Developing engineering students' willingness and ability to perform creative tasks

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Abstract

Purpose – The purpose of this study is to explore creativity and how it changes over time among engineering students in practice-based entrepreneurship in higher education. This change was examined in students over a one-semester course in entrepreneurship. Entrepreneurship courses that use creativity tools for practice-based learning are expected to develop creativity as a learning outcome. This study discusses the extent to which some learning outcomes are more easily developed than others.

Design/methodology/approach – This research uses a longitudinal design by applying a pre- and post-test survey. The student population consists of engineering students enrolled in an entrepreneurship course with practice-based learning involving creativity tools. The course includes team-based idea generation and business model development. To measure actual changes in students' creativity, two measures were used to reflect different aspects.

Findings – The results show that students' ability to perform creative tasks increased, while students' willingness to engage in and their enjoyment of creative tasks decreased as a result of the course. Non-significant differences in changes were found between the two measures, but a difference was found in how the two measures changed during the course. In line with the research question, the results suggest that education may influence ability to a greater extent than willingness.

Originality/value – The research used two different creativity measures to explore the extent to which engineering students experienced a change in creativity over a one-semester entrepreneurship course. In this way, the research contributes to the discussion on what could be learnt and by what means.

Keywords Creativity, Entrepreneurship education, Engineering students, Practice-based learning, Creativity tools, Bisociation

Paper type Research paper

Introduction

In today's globalized world, organizations and industries face rapid technological and societal changes leading to novel competence needs (Bourgeois-Bougrine, 2017). In this emergence, creativity contributes to provide new competitive technological solutions (Bourgeois-Bougrine *et al*., 2017; Runco, 2004). Entrepreneurs and employees in the twenty-first century need novel ideas to respond to rapid technological changes, solve complex problems and create new solutions for the future (Bakhshi *et al*., 2017).

Engineers in the field of technology are well placed to act upon new opportunities and to solve technological problems. Moreover, they need to combine their technological competence with creativity to develop new solutions and compete globally. Therefore, creativity has become a requisite skill for engineers and a necessary part of their basic training (Bourgeois-Bougrine *et al*., 2017). Engineers can also become high-tech entrepreneurs, providing novel technologies and establishing new business ventures. Entrepreneurship scholars see creativity as an essential human ability in entrepreneurial behaviour (Ko and Butler, 2006; Ward, 2004). Consequently, entrepreneurship education is highly relevant for expanding engineers' technological competence. In entrepreneurship education, scholars aim to develop students' entrepreneurial mindsets and behaviours, which include creativity (Hamidi *et al*., 2008; Lin and Nabergoj, 2014).

Universities are increasingly expected to implement creative problem-solving in educational offerings to satisfy the competence needs of a profoundly changing society. However, educators struggle in their efforts to develop effective pedagogy to induce and nurture creativity among students (Bourgeois-Bougrine *et al*., 2017; Lin and Nabergoj, 2014). Nevertheless, scholars agree that traditional pedagogical practices are insufficient for developing skills and abilities to manage the complexities of today's business environment (Lin and Nabergoj, 2014). They call for new pedagogical approaches that encompass experiential and practice-based learning, enabling students to respond creatively to real-world problems (Bourgeois-Bougrine *et al*., 2017; Higgins and Galloway, 2014; Lin and Nabergoj, 2014). Creativity tools used in education are assumed to induce creative thinking, facilitating the development of new solutions, and creative problem-solving in team-based entrepreneurial projects (McFadzean, 1998). This study explores the extent to which pedagogy encompassing practice-based learning with creativity tools may influence and enhance creativity among engineering students during a one-semester entrepreneurship course.

The change in creativity among students is explored in a longitudinal study through a pre- and post-test survey design. The student population consists of engineering students at the bachelor's level enrolled in an entrepreneurship course at a university in western Norway. In entrepreneurship education, developing creativity implies a focus on behavioural elements such as ingenuity and problem-solving skills (Colette *et al*., 2005). In general, entrepreneurship educators attempt to induce learning outcomes, including an entrepreneurial mindset, creative thinking and entrepreneurial skills (Hytti and O'Gorman, 2004). These learning outcomes differ; some are closely linked to individuals' personalities or dispositions and would be difficult to change, whereas others are more skills-based, and hence more easily acquired. In this paper, this assumption is explored through a pre- and post-test survey design, including two creativity measures (Jabri, 1991; Ko and Butler, 2006). With respect to creativity, we emphasize the concept of *bisociation* developed by Koestler (1964), which relates to creative thinking. Furthermore, we explore changes in students' creative problem-solving heuristics, abilities and skills, as well as changes in their intrinsic enjoyment of being in a state of creative workflow. The first relates to students' *ability* to be creative, and the second relates to students' *willingness* to be creative.

