreneurship recognize opportunities and generate creative business ideas. This research topic will be answered with both qualitative and quantitative data collected through a verbal protocol analysis experiment with engineering and entrepreneurship students. With this experiment, this study aims to recognize if, and what kind of, differences exist in the cognitive patterns used for the creative idea generation between these student groups. Also, it will assess the differences in the outcomes of the creative idea generation process between these student groups. As such, this research contributes to the prior literature into the role of pedagogical interventions in enhancing students' entrepreneurial skills by investigating if entrepreneurship students are more adept at producing ideas, both in quantity and in their degree of creativity. Our findings will have implications for the academic research in cognition and creative idea generation as well as the practical EE pedagogy.

This remainder of this research paper is structured as follows. Chapter 2 reviews the extant literature on the role of EE in creative idea generation in both entrepreneurship and engineering disciplines, which clarifies the research gap that this study aims to address and the hypotheses that will be tested. Chapter 3 explains the research method chosen and the sampling strategy used for the data collection, which will be analysed in Chapter 4. Chapter 5 provides an answer to the research question of this study and assesses the practical implications for the EE and the engineering pedagogy. Further, Chapter 5 examines the limitations of the study and provides improvements suggestions for the future research. Chapter 6 summarises the findings and highlights the relevance of this research.

Chapter 2. Theoretical Framework

This chapter reviews the extant entrepreneurial literature on the nature versus nurture debate and creative idea generation to accentuate the current achievements in these fields of research and to refine the research gap that this study aims to tackle. First, the role of individuals, and their cognitive capabilities, in entrepreneurship and idea generation will be discussed before the pedagogical literature is examined to explain the role of entrepreneurship education (EE) in enhancing students' creative idea generation. Second, the relationship between engineering education and EE will be discussed to explain the choice of these disciplines. At the end of the chapter, the findings from the prior literature will be synthesized and the analytical framework will present the hypotheses of this study.

2.1 Entrepreneurship as an individual level phenomenon

Entrepreneurship is a phenomenon that consists of many different sub-processes, among which are the emergence of new ventures, products and/or services (Shane & Venkataraman, 2000; Landström, 2020a). Therefore, the understanding and definition of entrepreneurship has varied in the past literature. For example, Landström (2020a) discusses three alternative approaches to entrepreneurship in defining it as a market function, process or individual, the entrepreneur. From these approaches, this research will focus on the entrepreneur as an individual, who is at the centre of driving entrepreneurship forward (Landström, 2020a). To conceptualize what this study understands as entrepreneurship, Shane and Venkataraman (2000, p.218) offer a seminal definition of entrepreneurship as the nexus of "the presence of lucrative opportunities and the presence of enterprising individuals," which emphasizes the key role of individuals, and their differences, in the phenomenon. In addition, they argue that the field includes the study of the processes of opportunity discovery, evaluation, and exploitation, and the people who discover, evaluate, and exploit them.

Following the traditions of Austrian economics and Schumpeter, individuals are agents of change in transforming our societies by being alert to market imperfections and states of market disequilibrium, and thereafter taking action to innovate for solutions that disrupt the market (Landström, 2020b; Jacobson, 1992). In characterizing the entrepreneur as a person, there are many schools of thought that define the actor in different ways (Landström, 2020a). For example, the management school understands entrepreneurs as individuals who organize, own, manage, and assume risk for new ventures, while the classical school emphasizes the role of creativity in driving their actions (Landström, 2020a). Regardless of the differing definitions, these different schools of thought agree on that the role of the individuals is central in driving entrepreneurial action, where the differences between people matter for the reasons to engage in and the outcomes of the activity (Landström, 2020a).

As a response to the increased emphasis on the individuals driving the process of entrepreneurship, the entrepreneurship scholars began researching what attributes characterize entrepreneurs and what makes one a successful entrepreneur. Especially, the debate of nature versus nurture emerged to ask the question of whether entrepreneurs are born or made (Peschl et al., 2021). On the one side of this debate is the trait-based approach, which argues that some individuals are born with innate entrepreneurial capabilities that give them a natural ability to become entrepreneurs (Peschl et al., 2021). According to the great person school, entrepreneurs are individuals, who are born with an intuitive ability to recognize opportunities and possess certain instincts and traits that make them successful entrepreneurs (Landström, 2020a). Prior research has, for example, identified differences between the personalities of entrepreneurs and managers and other non-entrepreneurs, where entrepreneurs were found to be more risk-taking and have higher need for achievement (Peschl et al., 2021). Central to this approach is that the skills required for entrepreneurship cannot be learned or taught externally, which characterizes entrepreneurship as an exclusive phenomenon of these 'great persons' who are lucky to be born with the entrepreneurial capabilities (Peschl et al., 2021; Landström, 2020a). Therefore, this view characterizes the nature side of the debate, which emphasizes the natural skills and ability of people to undertake entrepreneurship.

On the other side of the debate is the competency-based approach, which argues that entrepreneurial skills can be taught through education and training (Peschl et al., 2021). In contrast to the nature view of entrepreneurship, this approach does not depict entrepreneurial skills as stable and inborn traits, but instead sees them as malleable through external influences (Landström, 2020a; Peschl et al., 2021). According to this approach, entrepreneurs may have different personalities and skills and there is no 'typical entrepreneur' mould that individuals would need to fit in (Peschl et al., 2021). Yet, there are some skills that enhance entrepreneurial success but are not personality traits or other abilities that people are born with, like identifying and evaluating opportunities, that must be learned somehow (Peschl et al., 2021). In the more recent literature, there seems to be a consensus that entrepreneurship can be taught and nurtured through education (i.e., Lindberg et al., 2017; Neergård, Aaboen & Politis, 2022; Pocek, Politis & Gabrielsson, 2021). Consequently, there has been a shift in the types of research questions addressed "from whether entrepreneurship can be taught to *how* it can be taught" (Peschl et al., 2021, p.2). While the existing literature on the nature versus nurture debate in entrepreneurship is seemingly inclining in the favour of nurture, a research gap exists in pinpointing the specific means to nurture entrepreneurship.

2.2 The role of cognition in creative idea generation

By understanding entrepreneurship as an individual level phenomenon, individual differences in prior knowledge, experiences and cognitive properties affect our ability to recognize certain entrepreneurial opportunities (Shane & Venkataraman, 2000; Baron, 2006; Camelo-Ordaz et al., 2020; Chen et al., 2020). Shane (2000) even proposes that for becoming an entrepreneur, the attributes of people are more determinant than the ideas, which goes to show that the person behind the venture plays a significant role. The entrepreneurial process begins with opportunity recognition, which Baron (2006, p.107) defines as "the cognitive process (or processes) through which individuals conclude that they have identified an opportunity," and is followed by opportunity exploitation and new venture creation (Camelo-Ordaz et al., 2020). As the first step in the process, individuals must identify business opportunities, which are novel, desirable, feasible and have potential economic value (Goldsby, Kuratko, Marvel & Nelson, 2017; Baron, 2006). As such, the prior literature on opportunity discovery has debated whether opportunities are recognized or made, where the human agency in the process has been inquired (Lindberg et al., 2017). In either case, the question remains of why some individuals are better than others in discovering entrepreneurial opportunities and in generating creative business ideas to meet the needs. One explanation could lie in the cognition of individuals.

The existing literature has emphasized the importance of individuals' cognitive capabilities in the opportunity recognition process (e.g., Baron, 2006; Ward, 2004). Especially, alertness has been identified as an important cognitive capacity in this process, which assists individuals with the pattern recognition for new business opportunities (Baron, 2006). Further, there are various other cognitive skills, including information processing, problem-solving and the ability to discover new mean-ends relationships, that make certain individuals more adept at becoming entrepreneurs (Peschl et al., 2021; Shane, 2000; Shane & Venkatraman, 2000). Moreover, high intelligence and creativity have been related to the heightened ability to identify needs and to imagine novel solutions (Runco & Chand, 1995; Simonton, 2000; Baron, 2006; Weinberger et al., 2018; Puente-Díaz, Cavazos-Arroyo & Puerta-Sierra, 2021). In sum, these different cognitive capabilities help individuals in generating new business ideas, where especially one's creativity matters.

In the academic research on entrepreneurship, idea generation is one of the central themes that has been subject to numerous studies (i.e., Lloyd-Cox, Christensen, Silvia & Beaty, 2021, Weinberger et al., 2018; Puente-Díaz et al., 2021; Shimizu & Okada, 2021). These studies have aimed to explain how the thinking processes of individuals, especially in relation to creativity, lead them to generate new business ideas. In this strand of literature, the role of creativity and imagination has been emphasized as core skills that individuals need to train and apply when attempting to generate new ideas (Kier & McMullen, 2018; Lloyd-Cox et al., 2021; Shimizu & Okada, 2021). However, creativity has been also portrayed as a double-edged sword in that it can assist in producing novel ideas, but its grounding in the individuals' knowledge and experiences can actually pose constraints on their creative cognition (Ward, 2004). Noting the paradoxical nature of creativity, it is relevant to further research what nurtures creativity to be empowering for generating new ideas and what poses barriers to its usefulness. Most of the current literature on creativity conceptualizes it as the process of producing new ideas, which makes it a synonym for idea generation (e.g., Weinberger et al., 2018). There is also *creative* idea generation, where the ideas generated are novel, original, and surprising, but also useful (Weinberger et al., 2018; Shimizu & Okada, 2021). For the nature versus nurture debate, the differences in creativity between individuals poses an interesting research direction.

2.3 Entrepreneurship education and creative idea generation

While earlier literature has portrayed creativity as a personality trait that cannot be taught, more recently studies have found that creativity is a malleable skill that can be taught and developed (Weinberger et al., 2018). In developing the creative idea generation skills, EE has been seen as a means to enhance students' entrepreneurial mindset (i.e., Peschl et al., 2021; Pocek et al., 2021; Lindberg et al., 2017; Neergård et al., 2022). The shift from asking *if* entrepreneurship can be taught to *how* to do this has been met with more studies researching the pedagogical methods, including academic university courses, improvisational training, entrepreneurship camps and extra-curricular start-up programs, to teaching entrepreneurship (i.e., Lindberg et al., 2017; Pocek et al., 2021; Neergård et al., 2022; Balachandra, 2019; Peschl et al., 2021). These studies have focused on identifying the most effective exercises for students to develop their entrepreneurial mindset, skills and competencies that will help them in, among others, opportunity recognition, idea generation and founding new ventures (Lindberg et al., 2017; Neergård et al., 2022; Peschl et al., 2021; Pocek et al., 2021). Thereupon, several methods and approaches to teach EE have emerged, including the effectual approaches of discovery-driven planning, prescriptive entrepreneurship, business planning, the lean start-up method and design thinking (Peschl et al., 2021; Mansoori & Lackéus, 2019). Altogether, these diverse approaches equip entrepreneurship students with multiple strategies to problem-solving and creative idea generation, which induces creative thinking outside the box (Mansoori & Lackéus, 2019).

Apart from learning these entrepreneurial abilities, it is critical for the students to evaluate business ideas based on numerous criteria such as feasibility, desirability, and viability in the creative idea generation process (Menold, Simpson, & Jablakow, 2016; Brown, 2009). Correspondingly, Goldsby et al. (2017) identify three proof-of-concepts that must be conducted to validate business ideas. First, the feasibility test determines whether a solution is functionally feasible and can be produced in the near future. Second, the desirability test determines whether a solution is appealing to specific consumers or customers. Third, the viability test answers the question of whether the concept can create economically feasible results, which determines the viability of a solution's business model. Altogether, the students must be able to demonstrate, with supporting evidence, that a product or service is feasible to produce, appealing to buyers, and financially viable. As a result, the entrepreneurship students are taught to look at business opportunities from these three different dimensions.

Besides the more traditional EE for business students, the recent literature has recognized the novelty of researching entrepreneurship across other disciplines (Neergård et al., 2022; Svensson, Adawi, Lundqvist & Williams Middleton, 2021). Minding that the future workforce is required to be adaptive and innovative, entrepreneurial skills are not only relevant for business students, but have pertinence in all disciplines, including nursing and engineering (Neergård et al., 2022; Svensson et al., 2021). At the current state of the literature, most studies have focused on EE offered to business students through their traditional university courses without providing a comparison group from other disciplines. For this reason, the literature has remained one-sided in applying EE across different disciplines, regardless of the realisation of the benefits of EE for graduates across board. More recently, the relevance of EE and the skills it teaches has been highlighted in the engineering pedagogy literature.

2.4 Engineering and entrepreneurship education

Prior studies highlight the possibility of incorporating EE into the engineering discipline, which has resulted in the development of specific methods aimed at engineer students (Duval-Couetil et al., 2016), such as practice-oriented programs (Eager & Cook, 2020), problem-based learning (Chau, 2005) and case studies (Creed et al., 2002). A growing number of engineering students are receiving EE through a variety of courses, seminars, and experiential learning activities (Duval-Couetil et al., 2016). Most programs are designed to help engineering students through their departments and colleges, or are cross-campus, university-wide endeavours to benefit students from a variety of disciplines. So far only few studies have looked at the extent to which different degrees, program models, and experiential activities influence students' entrepreneurial skills, knowledge, and self-efficacy. One study addressing this is by Duval-Couetil et al. (2016), who found that the number of entrepreneurship courses taken and the participation in experiential learning activities were connected to a higher sense of entrepreneurial knowledge among technical students.

The push to include more entrepreneurial knowledge and skills in the technical education, especially engineering, is gaining traction (Duval-Couetil et al., 2016). Thereupon, engineering students are exposed to more entrepreneurship coursework and practical learning opportunities than ever before, both within and outside of their engineering courses. One of the trends affecting this increase lies in the expanded positions and responsibilities that engineers have within organizations, which has created a demand for new skills that will enable them to generate value in the new economy (Rover, 2005; Yurtseven, 2002; Duval-Couetil et al., 2016). Also, modifications in the certification requirements that highlight a broader variety of abilities useful to engineers has an impact, akin to the rising interest in and support for entrepreneurship programs aimed at the engineering students on a national level (Shuman, Besterfield-Sacre & McGourty, 2005; National Science Foundation, 2011).

Most entrepreneurship programs are geared toward technical or science students, and thus are often known as "technology entrepreneurship" or "engineering entrepreneurship" programs (Duval-Couetil et al., 2016). Standish-Kuon and Rice (2002) examined which models of entrepreneurship programs were primarily targeted at engineering and science students in a study with a sample of six different programs. The sample was divided into three groups: first, business schools with formal technology entrepreneurship curricula developed in collaboration with engineering/science students; second, structured technology entrepreneurship curriculum designed in partnership with engineering/science schools or course providers; and third, multi-school programs with a formal technology entrepreneurship curriculum developed in active collaboration with business schools. Therefore, the types of programs that can be utilized to teach entrepreneurship to technology students vary widely. The degree to which the models are technical or multidisciplinary, as well as the type and number of courses and activities they comprise, account for these differences. According to Standish-Kuon and Rice (2002), these multidisciplinary programs can help students gain a deeper understanding of business topics that are relevant to engineers. Also, they have discovered that involvement in entrepreneurship-related experiential activities should be incorporated into engineering courses and programs. However, engineering students must take at least two courses before they may feel comfortable undertaking entrepreneurial duties, which shows that a longer exposure to EE is required.