The paper is organised as follows. First, the theoretical perspectives are described to offer an outline of creativity research primarily from the psychology field and anchor the idea of the research paper. Then, we discuss creative thinking related to the concept of bisociation. Next, we describe the importance and relevance of creativity in entrepreneurship education and discuss the pedagogical challenges of developing it. Then, we explain our exploration of creativity in the study. Second, we present the methods, measures and educational context, focusing on the course content. Third, we describe the data analysis and results. Fourth, we present the conclusion and discussion, and report the implications for entrepreneurship education. Finally, we address the limitations and future research.

Theoretical perspectives

Creativity, creative thinking and the bisociation concept

Creativity is truly among the most important and prevalent activities in human society (Runco, 2004; Simonton, 2000). Creativity research expanded during the 1960s and early 1970s. The trait approach, or the identification of personality differences between creative and non-creative individuals, long dominated creativity research (Amabile, 1983; Runco, 2004; Simonton, 2000), leading to the learning and social environments being overlooked as sources of creativity. Today, researchers (e.g. Lazar, 2018; Rodrigues *et al*., 2019) tend to perceive creativity as a behaviour resulting from particular patterns of personal characteristics, cognitive abilities and social environments.

According to cognitive psychology (Simonton, 2000), creativity is a mental phenomenon that results from ordinary cognitive processes, such as visual imagery and the use of open-ended problems to induce creative ideas. The main argument is that quite ordinary cognitive processes are involved in creative activities, so creative thought and behaviour is accessible to virtually anyone (Simonton, 2000). Therefore, all individuals are assumed to possess the basic ability to perform creative acts (Guilford, 1950). Researchers have long recognized that creativity is as much a dispositional as an intellectual phenomenon (Simonton, 2000). Creativity is an activity that develops over the course of the human lifespan. Individuals' childhood and adolescent experiences, including schooling, family and role models, appear to be important for the development of creative potential.

Furthermore, research has demonstrated that exceptional talents are less often born than made, in any domain (Simonton, 2000). For individuals to develop strong creative abilities, they require extensive and systematic training and practice to acquire this form of optimal functioning (Simonton, 2000). Moreover, creative individuals do not produce new ideas de novo (Sternberg, 2006), as ideas are based on a rich body of domain-relevant knowledge (Amabile, 1983; Simonton, 2000).

The education system has traditionally downgraded creative skills and divergent thinking and emphasized analytical skills and convergent thinking (Runco, 2004; Sternberg, 2006). In higher education, creativity is less incorporated in curriculums and assessments (Runco, 2004). Therefore, to remedy this situation, scholars now emphasize divergent thinking and stimulating creative thinking, paradigm stretching and paradigm breaking, rejecting and opposing conventional knowledge and paradigms (Runco and Acar, 2012; Scott *et al*., 2004; Sternberg, 2006). The concept of bisociation is relevant in this context.

Koestler's concept of bisociation

Koestler (1964) developed a model of creative thinking called *bisociation*. This concept has been applied in both creativity and entrepreneurship research (Bulut *et al*., 2013; Ireland *et al*., 2003; Scott and Bruce, 1994; Smith and Di Gregorio, 2002; Sung and Choi, 2012). This paper builds upon Koestler's concept of bisociation, as well as research that has expanded the concept further (Jabri, 1991; Ko and Butler, 2006). Associative thinking pertains to habits, routines and the more familiar thinking that dominates everyday life. As such, it combines elements of the same "matrix" of thought. The bisociative mode underlines the creative act and combines hitherto unrelated and perhaps conflicting information in a new way. Bisociation enables the mixture of concepts from two contexts or categories of objects that are unconnected by the normal processes of the mind. Bisociation distinguishes the type of metaphoric thinking that leads to acts of great creativity (combining elements from different "matrices" of thought) from the associative style of thinking (combining elements from the same "matrices" of thought). When individuals combine previously unconnected matrices of thought, they experience the creative act of bisociation (Dubitzky *et al*., 2012).