In engineering pedagogy, EE has received little attention (Holzmann et al., 2018). This discovery is surprising considering that receiving EE can help engineers to take advantage of the entrepreneurial opportunities that arise as a consequence of technology breakthroughs. As a corollary, Holzmann et al. (2018) believe that engineering education should include EE as its core component. They discuss the Entrepreneurial Campus Villach, part of the Carinthia University of Applied Sciences (CUAS) in Austria, as a real-life illustration of a scientifically sound entrepreneurship program. This program focuses on four primary areas. First, most of their *research* initiatives are intertwined with technology, business and organization, and the technology-oriented start-ups and small- and medium-sized businesses are their primary study subjects. Second, they offer broad *EE* encompassing everything from business development to venture formation, but by far their most popular courses are business planning and new venture creation ones. Third, they provide *coaching and support* for students and graduates, who want to pursue entrepreneurial endeavours through its own 'Start-up Initiative' program since 2013. The aim of this program is to enhance the number of new enterprises launched with individual coaching and support to its participants throughout the whole founding process. Finally, CUAS has a variety of *infrastructure* to help technology-oriented entrepreneurs to succeed with their ventures, including its spatial proximity to and location at the CUAS, which allows for quick prototyping and product development.

As shown above, there is an increased interest in combining the entrepreneurship and engineering pedagogies in formal and informal "technology entrepreneurship" as a result of the recognition of the beneficial effects of EE on the capabilities of the engineering students. Yet, the concrete differences between the engineering and entrepreneurship students' creative idea generation have not been researched to elucidate what the impact of EE is on it. To answer this question, it is important to identify the principal characteristics of the entrepreneurship and engineering approaches.

2.5 Synthesis of key findings

To synthesize the main findings from the prior literature on EE and the engineering pedagogy, Table 1 describes the key differences between the entrepreneurship and engineering approaches on three dimensions. The purpose of Table 1 is to clarify the main characteristics of and the distinction between the approaches, which may potentially contribute to (the differences in) the creative idea generation process between the students. Understanding the bigger picture of the approaches guides the formulation of this study's hypotheses.

Table 1

Synthesis of the Differences Between Entrepreneurship and Engineering Approaches

	Entrepreneurship approach	Engineering approach
1. Decision-making logics	Causation, logic of prediction Effectuation, logic of control	Sequential and logical thinking
2. Problem-solving approaches	Multiple strategies (i.e., lean start-up, design thinking)	Mathematical structures Mathematical frameworks Scientific verification
3. Focus on opportunity	Desirability, feasibility, viability	Feasibility

To clarify these three dimensions, each is defined and discussed separately below.

2.5.1 Decision-making logics

The first dimension relates to the underlying decision-making logics that guide the cognitive processes of the entrepreneurs and engineers. On the one hand, entrepreneurs make decisions based on two iterative processes; causation and effectuation, which refer to the logics of control and prediction respectively (Sarasvathy, 2001). Against this, engineers make rational decisions as a result of the linear and logical step-by-step process (Horváth & Rudas, 2008). Noting the principal difference to lie in the iterative versus linear nature of these thinking processes, the decision-making logics are likely to have an impact on the students' ability to generate creative ideas because cognitive flexibility has been identified as an important skill in ideation (Ward, 2004; Baron, 2006). To clarify, by relying on the sequential thinking processes, the engineering students may prevent themselves from recognizing the opportunities that the entrepreneurship students can see by switching between the cognitive processes of causation and effectuation.

2.5.2 Problem-solving approaches

The second dimension refers to the cognitive approaches that engineers and entrepreneurs use in problem-solving, where engineers tend to solve problems based on mathematical structures and frameworks and use scientific verification, whereas entrepreneurs employ many different problem-solving strategies, such as design thinking, depending on the context (Czocher, 2013; Peschl et al., 2021; Mansoori & Lackéus, 2019). Considering that business idea generation has problem-solving at its core, the problem-solving approaches of the participants are likely to impact their results. Especially, by relying on the scientific and mathematical method of solving problems, the engineering students may not be able to apply their approach in all contexts while the entrepreneurship students have tools for different contexts and challenges, which may help them in solving complex challenges.

2.5.3 Focus on opportunity

The third dimension considers what the engineers and entrepreneurs focus on when thinking about business opportunities. While entrepreneurs evaluate business ideas based on feasibility, desirability and viability as equally important dimensions, engineers tend to concentrate on the practical feasibility of opportunities (Goldsby et al., 2017; Duval-Couetil et al., 2016; Creed et al., 2002). This is a relevant difference to consider in their creative idea generation processes as the engineering students may limit their thinking by focusing on the real-life practicality of the opportunities, whereas the entrepreneurship students also take the customer and business model into account when thinking about ideas.

2.6 Analytical framework

Based on the synthesis of the prior literature given above, there are major differences between the entrepreneurship and engineering approaches on three levels. Considering the differences in the cognitive approaches to problem-solving and decision-making, which are processes that are related to also opportunity recognition, there is room to argue that these differences will be relevant in the creative idea generation processes of engineering and entrepreneurship students.

Especially, these cognitive processes contribute to the students' ability to identify opportunities for creative business ideas (Baron, 2006; Camelo-Ordaz et al., 2020; Chen et al., 2019; Peschl et al., 2021). Noting that EE aims to teach diverse methods that train the cognitive flexibility or develop new cognitive strategies of the entrepreneurship students that help them in thinking outside the box and generating new ideas, it can be argued that they will be more successful in creative idea generation than the engineering students (Baron, 2006; Ward, 2004; Peschl et al., 2021; Mansoori & Lackéus, 2019). Correspondingly, the engineering pedagogy focuses on teaching the students mathematical structures and frameworks that can be applied in the linear process of problem-process-solution approach (Horváth & Rudas, 2008; Czocher, 2013). This could potentially limit the thinking processes of the engineering students in creative idea generation and restrict their ability to identify different opportunities that do not fit their (scientific) logic (Horváth & Rudas, 2008; Czocher, 2013; Ward, 2004).

Consequently, when comparing the diversity of thinking styles and strategies that the entrepreneurship students are equipped with through EE with the problem-solving approach of the engineering students, it can be assumed that the entrepreneurship students will be able to generate more business ideas and more *creative* business ideas than the engineering students. In other words, the quantity and creativity of ideas generated can be expected to be higher for the entrepreneurship students than for the engineering students, as hypothesized below.

> **Hypothesis 1.** *There is a significant difference in the outcomes of the creative idea generation process between engineering and entrepreneurship students.*
>
> **Hypothesis 1a.** *Entrepreneurship students generate more business ideas than engineering students.*
>
> **Hypothesis 1b.** *Entrepreneurship students generate more creative business ideas than engineering students.*

Besides addressing the outcome of the creative idea generation process, another aspect that is relevant for this study is the cognitive patterns used for generating creative ideas. Recognizing the differences in the decision-making and problem-solving approaches between engineers and entrepreneurs, it can be assumed that the engineering and entrepreneurship students will adopt different cognitive approaches to generating creative ideas (Horváth & Rudas, 2008; Czocher, 2013; Sarasvathy, 2001; Peschl et al., 2021; Mansoori & Lackéus, 2019).

Indeed, noting the different pedagogical methods to teaching entrepreneurship that EE includes, the entrepreneurship students gain access to a wider pool of cognitive strategies that can be used for creative idea generation (Peschl et al., 2021; Mansoori & Lackéus, 2019; Sarasvathy, 2001). Alternatively, the engineering pedagogy has focused on the scientific and mathematical reasoning as *the* cognitive strategy to problem-solving (Horváth & Rudas, 2008; Czocher, 2013). Considering the salience of cognitive capabilities in opportunity recognition, it can be assumed that by learning multiple cognitive strategies, the entrepreneurship students will be more competent in seeing connections between the cues, or in other words, 'connecting the dots', than the engineering students (Ward, 2004; Baron, 2006). While the entrepreneurship students have been trained to deal with ambiguity and incomplete information, the engineering students require full information to use their problem-solving method, which poses a limit to the application of the engineering approach (Shane, 2000; Horváth & Rudas, 2008).

Based on the different pedagogical approaches used in entrepreneurship and engineering disciplines, it can be assumed that the students have the propensity to use divergent cognitive processes when generating creative ideas, which leads to the following hypothesis.

Hypothesis 2. *Entrepreneurship and engineering students use different creative idea generation patterns.*

In hypothesizing that the outcomes of and cognitive processes for creative idea generation will differ between the entrepreneurship and engineering students, this research assumes that these differences will be explained by exposure to EE. As argued above, the expected differences for the quantity and creativity of ideas generated as well as the use of cognitive patterns by the entrepreneurship and engineering students are based on the impact of EE. Correspondingly, it is expected that the pedagogical tools, frameworks, and interventions that EE includes will provide the entrepreneurship students with knowledge, skills and capabilities that make them more proficient in creative idea generation than the engineering students. This leads to the final hypothesis.

Hypothesis 3. *Entrepreneurship education has a significant impact on students' creative idea generation capabilities.*

CHAPTER 3. METHODOLOGY

This chapter describes the research design of this paper that will be used to test the hypotheses outlined in the previous chapter. First, this chapter explains the data collection method before justifying the population and sample of engineering and entrepreneurship students of this study. Second, the data collection will be explained in detail before the variables are operationalized.

3.1 Data collection method

To test the hypotheses of this study, qualitative and quantitative data will be collected with an experiment design, which has a precedence in cognitive and creative idea generation research. Indeed, multiple published papers in these research areas collect data through experiments (i.e., Costa, Ehrenhard, Caetano & Santos, 2016; Shimizu & Okada, 2021; Puente-Díaz et al., 2021; Sarasvathy, 2001). Other sources of experiential data are also common in the entrepreneurship pedagogy research, including alternative training approaches (Balachandra, 2019), case studies with pedagogical interventions (Holzman et al., 2018; Lindberg et al., 2017; Neergård et al., 2022), and different types of extra-curricular programs (Pocek et al., 2021). Since this research is measuring the cognitive processes of students leading to creative idea generation, conducting an experiment allows for assessing both the explicit and implicit cognition of the participants, which reflects their thinking processes (Chaston & Sadler-Smith, 2011; Hurst, 2019). In other methods, such as in a survey design, the implicit cognition, which refers to the intuitive and unconsciously held part of cognition, would not be measured at all (Hurst, 2011). Therefore, conducting a qualitative experiment has been identified as the most suitable way to measuring the cognitive processes of the participants (Chaston & Sadler-Smith, 2011).

Further, to understand the cognitive processes in-depth, the data will be collected with a verbal protocol analysis (VPA), which allows for measuring the participants' thinking processes in real time (Carroll & Johnson, 1990). VPA is a think-aloud method to measuring the cognitive processes of the participants by following their strain of thought based on what they say during the experiment (Carroll & Johnson, 1990). Especially, this method is fitting for understanding the thinking processes behind the answers, which not only allows for assessing the outcome, but also the cognitive processes leading to these outcomes. During the VPA, the participants' verbal reasonings are recorded, which are then transcribed and coded to identify the cognitive reasoning patterns the participants used to arrive at the proposed solutions to the case. However, it can be difficult to measure and understand their cognitive processes as the information provided by the participants is often incomplete and therefore, the entire extent of their cognitive processes cannot be captured. For example, the participant may not share all the thoughts they have had when thinking about the ideas. This will affect the results of this study, which is why it is important to be aware of this limitation in studying the participants' cognitive processes and patterns.

3.2 Population and sample

The population of interest for this study consist of engineering and entrepreneurship students at Lund University (LU). LU is a public research university located in Southern Sweden with 43,700 students (Lund University, 2022b). The university offers over 130 international master programs, which include 18 engineering programs at the Faculty of Engineering (LTH) and one entrepreneurship program at the School of Economics and Management (LUSEM) (LTH, 2020; LUSEM, n.d.). There are approximately 10,000 bachelor- and master-level engineering students studying at LTH, while the entrepreneurship master program has a class size of 66 students for the 2021-2022 cohort (LTH, 2020; LUSEM, n.d.). Additionally, LUSEM offers stand-alone courses in entrepreneurship on the bachelor-level (Lund University, n.d.). Out of this student population, this study will have a sample of 10 engineering master students and 10 entrepreneurship master students participating in the data collection experiments. The sample size was justified on the basis that by having 10 participants from each group, the study will collect comparative amount of data for each participant group, which is sufficient for both the qualitative and quantitative data analyses while being manageable for the timeframe provided for conducting this research. Overall, with a larger sample size this study will likely have more variance in the results, which potentially yields deeper insights in the research topic.

To be eligible for this study, the following sampling strategy will be used. First, the base requirement for the participants is that they are studying either one of the engineering programs or entrepreneurship program at LU. This is a necessity for confirming that the participant fits within one of the participant groups, but also to distinguish which group they belong to. Second, they must follow a master's level study. This requirement relates to the extent of their knowledge bases and cognitive capabilities to process information and reason that are accumulated through education (Kauppila & Tempelaar, 2016; Mom, van den Bosch & Volberda, 2009). By studying on the university level, students improve their knowledge and cognitive capabilities, which potentially affect their creative idea generation processes as well. Thus, to mitigate the effect of the different levels of education on the results of this study, only master students will be recruited to participate. Third, they should be studying in English. This condition is based on the nature of the research. As the experiment will be conducted in English, it is crucial that the participants can understand the experiment instructions and verbally discuss their solutions in English during the VPA. Overall, the experiment demands high command of the English language. Considering the language requirements for following a master's level study in English at LU, each participant must have proven their advanced English language proficiency in the application process (Lund University, 2022a). Thus, by fulfilling the first two criteria of the sampling strategy, the participants have proven sufficient language skills for undertaking the experiment. Fourth, as the final criterion, the participants must be available for the whole duration of the experiment and be willing to participate on a volunteer basis. Indeed, the only incentive for participation is that the participants get to contribute to research and work on the problem-solving task. To be able to conduct the experiment, each participant must be available for 30 minutes at a time. As the data is collected through the VPA, the participants must be willing to speak for 25 minutes for the recording.

Considering that the entrepreneurship master's program has students with various study backgrounds, an additional criterion was set for selecting participants from this group. In order to keep the participant groups as distinct as possible, the entrepreneurship students with an engineering background were not considered for participation. The reason for this is that if they have previously received engineering education, their thinking processes are aligned with those of the engineering students, per the hypotheses of this study. Therefore, when selecting which students to approach from the entrepreneurship program, the educational backgrounds of the students were checked. Noticing that there are 23 students with business background in the class, it was decided to only invite participants with this background to join the study. From these students, 5 female and 5 male students were approached with a request for participation. In choosing these 10 candidates out of the 23 students, the authors aimed to choose individuals who are not familiar with the study topic and research method to reduce potential biases from knowing the research subject as participant. Hence, only students from other thesis supervision groups were invited to join the experiments.

In reaching out to the engineering students attempts were made to control for the study program. Initially, the master's program in *Machine Learning, Systems and Control* was randomly selected as the program from which the participants would be invited because it was assumed that this program relies on more mathematical structures and frameworks that were identified as characteristics of the engineering approach. After reaching out to the international coordinator of this master program, a message was forwarded to the students of this program with a request to participate into the experiment. This call for participants did not yield any sign-ups and thus the scope was expanded to include also other engineering programs. The international coordinators of other engineering programs were contacted, and they forwarded the message to all engineering master students through Canvas, but this was also unsuccessful. Consequently, the third round of recruiting was done in person by approaching the engineering students at the LTH campus to ask them to sign up for the experiment, which is a convenience-sampling method. At this point, the specific engineering study program no longer played a role in the participant selection, but it was made sure that the participants fulfilled the participation criterion.

3.3 Data collection

The design of the experiment followed the process used by Costa et al. (2016) and Puente-Díaz et al. (2021). Both articles start their experiments with a hypothetical problem scenario that the participants must solve by through creative idea generation. Inspired by these scenarios, this research also included a hypothetical problem scenario to test the participants' creative idea generation capability. Since the participants in this study are university students, the problem scenario related to student life and called for creative business ideas to solve. The design of the problem scenario considered the differences in the participants' prior knowledge and skills in the sense that it did not demand in-depth business or engineering knowledge, and thereby it did not favour one group of students over the other. Instead, it was relatable to participants across disciplines. The case and experiment instructions used can be found in full under Appendix A. In sum, the students were tasked with solving the problem of lacking study places in Lund with creative business ideas. Several cues were to be found in the case to give students directions in which they could look at the problem. For example, the issues with unergonomic furniture and noise levels were mentioned as well as the differing needs of individuals and groups for their study places. As entrepreneurship relies a process of opportunity recognition without complete information about the business opportunity, this study aimed to assess whether the students are able to make use of the incomplete information provided in the case to generate many creative business ideas (Shane & Venkataraman, 2000; Baron, 2006; Shane, 2000).

After providing the participants with the experiment instructions, including the hypothetical problem scenario case, they had 25 minutes to talk about their solution ideas aloud during the VPA. As explained above, their verbal reasonings were recorded. Also, during the experiments, the participants were given a pen and paper to make notes, drawings or use it in other ways. The decision to include this aspect was inspired by Shimizu and Okada's (2021) experiment in embodied cognition, where one participant group could build their children's toy ideas by physically touching the materials. They found that those who could touch the materials had higher creativity scores. Hence, in this study, the opportunity to use the pen and paper for prototyping is provided. During the first 25 minutes of the experiment, only the participant was allowed to speak, and no feedback or other comments were made by the authors. However, the authors wrote notes about the participants' answers and reasoning and other observations they made during the experiments.

After the VPA, the participants were asked two questions. First, "how did it go?" to assess whether the participant had specific feedback on the set-up of the experiment or their own performance. Second, "out of all the ideas you came up with, which do you think is the most creative and why?" to make the participants self-assess their ideas, choose which one they find most creative personally and give a brief reasoning for this. Essentially, this question helps to recognize the different understandings of what it means to be creative and what constitutes a creative business idea to the participants. Especially, this study measures creativity based on Dean, Hender, Rodgers and Santanen (2005) and Golsby et al. (2017), which may be different from the students' understanding of creativity. Thereupon, the second question was also used to reflect on how creativity is measured academically and how it is understood in practice. With these questions, this study aimed to understand how the process of generating creative ideas was for the participants and what kind of ideas they considered to be creative.

The final part of the experiment was a survey to collect the demographic data and background information of the participants. The survey questions can be found under Appendix B. For all participants, their age, gender, and nationality were asked for. At the end of Section 1, the participant chose which program they are following, either MSc in Entrepreneurship and Innovation or one of the engineering master's programs. The rest of the survey was conditioned on this question so that entrepreneurship students filled in Section 2 and engineering students Section 3. Section 2 included questions about prior EE and start-up founding experience before the start of the master's study. These questions were used to estimate the intra-group variance in case some participants have more EE or start-up founding experience, which may help them in generating business ideas. Section 3 also included these two questions, which were used to understand whether the engineering students have been exposed to EE or entrepreneurship in general in the past. To support the internal validity of this study, it was important to ensure that the participant groups are as distinct as possible, and hence, if engineering students have been exposed to entrepreneurship in some form, this may affect their results.

All the experiments to collect data were conducted between April 12 and May 6, 2022. The experiments with the entrepreneurship students were held on three occasions: April 12, April 20, and April 29. The experiments with the engineering students were held on five occasions: April 20, April 29, May 2, May 3, and May 6.

One of the strengths of this data collection method is that it yields both qualitative and quantitative data, which allow for more detailed information about the cognitive processes and the outcomes of the experiments. On the one hand, the VPA generates qualitative insights into the thinking processes used by the participants, which explains how they arrive in the ideas for solving the case. On the other hand, when processing the data, quantitative measures for the quantity and creativity of ideas generated will be used to produce comparable data. Overall, this dual method allows for having quantitative comparison for the outcomes of the experiment, which are complemented by qualitative insights into the cognitive processes leading to these outcomes. When combined, the quantitative and qualitative insights will produce a more well-rounded understanding of the phenomenon as both the cognitive processes behind the ideas as well as the quantity and creativity of the ideas generated will be measured.

3.4 Measures

The variables measured in this research are the following.

Quantity of ideas generated. To measure the outcomes of the experiments, the quantity of ideas generated by participants will be measured. This variable is operationalised by counting every distinct business idea that the participant proposed during the VPA to yield quantitative data. This variable measures the students' ability to generate as many ideas as possible within the 25 minutes provided for the VPA.

Creativity of ideas generated. Besides assessing the quantity of ideas generated, this study will also score the participants' ideas with the four-dimension criterion for assessing ideas by Dean, et al. (2006). This criterion consists of four quality dimensions. First, *novelty* to measure "the degree to which an idea is original and modifies a paradigm" (Dean et al., 2006, p.663) based on two sub-dimensions of originality and paradigm relatedness. Second, *workability/feasibility* to test whether the idea "can be easily implemented and does not violate known constraints" (Dean et al., 2006, p.663), which has acceptability and implementability as the sub-dimensions. Third, *relevance* to assess if "the idea applies to the stated problem and will be effective at solving the problem" (Dean et al., 2006, p.663), which considers applicability and effectiveness as sub-dimensions. Fourth, *specificity* to evaluate if the idea is clear and worked out in detail, which relies on three sub-dimensions of implicational explicitness, completeness, and clarity. Overall, these four quality dimensions and nine sub-dimensions offer a comprehensive tool to evaluating the ideas generated by the experiment participants. In operationalising the criterion, each dimension can receive a score of 0 or 1 based on whether the idea fulfils the requirements. The score is based on meeting the sub-dimensions, where all dimensions must be met to have a score of 1 for the higher-level quality dimension. Therefore, each idea receives a score on the scale from 0 to 4, where higher the value, higher the creativity of the idea, and vice versa.

In addition, Goldsby et al.'s (2017) understanding of business ideas based on the three dimensions of feasibility, desirability and viability will be used to complement the above-mentioned criterion by Dean et al. (2006). As the criterion by Dean et al. (2006) focuses on the creativity and feasibility of ideas, it misses the desirability and viability dimensions of business ideas. Thus, these two will be added to the criterion to assess the ideas based on Goldsby et al. (2017). First, *desirability* will be used to evaluate the appeal of the idea to customers or users. Second, *viability* will be used to measure whether the business model behind the idea can lead to economic outcomes. In operationalising these dimensions, they will be scored either as a 0 or 1 based on whether the participant mentioned anything about the dimension when proposing an idea. Thereby, each idea will be scored on a scale from 0 to 6 based on the six dimensions and nine sub-dimensions, which are shown in Table 2.

Table 2

Measures, Definitions and Operationalisations

Dimension	**Sub-dimension**	**Definition**	**Operationalisation**
Novelty	*Originality*	The degree to which the idea is not only rare but also ingenious, innovative, or surprising (Dean et al., 2006, p.663).	The idea was considered original when it was not proposed by multiple participants and had surprise element, which resulted in the score of 1. If the idea was common, it scored 0.
	Paradigm relatedness	The degree to which an idea is paradigm preserving (PP) or paradigm modifying (PM) (Dean et al., 2006, p.663).	Paradigm relatedness was understood based on the study location, where ideas proposing studying at LU or other current study buildings were considered PP and scored 0. Against this, proposing studying elsewhere was considered PM and scored 1.
Workability / feasibility	*Acceptability*	The degree to which the idea is socially, legally, or politically acceptable (Dean et al., 2006, p.663).	If the idea does not raise any acceptability concerns, it scored 1, and if it does, it scored 0.

	Implementability	The degree to which the idea can be easily implemented (Dean et al., 2006, p.663).	If the idea would be easy to implement in its current format without a large investment, it scored 1, and if it requires a large investment, it scored 0.
Relevance	*Applicability*	The degree to which the idea clearly applies to the stated problem (Dean et al., 2006, p.663).	The stated problem was understood as adding study spaces in Lund. If the idea adds study spaces in Lund, it scored 1, and if it does not, it scored 0.
	Effectiveness	The degree to which the idea will solve the problem (Dean et al., 2006, p.663).	Effectiveness was measured based on how many study places were added by the idea. If the idea adds a lot of new study places in Lund, it is effective and scored 1. If the idea does not add any or many study places in Lund, it is not considered effective and scored 0.
Specificity	*Explicitness*	The degree to which there is a clear relationship between the recommended action and the expected outcome (Dean et al., 2006, p.663).	If the relationship between the proposed solution and the problem is clear, the idea scored 1. If the relationship was not explicit, it scored 0.
	Completeness	The number of independent subcomponents into which the idea can be decomposed, and the breadth of coverage with regard to who, what, where, when, why, and how (Dean et al., 2006, p.663).	If the idea was explained in detail and included information about, for example, the stakeholders involved in the implementation of the idea, the idea scored 1. If the idea was briefly mentioned and included no details, it scored 0.
	Clarity	The degree to which the idea is clearly communicated with regard to grammar and word usage (Dean et al., 2006, p.663).	If the idea was easily understandable from the verbal explanation, it scored 1, and if it was not, it scored 0.
Desirability		Whether a potential solution is desirable to specific users or customers (Goldsby et al., 2017, p.408).	If the end users or their needs were mentioned when proposing a solution, it scored 1. If there was no mentioning of the customers, it scored 0.
Viability		Whether the concept can produce viable economic outcomes (Goldsby et al., 2017, p.408).	If a way to make money with the idea was mentioned, it scored 1. If no business model was discussed, it scored 0.

Creative idea generation patterns. To research how the participants arrived at the ideas, their cognitive patterns were identified and processed in a similar manner to the procedure used by Shimizu and Okada (2021). First, the VPA recordings were transcribed and checked for details.

Second, each distinct idea was treated as the unit of analysis and the reasonings leading to the generation of the idea were collected. Third, these reasonings were coded and categorized into creative idea generation patterns. In coding the patterns, the authors constructed pattern groups based on the similarities between the cues (see Table 12 for the patterns and underlying cues). After that the frequency of using the patterns was counted and the comparisons between the entrepreneurship and engineering students were made. Overall, this variable was measured in a qualitative manner rather than quantitatively despite counting the frequencies.

Controls. In addition to the measures listed above, the following demographic control variables were added to the study: *age*, *gender*, *study*, *EE* and *venture founding experience*.

CHAPTER 4. RESULTS

This chapter explains the data processing process and the analyses used to test the hypotheses of this study and reports the results. First, the experiment sample characteristics are presented before the quantitative data analysis is explained to test Hypotheses 1, 1a and 1b. Second, the qualitative data analysis is conducted to test Hypothesis 2. Third, the results from both analyses are synthesized to test Hypothesis 3.

4.1 Experiment sample characteristics

After the experiment, the participants were anonymised and their names were turned into codes, like Ent Par 1 or Eng Par 7. The sample characteristics for the participant groups are presented in Tables 3 and 4. For the entrepreneurship students, the average age is 25.6 years (*SD*=3.3), the gender distribution of 50.0% female participants and 50.0% male participants and the participants hold one of the following six nationalities: German (30.0%), Swedish (20.0%), Dutch (20.0%), American (10.0%), British (10.0%) and Hungarian (10.0%). For their EE before starting the master's program, 50.0% have received courses in entrepreneurship. In addition, 20.0% have venture founding experience, whereas 80.0% do not.

Table 3

Entrepreneurship Student Participant Demographics

Age (years)		*Gender*		*Nationality*		*EE*		*Venture Ex.*	
M	25.6	*Male*	50.0%	*German*	30.0%	*Yes*	50.0%	*Yes*	20.0%
SD	3.3	*Female*	50.0%	*Swedish*	20.0%	*No*	50.0%	*No*	80.0%
				Dutch	20.0%				
				American	10.0%				
				British	10.0%				
				Hungarian	10.0%				
N = 10									

For engineering students, the average age is 26.8 years (*SD*=2.8), there are 50.0% female participants and 50.0% male participants, and the participants hold one of the following five nationalities: Swedish (60.0%), American (10.0%), Peruvian (10.0%), Icelandic (10.0%) and Italian (10.0%). Also, none of the participants have received prior EE and they do not have any venture founding experience. The participants are on their fifth year of study, which refers to the second year of the master-level studies, in one of the following engineering programs: *Water Resources Engineering* (20.0%), *Civil Engineering* (20.0%), *Electrical Engineering* (20.0%), *Environmental Engineering* (20.0%), *Mechanical Engineering* (10.0%), and *Building Engineering* (10.0%).

Table 4

Engineering Student Participant Demographics

Age (years)		*Gender*		*Nationality*		*EE*		*Venture Ex.*	
M	26.8	*Male*	50.0%	*Swedish*	60.0%	*Yes*	0.0%	*Yes*	0.0%
SD	2.8	*Female*	50.0%	*American*	10.0%	*No*	100.0%	*No*	100.0%
				Peruvian	10.0%				
				Icelandic	10.0%				
				Italian	10.0%				
$N = 10$									

4.2 Quantitative data analysis

In this part, the processing and analysis of the quantitative data is discussed. The quantitative data analysis is used to test the following hypotheses.

> **Hypothesis 1.** *There is a significant difference in the outcomes of the creative idea generation process between engineering and entrepreneurship students.*
>
> **Hypothesis 1a.** *Entrepreneurship students generate more business ideas than engineering students.*
>
> **Hypothesis 1b.** *Entrepreneurship students generate more creative business ideas than engineering students.*

To conduct the quantitative data analysis, the IBM Statistical Package for the Social Sciences version 25 was used to execute different statistical analyses in the following order.

4.2.1 Normality analysis

To test whether the variables are normally distributed, which is commonly assumed by many statistical tests, a normality analysis was conducted that consists of several tests that compare the distribution of the variables against normal distribution (Field, 2018). Before this analysis, the variables for the quantity of ideas generated and creativity of ideas generated were created. First, to have a measure of the quantity of ideas generated, the experiment transcripts were used to identify and count each distinct idea that the participant proposed as a solution to the case. Tables 5 and 6 show the quantity of ideas generated by the entrepreneurship and engineering students respectively and report the sum and the mean of ideas per participant group.

Table 5

Quantity of Ideas Generated by Entrepreneurship Students

Par 1	Par 2	Par 3	Par 4	Par 5	Par 6	Par 7	Par 8	Par 9	Par 10	Sum	Mean
6	23	4	13	14	9	25	11	7	7	119	11.9

Table 6

Quantity of Ideas Generated by Engineering Students

Par 1	Par 2	Par 3	Par 4	Par 5	Par 6	Par 7	Par 8	Par 9	Par 10	Sum	Mean
9	11	9	2	8	5	14	10	6	9	83	8.3

Second, to assess the creativity of ideas generated, each idea was scored based on the criteria presented in Section 3.4. Thereupon, the creativity of ideas generated variable was formed by computing means, which means averaging the scores for all ideas to get the overall score for the participant creativity. Tables 7 and 8 present the average creativity scores of the entrepreneurship and the engineering participants respectively, and the mean for each participant group.