Entrepreneurship education and creativity

In entrepreneurship, creative individuals are those who develop novel ideas and search for new opportunities to generate added value (Ko and Butler, 2007; Ward, 2004). Likewise, entrepreneurial creativity is associated with individuals' flexibility in uncertain surroundings, using creative thinking to adapt to unplanned events (Hytti and O'Gorman, 2004). Thus, entrepreneurial behaviour materializes in the pursuit of solutions to problems in uncertain surroundings, and creativity is embedded in entrepreneurial process and behaviours. Ward (2004) emphasizes that creative (entrepreneurial) failures are often due to limited and constrained thinking. He further highlights the ability to combine separate and opposing ideas to move beyond established knowledge (Ward, 2004: 176) towards divergent thinking and creative thinking, similar to the concept of bisociation.

In entrepreneurship education, a key issue is how to teach entrepreneurial behaviour and support students to develop abilities and skills enabling them to perform entrepreneurial tasks (Colette *et al*., 2005). In this respect, creativity is important in entrepreneurship education (Hamidi *et al*., 2008; Lin and Nabergoj, 2014). In efforts to develop and stimulate creativity and creative problem-solving skills, educators emphasize practice-based learning. Furthermore, students engage in creative and explorative tasks to build the necessary skills (Colette *et al*., 2005). Moreover, creativity tools are used to support the entrepreneurial process. Educators progressively introduce course content that emphasizes real-life projects, experimental learning and creative thinking that includes imagination and intuition (Higgins and Galloway, 2014).

Entrepreneurship education is highly relevant for engineers, as it increases their technological competence. Engineering education is particularly important when combined with creativity to solve technological problems in increasingly complex societies (Bourgeois-Bougrine, *et al*., 2017; Runco, 2004). Universities are progressively introducing course content that nurtures creative problem-solving among engineering students to meet current needs. However, educators face the challenge of developing the appropriate pedagogical methods to build creative skills and assess the effectiveness and impact of training (Bourgeois-Bougrine *et al*., 2017).

The pedagogical challenge of developing creativity

The social context surrounding the creative act is influential (Amabile, 1983; Simonton, 2000; Runco, 2004). Researchers see intrinsic and extrinsic motivations as particularly critical for the performance of a creative task. An individual is intrinsically motivated if the creative task is perceived as an end in itself and not as a means to an extrinsic (externally imposed) goal (Amabile, 1983). Generally, it is considered beneficial for creativity if the individual is driven by inherent enjoyment (intrinsic) rather than some external pressure or incentive (extrinsic). Yet, in some circumstances, extrinsic motivation can strengthen and amplify individual creativity (Simonton, 2000). These findings are especially valid and pertinent for developing creativity in education where written evaluations and examinations are imposed on students (external pressures and rewards).

In education, various pedagogical methods and tools can be used to stimulate students' creativity. There is an abundance of creative problem-solving tools, ranging from familiar concepts such as brainstorming to more imaginative techniques such as wishful thinking (McFadzean, 1998). These various tools may be appropriate for different stages of the creative process, e.g. idea generation, problem analysis or evaluation. Creativity tools can be classified into two groups: *analytical* and *intuitive*. Analytical techniques "*use a structure to generate a logical pattern of thought*", whereas intuitive techniques let the student take huge jumps or use imagery to arrive at some product or result. Couger (1995) suggests that individuals favour certain types of tools depending on their personalities. Moreover, certain creativity tools may force individuals to look at a problem or opportunity from a completely novel perspective. This switch can be encouraged and nurtured and is not necessarily a talent that a person is born with. Creativity tools involving imagination and intuition that are paradigm-breaking require individuals to be more experienced; less experienced individuals may feel uncomfortable and insecure with these tools.

In this study, we explore the extent to which engineering students' creativity may change through education. We base our exploration on the concept of bisociation, involving the activity to link unrelated ideas and things. First, we explore and measure individuals' intrinsic enjoyment of being in a state of uncertainty and workflow, experimenting and exploring, finding themselves in a highly creative process not explicitly leading to a concrete outcome. Hence, we explore individuals' dispositional tendencies of creative thinking and actions. In addition, we explore individuals' intrinsic motivations and enjoyment of the creative state, and thus explore students' *willingness* to be creative. It is uncertain whether education has the strength and impact to induce this kind of intrinsic motivation and enjoyment in students, or to change students' creativity in such a way. It is likely that this creative tendency in individual personalities needs more time to grow.