Table 7

Creativity of Ideas Generated by Entrepreneurship Students

Par 1	Par 2	Par 3	Par 4	Par 5	Par 6	Par 7	Par 8	Par 9	Par 10	Mean
3.17	3.13	4.75	3.54	4.43	4.00	2.76	2.64	3.86	2.71	3.50

Table 8

Creativity of Ideas Generated by Engineering Students

Par 1	Par 2	Par 3	Par 4	Par 5	Par 6	Par 7	Par 8	Par 9	Par 10	Mean
2.78	2.45	4.00	3.00	3.13	2.33	3.71	2.70	1.33	1.63	2.71

After creating these variables, the data was screened for skewness and kurtosis, which measure deviations from the normal distribution. The results of this analysis found no issues with either skewness or kurtosis for the creativity of ideas generated with the values of -.071 and -.043 respectively. Against that, skewness and kurtosis are substantially positive for the quantity of ideas generated with the scores of 1.411 and 2.208 respectively that are above the |1| limit (Field, 2018).

To verify these results, a Kolmogorov-Smirnov test of normality was run, which tests whether the variable distributions are significantly different from the normal distribution (scores $p < .05$) (Field, 2018). Both the quantity of ideas generated scores, $D(20) = .187$, $p = .064$, and the creativity of ideas generated, $D(20) = .119$, $p = .200$, did not deviate significantly from the normal distribution, which means that the variables follow a normal distribution. Yet, the normal quantile-quantile (Q-Q) plot for the quantity of ideas generated distinguished Ent Par 2 and Ent Par 7 as outliers due to their significantly higher number of ideas. However, considering that the Q-Q plot follows a reasonably straight line, and the sample size is small (*n*

=20), these potential outliers will be included in the statistical analyses and their effect will be evaluated in the post hoc analysis.

4.2.2 Correlation analysis

Before conducting a correlation analysis, which assesses the strength of associations between the variables, the control variables were coded into four dummy variables. First, for *gender*, one dummy was made with men as the control group (0) and women as the comparison group (1). Second, for *study*, one dummy was created with MSc Entrepreneurship and Innovation as the control group (0) and MSc in one of the engineering programs as the comparison group (1). Third, for *EE*, one dummy was made with no education as the control group (0) and education as the comparison group (1). Fourth, for *venture founding experience*, one dummy was made with no experience as the control group (0) and experience as the comparison group (1). What was noted from the data is that none of the engineering participants had received EE or venture founding experience. In addition to these dummies, *age* was measured as a continuous variable.

The results of the bivariate correlation analysis are presented in correlation matrix in Table 9. The relations were examined using the Pearson correlation coefficient (r) and the two-tailed test of significance because there could be made no predictions about the direction of the relationships. Below the significant correlations will be highlighted.

Table 9

Overall Means, Standard Deviations, and Correlation of Research Variables

Variable	*M*	*SD*	1	2	3	4	5	6
1. Quantity of ideas generated	10.10	5.71	-					
2. Creativity of ideas generated	3.10	0.87	0.04	-				
3. Age	26.20	3.07	0.04	-0.26	-			
4. Gender [a]	0.50	0.51	0.09	-0.08	-0.23	-		
5. Study [b]	0.50	0.51	-0.32	-0.47*	0.20	0.00	-	
6. Entrepreneurship education [c]	0.25	0.44	0.20	0.28	-0.23	-0.35	-0.58**	-
7. Venture founding experience [d]	0.10	0.31	0.20	0.35	-0.08	0.00	-0.33	0.19

Note. $N = 20$. ** $p < .01$, * $p < .05$.
[a] 0 = male, 1 = female.
[b] 0 = MSc Entrepreneurship and Innovation, 1 = MSc in one of the engineering programs.
[c] 0 = no entrepreneurship education, 1 = entrepreneurship education.
[d] 0 = no venture founding experience, 1 = venture founding experience.

First, the study program of the participants is significantly negatively correlated with the creativity of ideas generated ($r = -.47$, $p < .05$). This means that the entrepreneurship students on average score higher on the creativity of ideas generated than engineering students.

Second, having received prior EE is significantly negatively correlated with the study program of the participants (*r* = -.58, $p < .01$). In other words, the entrepreneurship students on average score higher on prior EE than the engineering students, which is supported by the fact that none of the engineering students in the sample had been exposed to EE during their studies.

4.2.3 Independent samples *t*-test

To test the Hypotheses 1a, that the entrepreneurship students generate more business ideas than engineering students, and 1b, being that the entrepreneurship students generate more *creative* business ideas than engineering students, an independent samples *t*-test was conducted. This test can be used to compare means between two different participant groups to assess whether there is a significant difference (Field, 2018). Before interpreting the results, Levene's test of equal variances was used to determine whether the variances in the participant groups are equal (Field, 2018). The results of this test show that for the quantity of ideas generated, the variances for the entrepreneurship students and the engineering students were equal $F(1, 18) = 3.09$, $p = .096$. Similarly, for the creativity of ideas generated, the variances for the entrepreneurship students and the engineering students were equal $F(1, 18) = 0.00$, $p = .996$. Therefore, for the results of the independent samples *t*-test equal variances can be assumed. In assessing the effect sizes, Cohen's *d* will be used (Field, 2018).

On average, the entrepreneurship students generated more ideas (*M* = 11.90, *SE* = 7.11) than the engineering students (*M* = 8.30, *SE* = 3.34). This difference, -3.60, 95% CI [-1.62, 8.82], was not significant, $t(18) = 1.45$, $p = .164$, however, it represented an effect of *d* = 0.51, which is considered to be a medium effect size (Field, 2018). In other words, *d* = 0.51 means that there is a 0.51 standard deviations difference between the two groups in terms of their quantity of ideas generated (Field, 2018). Altogether, Hypothesis 1a was not supported. On average, the entrepreneurship students generated more creative ideas (*M* = 3.50, *SE* = 0.74) than the engineering students (*M* = 2.71, *SE* = 0.83). This difference, -0.79, 95% CI [0.05, 1.53], was significant $t(18) = 2.25$, $p = .037$ and represented an effect of *d* = 1.07, which is considered to be a large effect size (Field, 2018). To put it differently, there is a 1.07 standard deviations difference between the two groups in terms of their creativity of ideas generated (Field, 2018). Thereupon, Hypothesis 1b was supported.

4.2.4 Post hoc analysis

After finishing the data analysis, the steps were repeated without the potential outliers that were identified before, namely Ent Par 2 and Ent Par 7. The removal of the outliers changed neither the significance of the finding that the entrepreneurship students generated more ideas than the engineering students, $t(16) = 0.36$, $p = .728$, nor the finding that the entrepreneurship students generated more creative ideas than the engineering students, $t(16) = 2.44$, $p = .027$. Therefore, the results from the earlier data analysis will hold for these relationships.

4.3 Qualitative data analysis

In this part, the processing and analysis of the qualitative data is discussed. The qualitative data analysis is used to test the following hypothesis.

> **Hypothesis 2**. *Entrepreneurship and engineering students use different creative idea generation patterns.*

Using qualitative data in addition to quantitative data adds depth to the research by examining the cognitive processes behind the ideas generated by the participants. Indeed, the qualitative insights from the VPA explain how the participants cognitively process cues and information from the case, their experiences and surroundings to arrive in the ideas. After transcribing the recordings, the transcripts were coded to distinguish ideas and thinking patterns leading to the ideas. In addition, the participant notes and sketches made during the experiment (see Appendix C) were used to support the description of the ideas and patterns. First, a thematic analysis of the ideas generated will be presented and second, the creative idea generation patterns used by the students will be compared to clarify the differences between their cognitive processing.

4.3.1 Thematic analysis of ideas generated

After extracting all ideas generated by the participants (N=202), they were evaluated together by the authors to identify similarities between them. This analysis led to the emergence of four distinct theme categories. Once all 202 ideas were divided into the four theme categories, they were further categorized into sub-themes as shown in Table 10.

Table 10

Themes of Ideas Generated

Theme category	Sub-themes
LU campus	Booking system, interior design solutions, underutilized space within LU, awareness increasing, administrative solutions
Build	Digital solutions, containers, outdoor study spaces, building a study building
Underutilized space in Lund	Cafés and restaurants, companies/offices, hotels, social places (i.e., hospital, elderly home, churches), student places
Miscellaneous	Space and physics inspired, work from home, student feedback/involvement, vehicles, random

These themes were constructed by the authors based on the patterns that emerged between the ideas that the participants proposed. Based on the categorization, the frequencies per category are reported in Table 11.

Table 11

Count of Ideas Per Theme

Theme category	Entrepreneurship students	Engineering students	Total number of statements
LU campus	23	43	66
Build	25	13	38
Underutilized space in Lund	56	15	71
Miscellaneous	15	12	27
Total	119	83	202

To further explain these categories, they will be discussed below with supporting examples.

Theme 1. LU campus

Theme 1 concerns the LU campuses and their facilities and how they could be fixed, renovated or improved. Within this theme, there are five sub-themes, as shown in Table 10, from which examples of ideas are given below.

> *"Booking system for classrooms at the university." (*Ent Par 4)
>
> *"Create study pods within rooms."* (Ent Par 7)
>
> *"Open up teachers' rooms for students."* (Eng Par 1)
>
> *"Make students more aware of all the buildings they could use."* (Ent Par 6)
>
> *"Each faculty takes care of its own students."* (Eng Par 4)
>
> *"It would be good to make kind of an inventory of what spaces there are at LU and how they're being used and investigate whether they can be used in a better way or not."* (Eng Par 6)

As can be seen in Table 11, the engineering students came up with more ideas (*n*=43) focused on Theme 1 than the entrepreneurship students (*n*=23). Further, over 50% of all the ideas that the engineering students proposed were related to this category, while for the entrepreneurship students it was just 19%. This goes to show that the engineering students mostly thought about the LU campus facilities when ideating, which could be seen as 'thinking inside the box'.

Theme 2. Build new

Theme 2 is about building or creating new buildings or other kind of constructions around Lund to create more study places. This theme was divided into four sub-themes in the analysis, as shown in Table 10. Below examples of the ideas related to this category are provided.

> *"What would also be quite cool, but that only works during summertime, is to somehow build like an outside study place, which wouldn't be like building a whole new building because at least I would like to sit outside and study during summer."* (Ent Par 8)
>
> *"Shipping containers to build out study spaces around campus."* (Ent Par 7)
>
> *"Build more buildings."* (Eng Par 5)
>
> *"Rooftop workspaces for studying that is covered."* (Ent Par 4)
>
> *"VR [virtual reality] office spaces where students can collaborate online."* (Ent Par 7)

As can be seen in Table 11, the entrepreneurship students produced more ideas (*n*=25) focused on Theme 2 than the engineering students (*n*=13). As a percentage of all ideas generated, 21% of ideas by the entrepreneurship students and about 16% of ideas by the engineering students fell under this theme.

Theme 3. Underutilized space in Lund

Theme 3 is about making use of the underutilized spaces in Lund. This theme has been divided into five sub-themes, as depicted in Table 10. To clarify this theme, examples from each sub-theme are provided below.

> *"Like a church for example, because some churches are like not really used anymore? I don't know how you call it in English but in German there's a thing where you like kind of, like take the purpose of the church and then it's just a building."* (Ent Par 5)
>
> *"Restaurants that open in the evening turned into study places during the day."* (Ent Par 8)
>
> *"Use elementary school space during breaks and weekends."* (Ent Par 2)
>
> *"Cooperate with city libraries to offer space."* (Ent Par 6)
>
> *"Free space in student buildings."* (Eng Par 7)

As can be seen in Table 11, the entrepreneurship students came up with more solutions (*n*=56) focused on Theme 3 than the engineering students (*n*=15). Considering that 47% of all ideas generated by the entrepreneurship students fall under this category, contrary to the engineering students with just 18%, they have been thinking outside the box during the experiment.

Theme 4. Miscellaneous

Theme 4 includes miscellaneous ideas that the participants produced that do not fit one of the earlier categories. Within this theme, there are five sub-themes as shown in Table 10 and with the examples provided below.

> *"You make like a big, a big room and you make it an all like zero gravity room."* (Ent Par 4)
>
> *"Study trips for students to study together."* (Ent Par 2)
>
> *"Admit less students."* (Eng Par 2)
>
> *"Find a way to shrink all of us and create a dollhouse for everyone to sit in."* (Ent Par 7)
>
> *"Organize student feedback sessions."* (Eng Par 8)

As can be seen in Table 11, the entrepreneurship students generated more ideas (*n*=15) focused on Theme 4 than the engineering students (*n*=13). Least number of ideas for both groups were part of this theme, namely 13% for entrepreneurship students and 14% for engineering students. Considering that Theme 4 consists of ideas that could not be grouped into other categories, it is not a surprise that it contains the least number of ideas across all categories.

4.3.2 Creative idea generation patterns

In addition to the thematic analysis, the cognitive creative idea generation patterns (*N*=295) behind the ideas were assessed to identify what kind of cues probed the participants to generate their solutions to the case. In this process, the transcripts were analysed to recognize patterns among the reasonings that the participants provided for their ideas during the VPA. In total, six patterns emerged, which are presented in Table 12 along with example cues for each pattern. These patterns were recognized and constructed by the authors based on the verbal reasonings of the participants. Based on this grouping, the frequencies of use per pattern are reported in Table 13.

Table 12

Cognitive Patterns for Creative Idea Generation

Pattern	Example cues
Personal experience	Personal experience of having seen something happen in the past or in a different context, reminded the participant of something from their past, had first-hand experience with the problem
LU-Lund	Lund's student life with nations and student housing, personal experience of studying at LU campus, class team working on a related business idea
Sensory cues	Sunny weather, seeing the view outside the window, seeing issues with the room used for the experiments
Case cues	Not making efficient use of space, noisy areas, groups struggle to find a suitable place to work together, desks and chairs are unergonomic
Existing concepts	Applying existing business model in this context, video of a product or service that can be applied to solve the case
Corona	Remote working, offices downsizing after Corona

Table 13

Frequency of Cognitive Patterns

Pattern	Entrepreneurship students	Engineering students	Total number of statements
Personal experience	7	9	16
LU-Lund	28	8	36
Sensory cues	4	0	4
Case cues	102	121	223
Existing concepts	8	1	9
Corona	6	1	7
Total	155	140	295

Below the findings per pattern will be discussed along with examples from the participants. In addition, a comparison between the entrepreneurship and engineering students will be made to distinguish the similarities and differences between their cognitive processes for ideation.

Pattern 1. Personal experience

Three entrepreneurship students and six engineering students came up with ideas that were inspired by their own experiences while studying, which is a similarity in applying this pattern across the groups. For example, Ent Par 9 came up with the idea for a booking system for teaching spaces for students because it reminded them of their high school, which was similar to the group work booking system idea proposed by Eng Par 7, who said that they got the idea from their personal experience of having to come to campus early to get a group room. While the ideas differ in nuance, the participants followed the same cognitive approach leading to them.

"It reminds me of like a high school, that is not really useful to me the way that LUSEM is set up in particular." (Ent Par 9)

"Um, I agree that there just aren't enough study spaces apparently have to get here at like 6:00 AM to get a group room on campus." (Eng Par 7)

This pattern is aligned with the earlier literature finding that prior knowledge and experiences matter for opportunity recognition (Shane & Venkataraman, 2000; Baron, 2006; Camelo-Ordaz et al., 2020; Chen et al., 2020). Indeed, clearly the participants' earlier personal experiences of working from different locations or having seen creative solutions to this problem probed them to recognize opportunities that they would have otherwise overlooked.

Pattern 2. LU-Lund

Eight entrepreneurship students used Pattern 2 to propose ideas, but there was no evident pattern to study among their concepts because they went in all ways. This was not the case with the six engineering students. To generate ideas, five out of six engineering students followed the same pattern in proposing LU to take steps to improve or make better use of existing study facilities. Further, four of these five students all had the same notion; all their ideas were centred around LU.

"I think at least LTH sees the problems and trying to solve them by renovating the buildings one by one." (Eng Par 5)

"Yeah, and my office, we always have an argument about whose desk is the best height. So maybe even have adjustable Heights for your desks and chairs." (Eng Par 7)

"For example, I see that LUSEM is always more crowded than my building." (Eng Par 8)

Similar to the Pattern 1, Pattern 2 also confirms that individual experiences can serve as fuel for opportunity recognition (Shane & Venkataraman, 2000; Baron, 2006; Camelo-Ordaz et al., 2020; Chen et al., 2020).

Pattern 3. Sensory cues

Pattern 3 was exclusively used by three entrepreneurship students, which is unlike the other patterns. The key finding here is that the view from the experiment room helped the participants in recognizing the opportunity for creating outdoor study spaces.

"And I don't know, I just look outside and there's like a huge parking lot where it's like 10% only is used of it. So maybe you could use those outside areas a bit better." (Ent Par 2)

"You get some containers, like the shipping containers, stack them on top of each other around and in unused space on campus simply build out study spaces." (Ent Par 7)

"So that's, that's also something I would consider. It would be like a short-term solution only for like the nice days." (Ent Par 4)

The entrepreneurial process, according to Baron (2006), begins with recognizing possibilities, which is required for generating new business ideas. The location where the experiment was conducted had a large window and a view of empty parking lot. During the experiment, the entrepreneurship students picked up these sensory cues and used them to generate new business ideas whereas the engineering students were not able to connect the dots (Baron, 2006).

Pattern 4. Case cues

Pattern 4 analysed how the participants made use of the cues that were incorporated in the case scenario. In sum, six cues were included in the case description, which will be discussed below.

Cue 1. Looking for the best study spots in town

Three entrepreneurship and eight engineering students picked on this cue to spot opportunities for solving the case. However, there were distinct variances in how the pattern was applied. As a result, the engineering students suggested an additional eight ideas about where something should be built and twelve ideas about making better use of existing underutilized study spaces. Whereas the entrepreneurship students produced one idea, which involved the construction of new study areas and three ideas that involved making better use of underutilized study spaces.

"However, the problem description does not really explain how many study spots there are." (Eng Par 2)

"Having a monologue about that in 25 minutes is pretty unreasonable." (Eng Par 4)

"What spaces are there now at the moment and how are they used now." (Eng Par 6)

This disparity can be attributed to the disciplinary differences, particularly in the cognitive processes used in engineering and entrepreneurship. The engineering students observed the problem, absorbed information, and considered the circumstances to arrive at the ideal solution

(Czocher, 2013). Information was written down, and they rationally processed it in the ideation process. Thus, this pattern seemed to confirm the engineering way of thinking (Czocher, 2013). Against this, the entrepreneurship students may have relied on causal logic in applying this cue, in which a predetermined objective is established and the focus is on deciding amongst possible strategies to attain that outcome (Sarasvathy, 2001).

Cue 2. Not making efficient use of space

When evaluating the data, it became clear that both groups detect inefficient use of space at LU as well as in other places. However, the use of cues alters depending on the discipline. The entrepreneurship students produced 21 ideas centred on spotting the inefficient use of space in other areas and suggesting collaborations between LU and these external places. For example, Ent Par 7 proposed using a church as a study location.

> *"That it would be good to make kind of an inventory of what spaces there are at LU and how they're used and investigate whether they can be used in a better way or not"* (Eng Par 6)

> *"But there's probably a lot of community centers and public. Like, like church, for example, that has underutilized space. I mean, that could be fun. So repurposing other buildings"* (Ent Par 7)

In the entrepreneurial process, alertness has been highlighted as a crucial cognitive capacity that aids individuals in pattern recognition for new company prospects (Baron, 2006; Chen et al., 2020; Camelo-Ordaz et al., 2020). The alertness and ability to identify novel mean-ends relationships is particularly applicable to this cue as the entrepreneurship students uncover new mean-ends relationships between a potential study location and location that was not originally intended for this purpose (Peschl et al, 2021; Shane, 2000; Shane & Venkatraman, 2000).

Cue 3. Noisy areas, where it is hard to concentrate on studying

Both eight entrepreneurship students and eight engineering students used the cue for noisiness in their creative idea generation process. The results demonstrate that the engineering students are mostly concerned with building of additional buildings. For example, Eng Par 4 proposed the construction of a new study buildings because the participant believes it is unreasonable to come up with more novel ideas.

> *"Having a monologue about that in 25 minutes is pretty unreasonable."* (Eng Par 4)

"I listed off some ideas how to alleviate, alleviate this noise problem by expanding areas or separating areas." (Ent Par 10)

"So, every faculty for their own, uh, and then you're starting to, like, build up a building." (Eng Par 4)

Cue 4. Groups struggle to find suitable places to work together

The groupwork cue was used by nine entrepreneurship and seven engineering students. Both groups generated ideas for building a booking system for groups to reserve rooms at LU. Only entrepreneurship students came up with ideas for utilising underutilized space outside LU. It is noteworthy that as with the second cue, it is the entrepreneurship students who do not confine themselves to the LU campus but also consider other options, looking outside the box (Baron, 2006).

"Maybe you could even like rent Airbnb's and change them into groups, like working areas." (Ent Par 5)

"Maybe hotels would also be an option that we approach them and ask them if they have like conference rooms left." (Ent Par 2)

"So, a system like that would be preferable because then you can just log into the system and see where you can find different study places." (Eng Par 3)

Cue 5. Desks and chairs are unergonomic leading to physical discomfort

Three engineering students and nine entrepreneurship students came up with ideas after using the unergonomic furniture cue. What the participants have in common is that they had similar ideas for changing the furniture at LU to make it more ergonomic.

"To the comfortable and the fitting study place, so to come from comfortability I would go for standing desks maybe as well like they proven to be better." (Ent Par 4)

"So maybe even have adjustable heights for your desks and chairs." (Eng Par 7)

"Maybe like treadmills because I used to study at the gym a lot." (Eng Par 3)

Cue 6. Most convenient way for the students

Both groups had suggestions for (re-)designing spaces specifically for students and provided solutions for making remote working more accessible for students. What is remarkable about this cue is that only the engineering students suggested constructing study areas in a co-created manner with the students. This can be traced back to the engineers' sequential way of thinking (Horváth & Rudas, 2008). Verifying these solutions by experimentation, which is a common step in natural sciences, is the final stage in the thinking process (Czocher, 2013).

> *"Before I would execute my business idea I would probably ask as many students as possible what they would want."* (Eng Par 3)

> *"All of them should involve the students in designing the places."* (Eng Par 2)

Pattern 5. Existing things

Six entrepreneurship students and one engineering student proposed ideas that were inspired by current products, services, and concepts and applied them in new contexts. Eng Par 7 was inspired by a cafe in Tokyo where you may pay the workers to give you reminders to encourage you to be productive if you are a writer. Ent Par 1 demonstrated a real-time room tracking and booking system, 'the Ramen', that was inspired by the ramen vending machines in restaurants in Japan and Malmö. Coincidentally, both participants were influenced by a Japanese concept.

> *"There's like these in Japan, but I've seen them, like, I saw one in Malmö. And it's like, you come into the restaurant and there's like a machine and you choose your ramen. And then you press a button. And then you they like, they put your order in. It can be cool."* (Ent Par 1)

> *"Um, I heard about this cafe in Tokyo. If you're a writer or something, you can pay the staff to, like, give you reminders and like encourage you to be productive. If you get distracted easily, maybe have something along the lines of that."* (Eng Par 7)

This type of translation of an existing concept to a new context is aligned with the opportunity recognition literature emphasizing the importance of memory and past experiences to which new stimuli is compared to in order to recognize a business opportunity (Baron; 2006).

Pattern 6. Corona

The entrepreneurship students' ideas were primarily centred on the alterations brought on by corona's repercussions. Some participants mentioned that due to the pandemic, many offices are downsizing and having empty space.

> *"Due to the pandemic a lot of offices switched to remote work, and don't need their offices anymore. There are like some state funds that could pay the rent for the offices so they might be used by students."* (Ent Par 2)

> *"Like especially now there are many offices which are not used, like fully because people are more and more getting to a hybrid way of working."* (Ent Par 4)
>
> *"Well, now with COVID you could probably look at renting out office spaces that are being underutilized."* (Ent Par 7)

The way entrepreneurship students thought and used this trend can again be linked to their alertness as explained for Pattern 4's second cue. The ability to identify novel mean-ends relationships (turning vacant offices into study areas) provided by the cognitive skills of information processing (Pattern 6) and problem solving (empty offices) (Peschl et al, 2021; Shane, 2000; Shane & Venkatraman, 2000).

Comparison between entrepreneurship and engineering students

As the result of the qualitative data analysis, it was discovered that the two disciplines employ different cognitive patterns when generating ideas. The entrepreneurship students used Pattern 2 significantly more than the engineering students. Another notable difference was with Pattern 4, which was used 121 times by the engineering students and 102 times by the entrepreneurship students. The other patterns and cues had no significant differences between the participant groups. Altogether, the entrepreneurship students used the cues 155 times and the engineering students 140 times. In conclusion, Hypothesis 2, *entrepreneurship and engineering students use different creative idea generation patterns*, is confirmed by the analysis.

4.3.3 Participant notes during the experiment

During the experiments, it was notable that 8 out of 10 entrepreneurship students were using the pen and paper provided, while only 4 out of 10 engineering students chose to utilize them. When brainstorming for new ideas, Shimizu and Okada (2021) found that using pen and paper has an effect on memory and knowledge that can be applied in the participant's imagination. In this research, no significant impact of using the pen and paper to either the quantity or creativity of ideas generated was found. This could be because most participants merely listed ideas and did not use the paper for prototyping. Yet, there were two participants who used the paper for designing the interior design solutions, namely Ent Par 1 and Ent Par 4.

4.3.4 Participants' most creative business ideas versus based on scoring

To gather additional qualitative insights, at the end of the VPA, the participants were asked to choose their most creative idea and give a brief reasoning for the choice. This question aimed to understand what creativity means to the participants and what they understand as a creative idea. The results for this question and the reasoning for it are shown in Table 14, whereas the results for the most creative ideas based on the scoring are shown in Table 15.

Table 14

Participants' Self-Selected Most Creative Ideas and Their Reasoning

Participant	Most creative idea	Reasoning for choice
Ent Par 1	Real time room tracking and booking system ('the Ramen')	Novelty (application of an existing concept in a new context) Desirable for students (less annoyed, real time booking instead of in advance) Feasibility (not difficult or expensive to implement)
Ent Par 2	Study from elderly homes, where generations can exchange expertise and stories	Desirable for students (quiet, ergonomic) Desirable for elders (youthful spirit, entertainment) Feasibility (use empty space) Viability for elderly homes (save entertainment costs)
Ent Par 3	Summer office / outdoor working space in parks	Novelty (never heard of the concept before) Low on feasibility and viability (less practical than other ideas)
Ent Par 4	Zero gravity rooms	Desirability (optimal space usage) Not feasible at all
Ent Par 5	Companies offering parts of their office spaces as a study place and using it for employer branding	Feasibility (using empty office space) Desirability for students (meet real people, connect with the company) Desirability for companies (employer branding, attract good talent)
Ent Par 6	Make use of available spaces in high schools	Feasibility (using existing space and furniture) Desirability for students (comfort, ergonomic)
Ent Par 7	Use blimps to create workspaces in the air	Desirability for students (fun) Viability (cheaper than building underground) Not the most feasible idea
Ent Par 8	Create individual study pods	Feasibility (make use of existing space more efficiently)
Ent Par 9	Build a study space building in the central Lund	Desirability for students (popular concept in UK, location, designed for this purpose)
Ent Par 10	Collaborate with nations to offer accommodation for studying and	Novelty (innovative solution)

	other spaces that can be transformed into co-working spaces	Feasibility (transforming existing spaces, efficiency, mobility)
Eng Par 1	Transform teachers' offices into standardized offices that are also open to students	Novelty (requires changing the teachers' mind about this)
Eng Par 2	Digital study spaces through VR	No reason
Eng Par 3	Build specific building just for studying ('the Mall')	Felt creative in the process Feasibility questioned
Eng Par 4	Building a new study building	No other ideas to choose from
Eng Par 5	Booking app for study spaces that shows real time availability	Desirable for students (quick and more efficient)
Eng Par 6	Make inventory of spaces at LU and use empty spaces for study spaces	Feasibility (transforming existing spaces, efficiency, mobility)
Eng Par 7	Work together with student unions to create study places	Desirability for students (free access) Feasibility (using existing space)
Eng Par 8	Make more efficient use of laboratories and other underutilized spaces with movable things	Desirability for students (create their own workspace)
Eng Par 9	App for booking a place in the study buildings	No reason
Eng Par 10	Reconfigure spaces in a different way according to students' needs	Desirability for students (give feedback)

Table 15

Participants' Most Creative Ideas Based on Scoring

Participant	Most creative idea	Score	Match
Ent Par 1	Redoing the areas that are already here Real time room tracking and booking system ('the Ramen')	4 4	Yes
Ent Par 2	Study from elderly homes, where generations can exchange expertise and stories	6	Yes
Ent Par 3	Making use of empty buildings ('Antikraak') LU partnership to co-working at existing companies Summer office / outdoor working space in parks	5 5 5	Yes
Ent Par 4	Outside working facilities for students arranged by the municipalities	5	No

	Rooftop workspaces for studying that is covered Sea containers / modular solution on land	5 5	
Ent Par 5	Companies offering parts of their office spaces as a study place and using it for employer branding	6	Yes
Ent Par 6	Rent out rooms in office buildings Make use of available spaces in high schools	5 5	Yes
Ent Par 7	Shipping containers to build out study spaces around campus Renting out office spaces that are underutilized	5 5	No
Ent Par 8	Open up empty classrooms to use them	4	No
Ent Par 9	Incentives by coffeeshops / cafés offered to students to get them to go there Build a study space building in the central Lund	5 5	Yes
Ent Par 10	Collaborate with nations to offer accommodation for studying and other spaces that can be transformed into co-working spaces	5	Yes
Eng Par 1	Make more dedicated locations for studying	5	No
Eng Par 2	Use older buildings to build new ones on top of it to keep the value of the old building Companies providing study spaces	5 5	No
Eng Par 3	Studying at the gym	6	No
Eng Par 4	Building a new study building	5	Yes
Eng Par 5	Turn housing for international students into study spaces Empty spaces of start-ups at Ideon rented out to students	5 5	No
Eng Par 6	Divide general areas into group spaces Use seminar rooms for booking system when they are not used Recreating a room into a study place or study area or study rooms	3 3 3	Yes
Eng Par 7	Offering coffeeshops/lunchrooms for studying Co-working spaces / co-studying spaces	5 5	No
Eng Par 8	Work at parks and other open areas Make all LU buildings available for all students 24/7 regardless of the study program	4 4	No
Eng Par 9	Add more isolated desks to the rooms Fill the space with more chairs: design and organise the space better	2 2	No
Eng Par 10	Groups can work from coffeeshops	3	No

Table 14 shows that the entrepreneurship students are more likely to consider multiple criteria like desirability, feasibility, novelty, and viability when assessing ideas, while the engineering students frequently focused on a single criterion, such as desirability or feasibility, in their selection of the most creative ideas. When comparing the results from Table 14 to the scoring results in Table 15, there are some discrepancies between the ‘most creative’ ideas. While 7 entrepreneurship students selected the same idea as the most creative idea as was chosen based on the scoring, only two engineering students selected the same idea. This could mean that in general, the scoring of the ideas does not correspond well with the real-life understanding of what constitutes a creative idea as 11 participants did not agree with the scoring on which was the most creative idea. On the other hand, it could also be that the participants did not know how to evaluate creativity, as is visible from the several ‘no reason’ justifications, which made them less capable of assessing their own ideas and picking the most creative one. Considering that the entrepreneurship students were more accurate in choosing the creative ideas, it could be that their EE taught them what novel business ideas are and thus they could apply this in the decision-making (Goldsby et al., 2017). Especially, there was no consensus on what it means to be creative. While some participants found it to mean the out-of-this-world ideas, others also considered feasibility to be relevant in the criterion. Thereupon, it can be argued that creativity can be measured in multiple different ways and people have different ways to understanding creativity.