We also explore the extent to which students' creative abilities change in terms of the competence or skills they possess. We emphasize concrete outcomes related to creative ability, such as the ability to create a business model, to spot business ideas, or to produce sensations in the marketplace. What we measure is closely connected to education, a focal course and assignments. It is likely that students have improved these abilities during the course. Moreover, having been required to engage in creative activities, they may have enhanced their awareness of their creative potential. We emphasize students' extrinsic motivations, including the learning outcome of the course, to develop a business plan. Therefore, the exploration relates to students' creative and practical problem-solving heuristics, and it is likely that such creative abilities can be acquired through education and creativity training.

Based on the theoretical discussion, we formulate the following:

Research Question: *To what extent can students' creativity be changed, modified or enhanced during a one-semester course in entrepreneurship?*

We assume that education changes students' creativity positively, but also assume that its influence on students' creative abilities is greater than that on their willingness to be creative.

Methodology and study context

In this research, we use a quantitative approach and a survey design to collect data from students. The study is longitudinal and includes a pre-test at the beginning of the course and a post-test afterwards. Our population consists of 99 undergraduate engineering students at the Western Norway University of Applied Sciences, Bergen Campus, enrolled in the ING101 course during August 2016. The students came from a variety of engineering departments, including chemical engineering, computing, electronics and communication systems. We applied normal ethical procedures to recruit students to participate in the survey. Their participation was not mandatory.

The research centres on one specific course—ING 101: Technology Management, Economics and Entrepreneurship, (10 ECTS), which is mandatory for all undergraduate engineers. In the course, students are expected to develop their creative skills combined with their basic engineering discipline. See below for a detailed description of the course.

Creativity measures applied in the study

In the research, we use the bisociative scale (BS) developed by Jabri (1999) and the bisociative thinking mode (BTM) developed by Ko and Butler (2006, 2007). Jabri (1991) argued that Koestler's discussion of the conceptual differences between two modes of thinking (associative and bisociative thinking) is relevant for measuring creativity. He developed a pool of items based on Koestler's ideas (Jabri, 1991), the BS. The BS incorporates the basic idea of bisociation, centring on individuals' intrinsic enjoyment of being in a state of creative workflow. The BS includes items designed to determine whether the respondent is "likely to enjoy" or "not likely to enjoy" (rated on a seven-point Likert scale) activities such as searching for novel approaches, making unusual connections and being confronted with a maze of ideas. The BS determines the extent to which the individual enjoys being in a highly creative state, exploring combinations of unrelated knowledge elements, and in this way, explores student willingness.

The BTM developed by Ko and Butler (2006) incorporates the idea of bisociation as it centres on the ability to link unrelated ideas. The five-item measure reflects the extent to which an individual can engage in practical problem-solving by combining unrelated components. Respondents should respond on a seven-point Likert scale from "totally disagree" to "totally agree". The scale emphasizes individuals' creative abilities, referring to competence or skills acquired, and is highly relevant for capturing the entrepreneurial process, such as developing new business opportunities by linking unrelated ideas and domains.

The survey was conducted in English, the original item language. Norwegians, especially students, are assumed to be highly proficient in English. A pilot test was conducted by exposing a class in the middle of their semester to the survey (n = 49). We then discussed in class their interpretation of the scale items to verify their understanding of the wording of the survey items. This test resulted in one BS item being dropped from further data collections and analyses, as the students did not understand the meaning of the item (see Appendix 1). As the original item language was kept, the translation and ensuing measurement validity problems were reduced.

Description of the course

During the course, student teams identify a problem, develop a business idea and propose a final business model. The course aims to improve students' creativity and extend their engineering knowledge. The pedagogy emphasizes student-centred and action-oriented experiential learning methods (Åmo, 2012). All five modules of the course include a range of innovation and creativity tools, ranging from paradigm preserving (analytical and convergent thinking) to paradigm breaking (creative and divergent thinking). Students engage in practical tasks to create innovative solutions and must actively search for information to solve problems with fellow students in developing a business model. Students use innovative and creative tools to engage in an entrepreneurial process and finally complete a business plan. Figure 1 outlines the semester plan for ING 101. All modules combine traditional lectures with experiential learning.

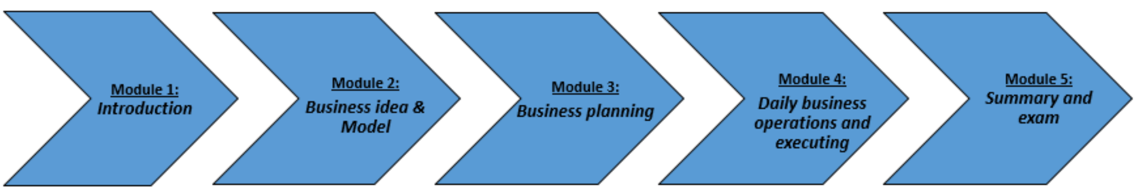

Figure 1: *The structure and modules of ING 101*

The course starts with an *introduction* (Module 1) to the five modules and the practical assignments. The lectures describe entrepreneurship theory and explain the problem-based learning didactics, preparing students for the practical assignment. Students work in teams of three or four developing an idea based on technology/industry problems (Lai *et al*., 2015). Educators and peer mentors (master students) facilitate and ensure the learning. The first lecture introduces industry challenges. The theoretical angle is problem finding, as described in Runco and Chand (1994; 1995). Students are encouraged to search for additional information and consider relevant industry challenges for their ideas. Moreover, ideas should relate to their field of engineering and be based on scientific research or stem from problems in industry. In this module, we use creativity tools to stimulate understanding of the problem and formulate questions and solutions, e.g. through brainstorming and the problem statement canvas.

The *business idea and business model* (Module 2) includes a 1-day creative workshop, designed and inspired by several creativity-evoking tools. The basic structure is a model for new service development (De Jong *et al*., 2003:33) with separate search and implementation stages. The search stage consists of idea generation, screening and commercial evaluation. In the idea generation phase, students first generate ideas individually and then in teams. The teams screen one or two problems they prefer and then start generating ideas. The lecturers use different tools to aid the creative process. First, they verbalize specific words such as *smaller, better* or *faster*. Second, they name random words to create new conceptual combinations. Third, lecturers show students pictures and abstract art to stimulate creativity. These tools facilitate and nurture creative and bisociative thinking (Dubitzky *et al*., 2012; Ko and Butler, 2007).

In the screening phase, students work in teams to decide which ideas to pursue and which to combine, and plan how to complete the practical assignment within the allotted time. In the evaluation phase, students use entrepreneurship theory combined with engineering knowledge to evaluate these ideas. Relevant questions include: "What problem needs to be solved?", "How big is it?" (scope and frequency), "What is the user utility?" "Is a solution already available in the marketplace?", and "How novel is the idea?" Typical ideas generated in the course were: 1) a tool to help people with multiple sclerosis who have difficulty stretching their fingers, 2) ways to make plastic out of waste and 3) an app to schedule work in restaurants. In the development stage, students work independently between lectures. The teams conduct market research, including tests on potential customers.