4.4 Synthesis of data analysis

In this part, the quantitative and qualitative data analyses are synthesized to test the following hypothesis.

> **Hypothesis 3**. *Entrepreneurship education has a significant impact on students’ creative idea generation capabilities.*

As shown above, the quantitative data analysis rejected Hypothesis 1a, confirmed Hypothesis 1b and thereby found partial support for Hypothesis 1. In addition, the qualitative data analysis confirmed Hypothesis 2. In summary, the entrepreneurship students score significantly higher on the creativity of ideas generated and used different creative idea generation patterns to get there. These findings confirm Hypothesis 3 by showing that EE has a significant impact on the entrepreneurship students’ creative idea generation capabilities on the dimensions of creativity and cognitive flexibility.

CHAPTER 5. DISCUSSION

This chapter discusses the answer to the research question and interprets the relevance of this study for practice. Also, the limitations will be evaluated before providing suggestions for the future research to overcome these limitations.

5.1 Answer to the research question

This research set out to examine whether EE could help students in generating creative ideas by equipping them with various cognitive strategies and skills. Overall, the results of the data analysis proved to be to some extent congruent with the hypotheses formulated in Chapter 2. To clarify, Table 16 summarises the results for the hypotheses.

Table 16

Support for Hypotheses

Hypothesis	**Results**
H1. *There is a significant difference in the outcomes of the creative idea generation process between engineering and entrepreneurship students.*	Partially supported
H1a. *Entrepreneurship students generate more business ideas than engineering students.*	Not supported
H1b. *Entrepreneurship students generate more creative business ideas than engineering students.*	Supported
H2. *Entrepreneurship and engineering students use different creative idea generation patterns.*	Supported
H3. *Entrepreneurship education has a significant impact on students' creative idea generation capabilities.*	Supported

Therefore, to answer the research question, *in what ways does the entrepreneurship education at the university master level affect the creative idea generation capacity of engineering and entrepreneurship students,* this research concludes that EE affects the creative idea generation capacity of entrepreneurship students in a positive way for the creativity of ideas generated and by equipping them with more creative idea generation patterns than the engineering students. For the quantity of ideas generated, no statistically significant difference was detected between the entrepreneurship and engineering students. Possible explanations for these findings will be discussed below.

The rejection of Hypothesis 1a means that there is no significant difference in the quantity of ideas generated between the two disciplines, which could be explained by following reasons. First, the measure of quantity is not sufficient alone to evaluate the outcomes of the experiment because the participants used different approaches, which could explain why no relationship was found. In other words, since the experiment instruction did not specify that the task was to generate as many ideas as possible, the participants did not necessarily list all the ideas they could produce. Instead, some participants focused on developing the ideas further with business models, which resulted in the high variance in the quantity of ideas generated. In the future replications of this study, the aim of the task should be clarified better if wanting to measure the quantity of ideas generated. Second, the case scenario was designed to be relatable for both student groups to make solving it as fair as possible. By designing the case in this way, the conditions for solving the case were made equally optimal for the participant groups, which could explain why the entrepreneurship and engineering students were equally good at coming up with business ideas to solve it. In the future research into the idea generation capabilities of engineering and entrepreneurship students, a different case scenario should be used to assess the ease of coming up with ideas when the case is not student-life related.

Hypothesis 1b was supported by the data, which means that there is a significant difference in the creativity of ideas generated between the entrepreneurship and engineering students. As hypothesized, the entrepreneurship students generated more creative ideas than the engineering students, which could be attributed to the following reasons. First, it could be that the mathematical approach to problem-solving used by the engineering students did not fit the nature of the task (Horváth & Rudas, 2008; Czocher, 2013). During the experiment, some of the engineering students first wrote down all the facts and asked for additional information regarding the size of the problem. This showed that the case was missing information that they found crucial for solving the problem, whereas the entrepreneurship students dealt with the incomplete information without similar trouble. Also, the engineering students could have been constrained by their sequential approach to problem-solving, which required them to verify the feasibility of ideas before moving forward (Horváth & Rudas, 2008; Czocher, 2013). In many cases this led them to reject ideas that they found unrealistic or impossible to implement and to choose ideas that already exist or that are easy to implement. This shows that the engineering students struggled to apply their linear problem-solving approach during the experiment.

This supports the arguments that EE equips the entrepreneurship students with multiple approaches and skills to dealing with complex challenges that make them competent in coming up with creative ideas (Peschl et al., 2021; Mansoori & Lackéus, 2019; Baron, 2006). Indeed, the entrepreneurship student came up with creative ideas during the experiment, which may relate to the iterative nature of the entrepreneurial way of thinking (Sarasvathy, 2001). By having access to a larger variety of cognitive methods, the entrepreneurship students may have been better at thinking outside the box and coming up with innovative solutions to the case

(Peschl et al., 2021). While the engineering students looked for certainty and logic in their approach to ideation, the entrepreneurship students considered all possibilities, regardless of whether they are realistic or not. This shows again that the two disciplines are very different when it comes to generating creative ideas. Due to the different problem-solving approaches, the engineering students may have limited themselves to thinking ‘inside’ a box. During the analysis of the results, it emerged that the engineering students mainly proposed LU-related ideas, while the entrepreneurship students thought outside the box and sought solutions beyond LU and existing study spaces.

During the experiments, it emerged that many engineering students did not fully understand the task and wondered what exactly 'novel business ideas' are. Therefore, they were less able to carry out the assignment because they did not know exactly what to do.

> *"What is considered a novel business idea?"* (Eng Par 4)
>
> *"What is novel?"* (Eng Par 10)
>
> *"Do you mean by novel business idea, new idea?"* (Eng Par 9)

This affected the students' creativity and thinking because they were unsure what the purpose of the task they had been given was. At the end of the experiment, many engineering students stated that they found it very difficult to know what exactly a business idea is and how to build a business model for the ideas they proposed. These were the main limitations they had during the experiment. Against this, the entrepreneurship students were taught what a novel business idea is and how to assess it based on feasibility, desirability and viability (Monsoori & Lackéus, 2020; Golsby et al., 2017). Considering this advantage of the entrepreneurship students, they were able to generate more creative business ideas that matched the scoring criteria based on Dean et al. (2006) and Goldsby et al. (2017).

Hypothesis 2 was also supported by the data, which showed that the engineering and entrepreneurship students use different creative idea generation patterns. The qualitative data analysis led to the emergence of six different patterns. Both disciplines used the patterns, but there were clear differences between the two groups. With Pattern 2, it was remarkable that only the engineering students used it, which focused on improving existing study facilities at LU. On the other hand, there was no pattern to establish among the entrepreneurship students. The sensory cues, with regard to Pattern 3, were used by the entrepreneurship students only. The entrepreneurial process, according to Baron (2006), begins with recognizing prospects for new business concepts. The entrepreneurship students picked on these sensory cues and utilised them to generate novel business ideas. Looking at Pattern 4, it is noticeable that the engineering students do more with this than the entrepreneurship students. In total, 102 cues were utilized by the entrepreneurship students and 121 cues with the engineering students. Looking at Pattern 5, it was remarkable that most of the ideas were generated by entrepreneurship students. With regard to Pattern 5, the entrepreneurship students mainly came up with ideas like using a church or an Airbnb platform. In relation to Pattern 6, the entrepreneurship students were mainly focused on the consequences caused by Corona. They looked at the opportunities to convert these consequences into possible business ideas. For example, many entrepreneurship students were focused on using underutilized office space after the downsizing of working at the office. This way of thinking and spotting opportunities can be linked to the alertness and ability to identify novel means-end relationships that are characteristic of entrepreneurs (Peschl et al, 2021; Shane, 2000; Shane & Venkatraman, 2000). This thinking ability was lacking in the engineering students, and they were therefore mainly focused on LU.

Altogether, this research confirmed that the entrepreneurship and engineering students tend think in different ways when it comes to creative idea generation. Thereby, this study contributes to theory by highlighting the differences in the approaches of these disciplines and the role of EE in improving students' creativity and cognitive capabilities for opportunity recognition and idea generation. However, by not confirming H1a, it has been brought to light that the distinction between the disciplines is not necessarily significant when assessing the quantity of ideas generated. This study demonstrates that the entrepreneurship students do not necessarily create more ideas than the engineering students, which shows that there is more to creativity than just education. Thus, this research encourages future research into what probes creativity and how one can become more creative. Yet, overall results show that EE has made a significant impact in the entrepreneurship students' creative idea generation capabilities that the engineering students could learn from.

5.2 Practical implications

This research has practical implications for the entrepreneurship and engineering pedagogies. By confirming the positive effect of EE on the entrepreneurship students' ability to generate creative business ideas, the pedagogical approaches to teaching the entrepreneurial skills and frameworks at LU can be considered successful. It is clear from the results that the students of this discipline possess various cognitive strategies that assist them in cue recognition and idea generation. Also, by confirming H1b, their high creativity scores are a sign of imaginativeness, cognitive flexibility, and alertness that they have developed as part of their curriculum. Thus, this research recommends LU to continue the master level EE and training of future employees with the entrepreneurial skills and cognitive capabilities needed to solve complex challenges.

For the engineering pedagogy, the findings of this research show that adding EE to the engineering master program curricula at the LTH could have far-reaching possibilities. Especially, considering that LUSEM offers a high-quality entrepreneurship program and has the tools to teach the students the entrepreneurial skills of opportunity recognition and idea generation, there lies great potential in designing entrepreneurial interventions targeted to the engineering students. Indeed, similarly to Neergård et al.'s (2022) entrepreneurship training for nurses, LUSEM could collaborate with LTH to provide entrepreneurial training and workshops to the engineering students. Since none of the engineering participants of this study had prior exposure to entrepreneurship in any form, it could yield favourable outcomes for the students' knowledge, skills and competencies to be exposed to new way of thinking and problem-solving that EE offers. Also, training the engineers in entrepreneurship could potentially lead to new innovations in the future. The world today is ambiguous, uncertain, complex, and fast paced. Including EE in the curriculum can help students prepare for job positions that will increasingly include open, dynamic, and complicated problems that cannot be solved with mathematical structures or problem-solving processes (Peschl et al., 2021). The ability to think outside of the box instead of restricting oneself to thinking sequentially and being able to distinguish oneself will have a positive effect on the employability of the engineering graduates.

5.3 Limitations and future research

Besides the aforementioned limitations of this research, the method and sample of this research may provide alternative reasons for the results of the data analysis. The research method has three main limitations. First, there are potential limitations in using the VPA for measuring the participants' cognitive processes, which may lead to incomplete understanding of their thinking behind the ideas. As the VPA relies on the participants' uninterrupted thinking aloud to assess the cognitive patterns, long silences during the VPA raise concerns about missing the full extent of cognitive information processing that the participant is experiencing. Therefore, in the future when using the VPA as a method, a list of probing questions could be developed to encourage the participants to explain their thinking processes and reasonings more when they might feel stuck or have no new ideas to discuss.

Second, as mentioned above, it was not clear from the case whether the goal was to generate as many ideas as possible or to provide detailed, thought-through solution(s) to the case. While the task called for generating solutions that are ‘most convenient for the students’, it did not clarify whether the participants should list all possible ideas or choose one best idea. This led to the participants understanding the task differently, which potentially affected the results of this study. In replicating this study, the task description should clarify what the aim of the research is so that the participants know what to expect. In addition, if deciding to go for generating as many ideas as possible approach, it could be fruitful to measure the time within which the participants generate the ideas to identify the speed of the cognitive processing used to come up with the ideas as well as when in sequence do the most creative ideas come up.

Third, the understanding of what is a ‘novel business idea’ was puzzling for the participants, especially from the engineering programs, which may have limited their creativity in coming up with new ideas. One of the limitations in the experiment instructions was that the term ‘novel business idea’ was not defined. The choice for leaving this term open was to allow for students to generate ideas more freely without restricting themselves to certain definition of a business idea. However, during the experiments, the engineering students struggled with knowing what constitutes a business idea and this may have given the entrepreneurship students an unfair advantage as they have background in business administration and understand what a novel business idea is and how it should be measured based on desirability, feasibility, and viability (Goldsby et al., 2017). One way to solve this could be provide a definition of a ‘novel business idea’ in the case and potentially also an example to ensure an equal understanding of the concept. Alternatively, the scoring dimensions for the ideas could have been provided to the participants, who could have used the criterion by Dean et al. (2006) and Goldsby et al. (2017) to discuss their ideas more in-depth.

In addition to these, the sampling strategy and sample have certain limitations. First, since this study used convenience sampling method to find the experiment participants, the sample consisted of engineering students from different study programs, which may have affected the results. Indeed, the attempts to control for the study program proved unsuccessful. As a remedy for this limitation, future research could narrow down the target audience more by choosing a target study program and conduct a more targeted search for respondents using non-convenience sampling techniques. Considering that approaching the students directly in-person was successful method in recruiting participants, this should be used in the future and perhaps approaching a whole class rather than individuals could help to control for the sample.

Second, while the sample size of $N = 20$ is sufficient for the quantitative and qualitative data analyses, it is still relatively small and does not offer much statistical power. To overcome this limitation, this study should be replicated using a larger sample size.

CHAPTER 6. CONCLUSION

This research set out to examine the impact of EE at the university master's level on the creative idea generation capabilities of the engineering and entrepreneurship students. The data analysis reveals that EE has a significant positive effect on the creativity of ideas generated of and the breadth of creative idea generation patterns used by the entrepreneurship students. However, for the quantity of ideas generated, no statistically significant results were found, which means that the entrepreneurship and engineering students were equally competent in solving the case. The current results signal that the pedagogical interventions of EE have successfully developed the cognitive strategies for opportunity recognition and idea generation of the entrepreneurship students, who are capable of thinking outside the box to generate creative solutions to complex problems. Thereupon, this research encourages future collaboration between the engineering and entrepreneurship programs at LU to design pedagogical interventions for the engineering students to learn entrepreneurial skills as well. Also, this study calls for the future research to replicate this study and to build on the found insights. Noting the relevance of teaching students, the entrepreneurial skills to prepare them for the working life challenges, this research has just taken the first step into uncovering the potential of EE in training future graduates that are competent in skill to undertake those challenges.

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APPENDIX A. EXPERIMENT INSTRUCTIONS

Thank you for helping us with our thesis research by participating in this experiment! This experiment is estimated to take in total **30 minutes** of your time. First, we have reserved a few minutes for you to carefully read these instructions. Then, we will give you 25 minutes to do the exercise. In the end, we have prepared a brief survey for you to fill in. If you have any question at any point of the experiment, please do not hesitate to ask us.

Purpose of this study

This experiment is conducted as part of our graduation thesis for MSc Entrepreneurship and Innovation at Lund University and Sten K. Johnson Centre for Entrepreneurship. The purpose of this study is to investigate the creative idea generation processes of entrepreneurship and engineering master students. With this experiment, we aim to test your ability to solve a hypothetical problem scenario by generating creative business ideas.

Data collection and privacy

The data collected will be only used for our thesis research and it will be treated with **confidentiality**. By participating in our study, you **consent** to have your data collected, stored, and used for the research. The recordings will be transcribed after the experiment, but the original recordings will be stored for the duration of the thesis writing process and deleted in June. The names of the participants will be **anonymised** in the thesis (e.g., engineering student 1) and no information will be shared that would lead to the identification of the participants. However, if you would like to **withdraw** your participation in our study, you can do so at any point of the experiment and also within 14 days after the experiment by emailing us at ne5057tu-s@student.lu.se or ve3844ke-s@student.lu.se. If you have any concerns about the data collection and processing, please do not hesitate to ask us.

Instructions

Below we present you with a short description of a student-life related problem that we ask you to solve. Please read the case carefully. The case explains the problem, its context and what your task is. What we ask you to do is to read the case and verbally discuss your answers. We will record you discussing the answers and we kindly ask you to explain your thought process throughout the experiment to clarify how you arrived at the answers. Throughout the experiment, you are allowed to write down notes and make use of the pen and paper we have provided for you.

During the experiment, we will not be providing feedback on your ideas or process. We kindly ask you to share all the ideas you come up with, no matter how feasible or realistic they are.

Please take a moment to read the hypothetical problem scenario below.

Hypothetical problem scenario: Lack of study places

There are over 40,000 students at Lund University, who are all looking for the best study spots in town. However, the study spaces provided by Lund University are not enough to accommodate for all of them.

The current study places are not making efficient use of space or are in noisy areas, where it is hard to concentrate on studying. Also, groups struggle to find suitable places to work together, where they can talk to each other without disturbing others. The desks and chairs in some study places are unergonomic, which leads to physical discomfort when studying for a long time. In general, students are disappointed with the availability of comfortable and fitting study places.

You are tasked with fixing this problem by coming up with novel business ideas to add study places in Lund. How would you go about solving this problem in the most convenient way for the students?

APPENDIX B. SURVEY QUESTIONS

Section 1. Demographics

Thesis Survey

Dear participant,

Thank you for participating in our thesis experiment! With this survey, we aim to collect data to supplement the insights gathered during the experiment. We will ask you questions about your personal demographics and your entrepreneurial experiences. Please answer all the questions as honestly as possible.

Let's get started!

Nea & Annefie

ne5057tu-s@student.lu.se (not shared) Switch account

* Required

Participant name *

Your answer

How old are you? (in years, e.g., 25)

Your answer

What is your gender?

- Female
- Male
- Prefer not to say
- Other:

What is your nationality?

Your answer

What kind of study are you following? *

- ○ MSc Entrepreneurship and Innovation
- ○ MSc in one of the engineering programs

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Section 2. Entrepreneurial Experience (only for entrepreneurship students)

Entrepreneurial Experience

In this section, we will ask you questions about your entrepreneurial experience.

Have you received entrepreneurship education prior to starting MSc Entrepreneurship and Innovation? *

- ○ Yes
- ○ No
- ○ Other: ____

If you answered yes to the previous question, what kind of entrepreneurship education have you received?

Your answer

Do you have experience with founding your own venture prior to starting MSc Entrepreneurship and Innovation? *

- ◯ Yes
- ◯ No
- ◯ Other: ________

If you answered yes to the previous question, what kind of experience do you have?

Your answer ________

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Section 3. Entrepreneurship Exposure (only for engineering students)

Entrepreneurship Exposure

In this section, we will ask you questions about your exposure to entrepreneurship courses, trainings and experiences.

Have you ever had an academic course in entrepreneurship as part of your engineering study? *

- ◯ Yes
- ◯ No
- ◯ Other: ________

If you answered yes to the previous question, what kind of academic course(s) in entrepreneurship have you had?

Your answer ________

Do you have experience in founding your own venture? *

- ◯ Yes
- ◯ No
- ◯ Other: ____________

If you answered yes to the previous question, what kind of founding experience do you have?

Your answer

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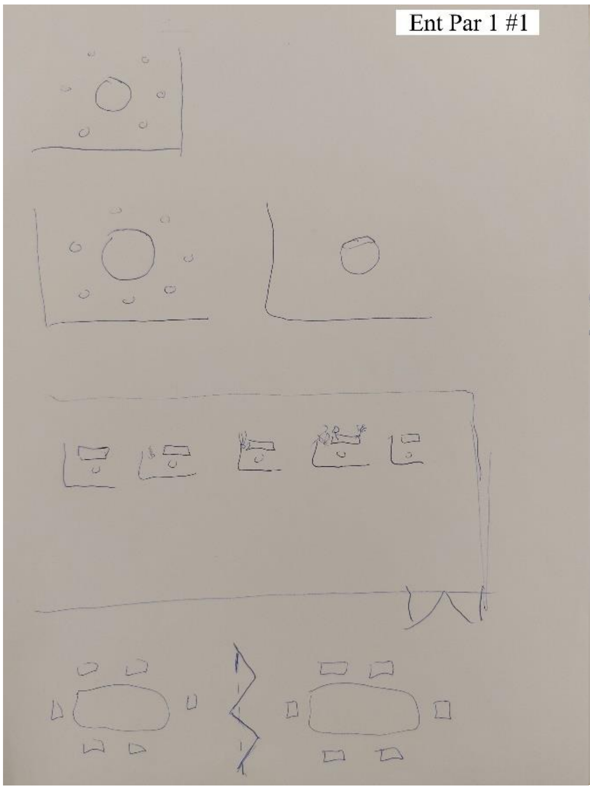
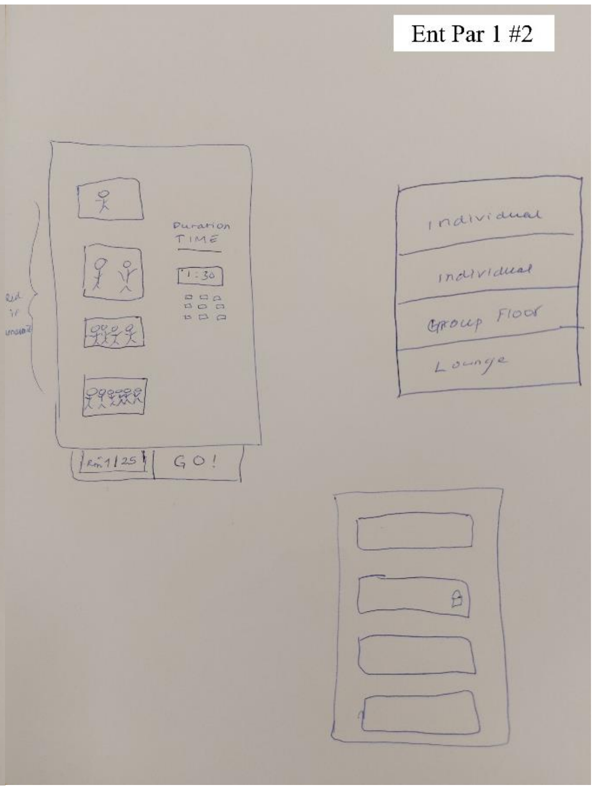
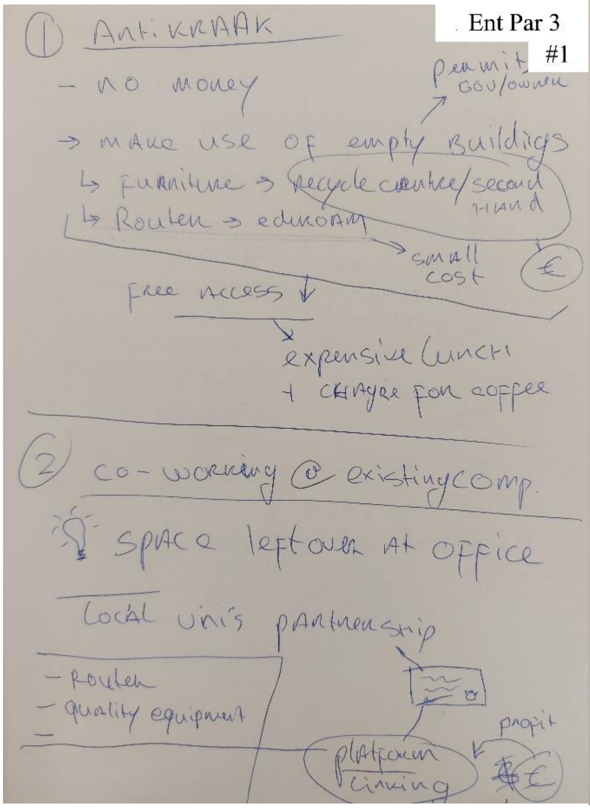
Appendix C. Experiment Participant Notes And Sketches

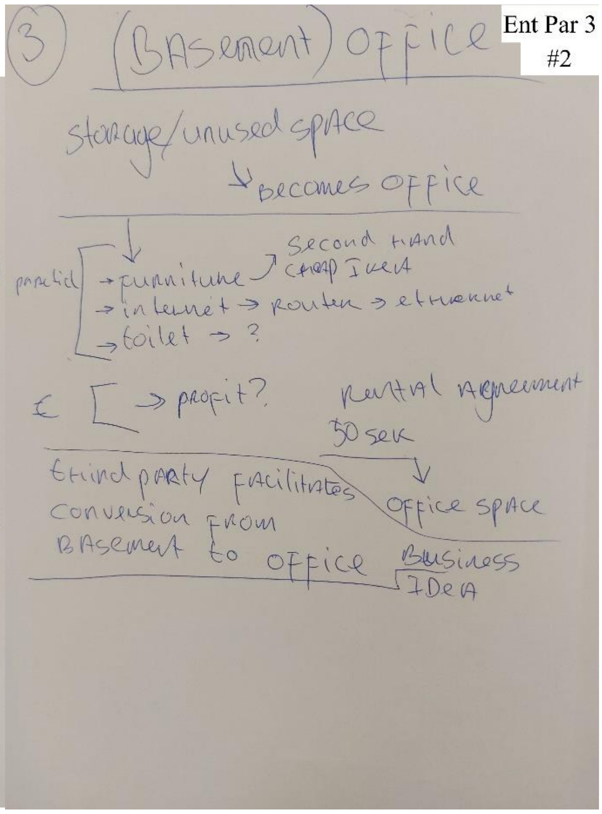
Entrepreneurship Participant 1

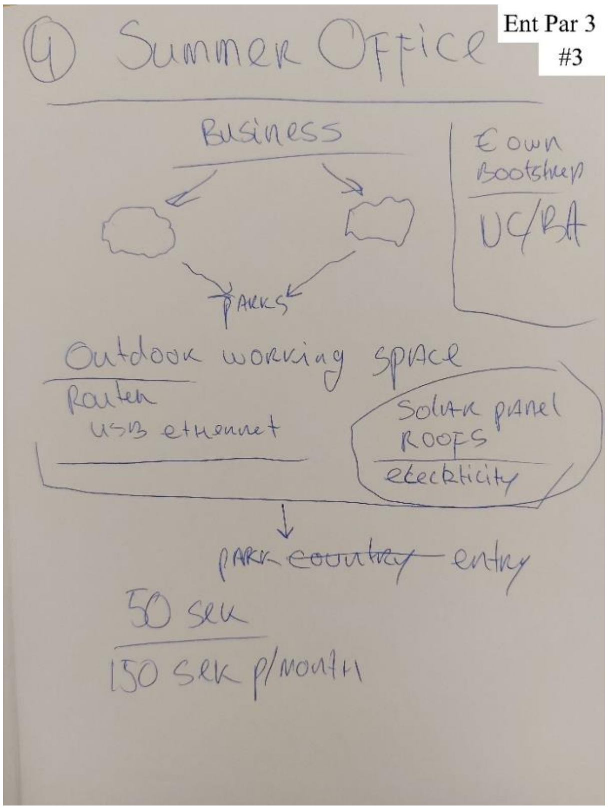




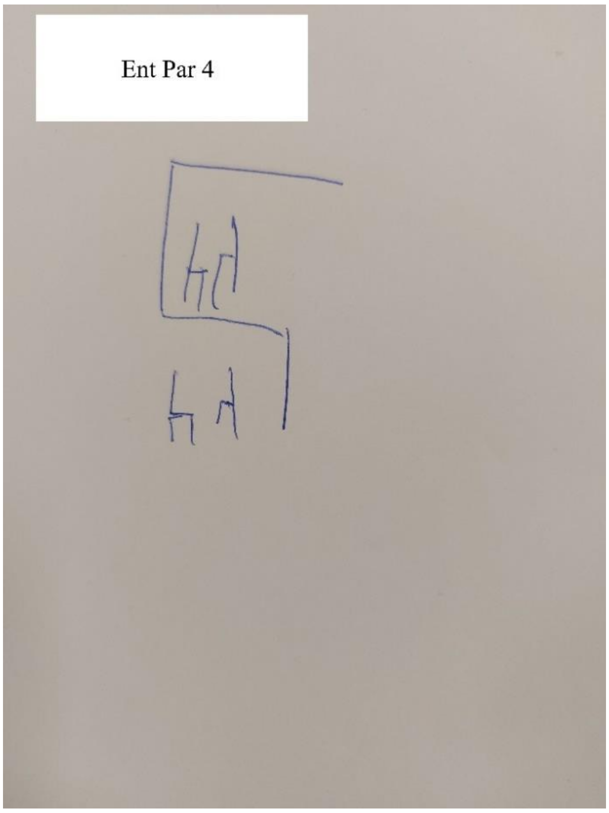
Entrepreneurship Participant 3



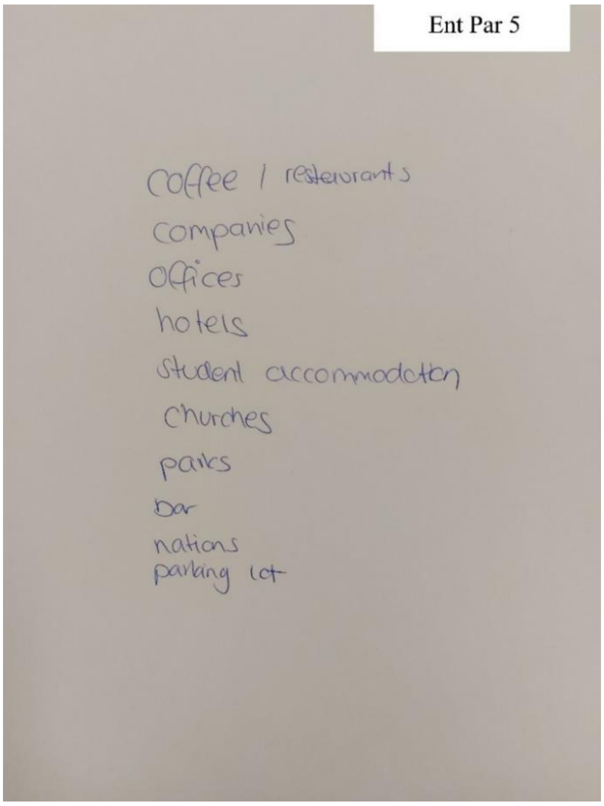




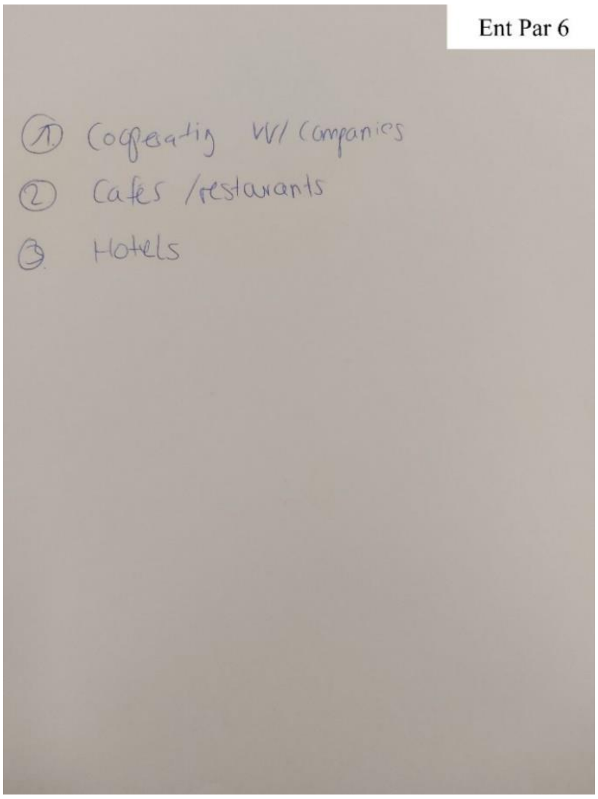
Entrepreneurship Participant 4



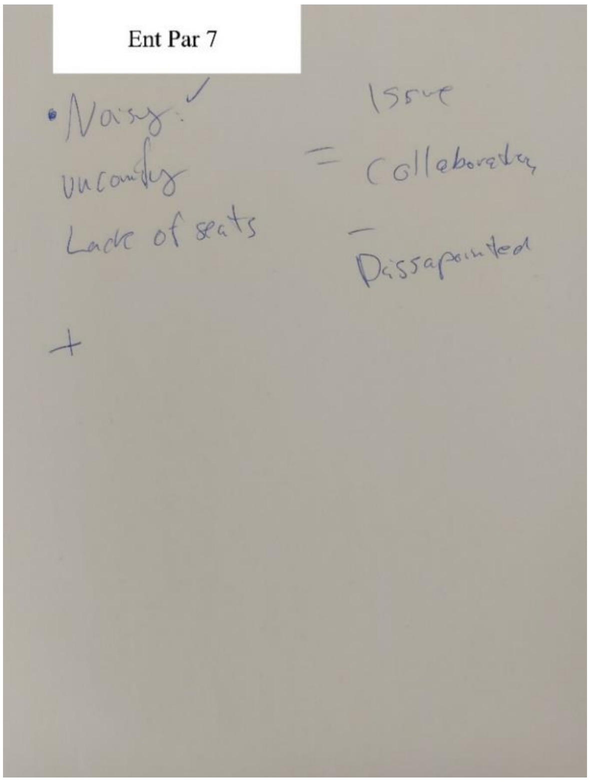
Entrepreneurship Participant 5



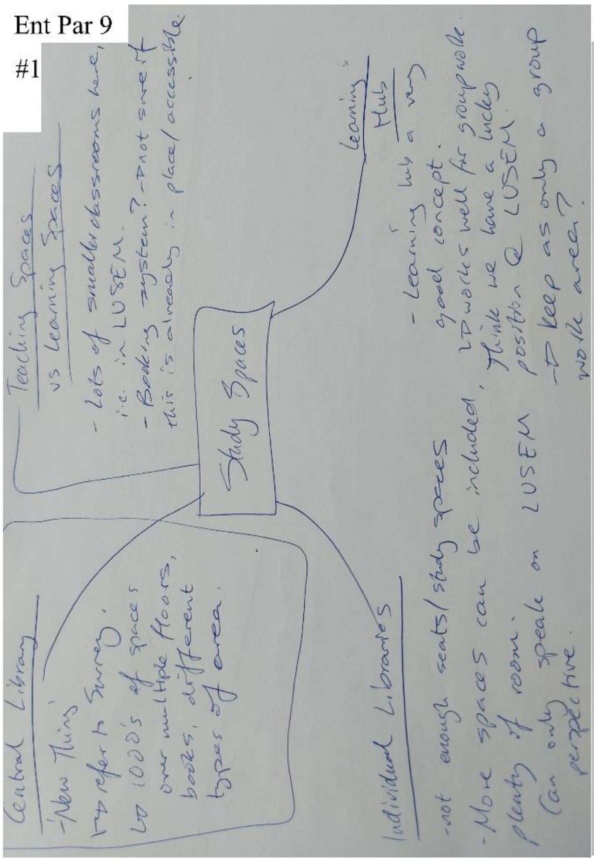
Entrepreneurship Participant 6

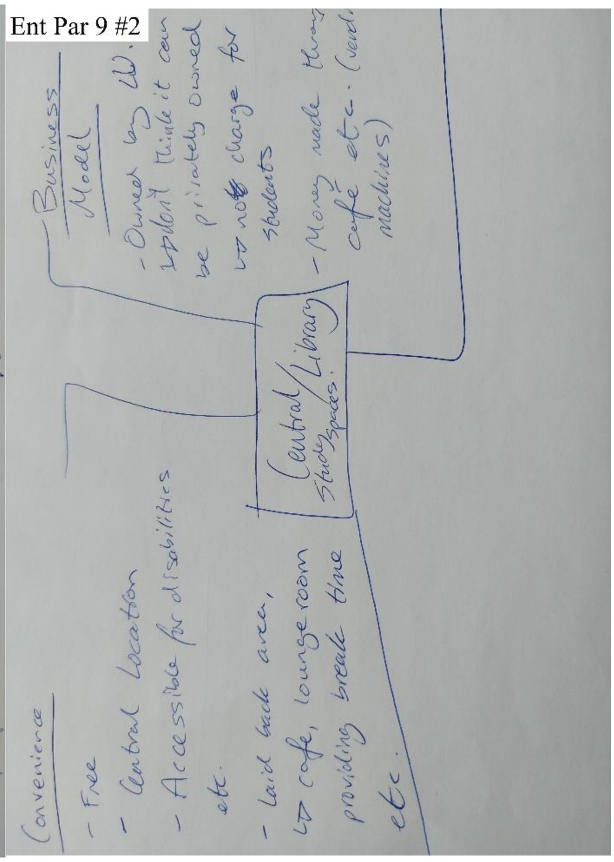


Entrepreneurship Participant 7

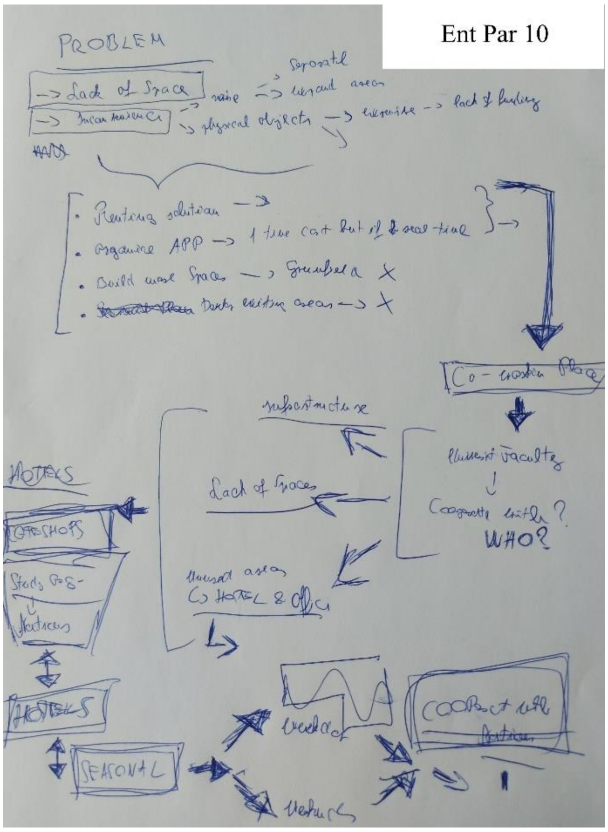


Entrepreneurship Participant 9

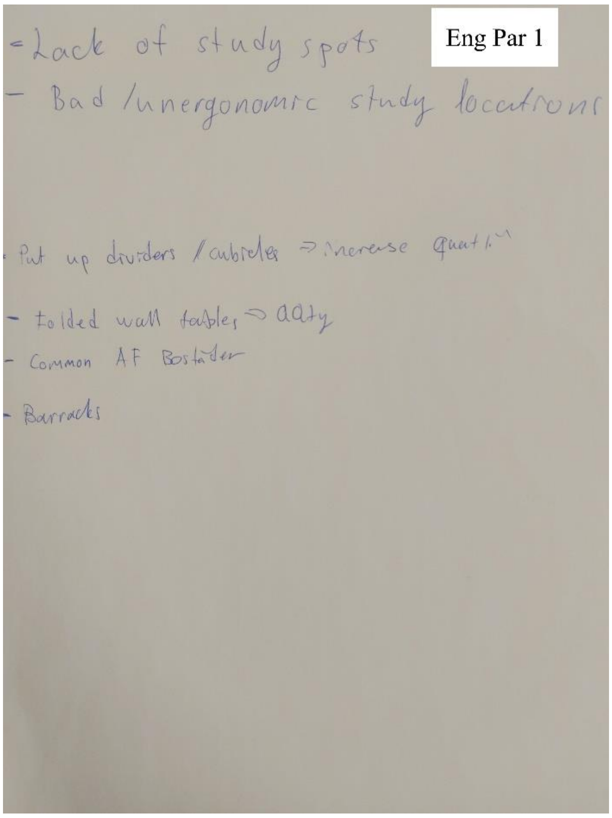




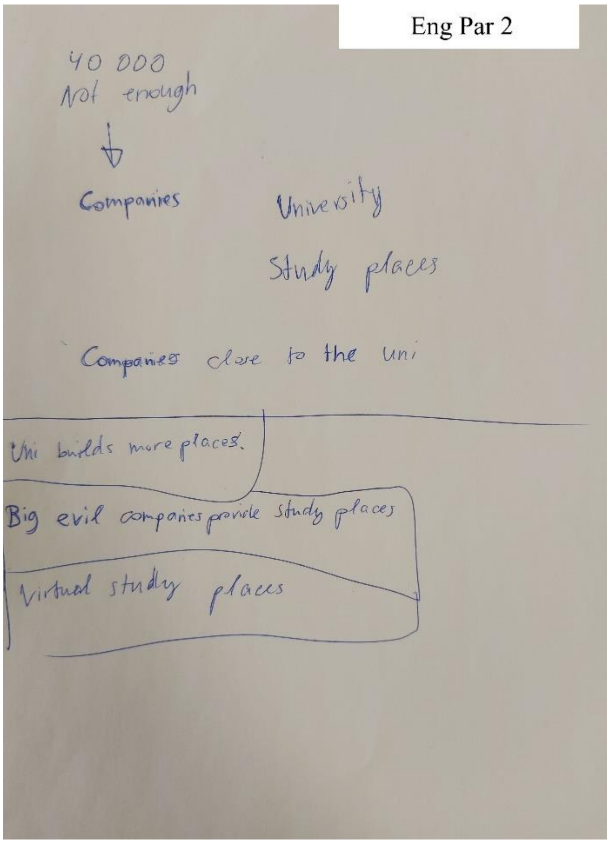
Entrepreneurship Participant 10



Engineering Participant 1



Engineering Participant 2



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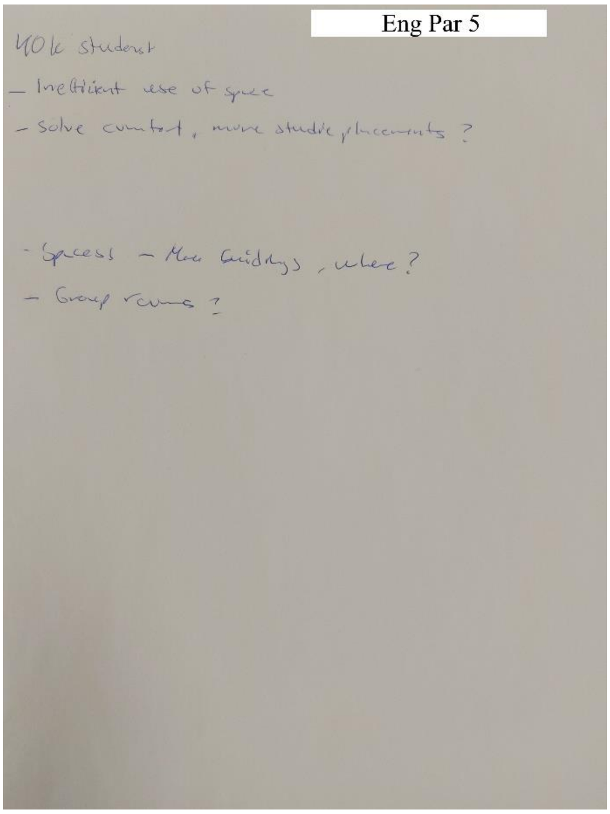
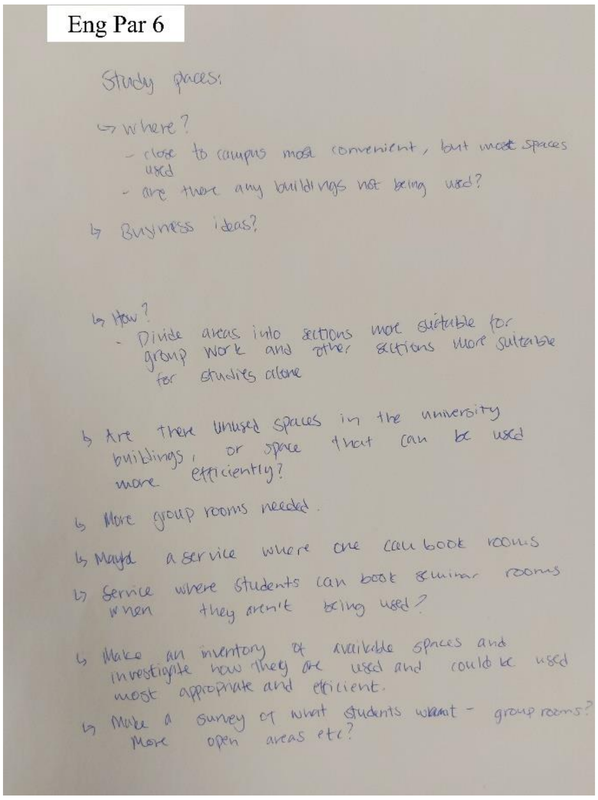


Engineering Participant 6


Eng Par 6

Study spaces:

↳ where?
- close to campus most convenient, but most spaces used
- are there any buildings not being used?

↳ Buyness ideas?

↳ How?
- Divide areas into sections more suitable for group work and other sections more suitable for studies alone

↳ Are there unused spaces in the university buildings, or space that can be used more efficiently?

↳ More group rooms needed.

↳ Maybe a service where one can book rooms

↳ Service where students can book seminar rooms when they aren't being used?

↳ Make an inventory of available spaces and investigate how they are used and could be used most appropriate and efficient.

↳ Make a survey of what students want - group rooms? More open areas etc?