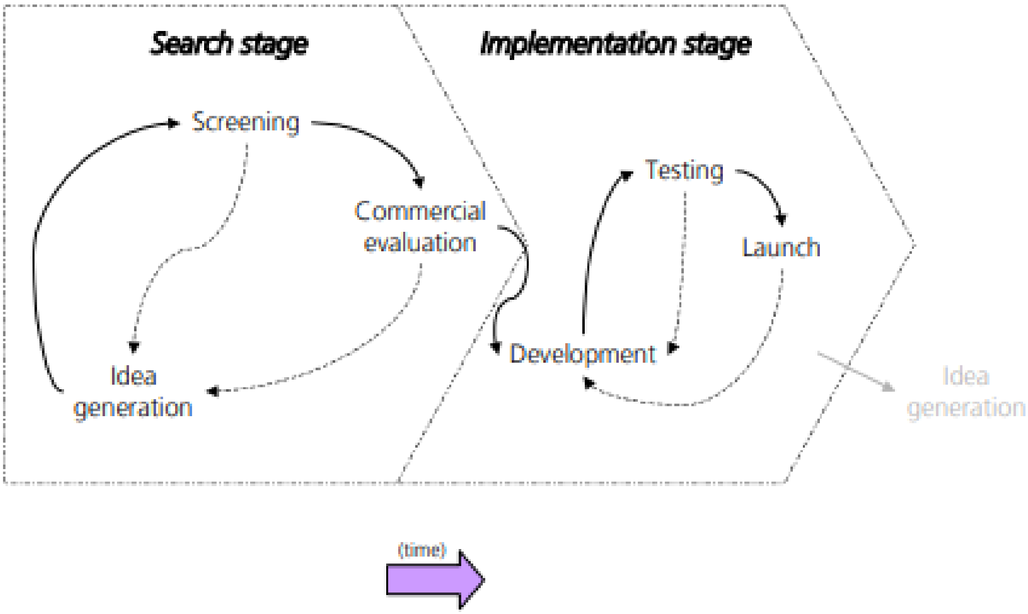

Figure 2: *A model for new service development over time (De Jong et al., 2003, p.33)*

Module 2 ends with a written assignment explaining the business idea and a first draft of the business model canvas. In addition, the groups make a video pitch and present their business idea and stakeholder analysis to an external panel of business experts. This panel assesses the students' ideas. The panel assessment and a board game in business financial management create a competitive environment between teams, enhancing their intrinsic and extrinsic motivation (Giordani and Moraes, 2015).

In the *business planning phase* (Module 3), students develop their business idea further and define market segments and their customers' needs. Furthermore, they estimate the financial forecasting, risk assessment and execution plans for realizing the idea in the market. In this phase, they learn to combine a business plan with the business model canvas, finding new creative solutions for their own business idea.

Daily business operations and execution (Module 4) includes themes such as leadership, organization, ethics, growth and exit strategies. The online teaching tool Hubro Business Simulation for business and entrepreneurship subjects is used (Hubro Education).

During the simulation, students compete in teams by running virtual production companies. The simulation spans several virtual years in which students control all the aspects of a company, including research and development, production, finance and sales (Giordani and Moraes, 2015). This module uses creativity tools to find new solutions to increase income and reduce the cost (bootstrapping) of the product or service. The teams then deliver a business plan and resubmit it to a panel of experts for revision before submission. The students also write an individual reflection report.

Summary and examination (Module 5) connects the theory in the curriculum with practical assignments. The course uses diverse tools to stimulate creativity in different ways. The student-centred pedagogy and creativity tools make the students set their own goals and become self-determined and creative (Genova and Gonzalez, 2017). The tools used during the creative workshops (Module 2) are assumed to stimulate students' creativity through workflow and enjoyment, triggering their inner motivations and willingness to create (BS). By contrast, the practical assignment of developing an idea into a business plan is expected to enhance students' creative abilities (BTM).

Data analysis and results

A web-based survey containing the five BTM items and the remaining eight BS items was administered to 99 students at the beginning of another entrepreneurship course. A total of 76 pre-test responses were received. At the end of the course, the same group of students was asked to respond to the survey. Some 35 post-test responses were received.

The construct validity was tested by calculating the Cronbach's alpha for the two measures over the total sample of 111 responses. The Cronbach's alpha for the eight BTM items was 0.869, while that for the five-item measure for the BS was 0.830, which was higher than the threshold of 0.7 suggested by Hair *et al*. (1998).

The item scores for the pre- and post-test group were averaged for the BS and BTM constructs into BSpre, BSpost, BTMpre and BTMpost measures. Three new measures, BSdiff, BTMdiff and Bdiff (BSdiff = BSpost – BSpre, BTMdiff = BTMpost – BTMpre and Bdiff = BTMdiff – BSdiff), were prepared for each of the 26 students who responded to all items of both the pre- and the post-surveys.

Table I displays the mean summed scores for the pre- and post-BTM and the pre- and post-BS, as well as the differences between these measures for the group of 26 students. The table indicates that the score for the ability to be creative (BTM) increased slightly (BTMdiff = .21), while willingness to be creative (BS) fell slightly following the completion of the course (BSdiff = –.33). Furthermore, Table I shows that there were only small deviations in the summed scores among the 26 students both before and after their classroom exposure to the creativity exercises. The BTM measure showed a positive change, whereas the BS measure showed a negative change. The differences in change between the BTM and BS from before to after the course was .53 (B_diff = .53). Table I indicates that students' BTM show a stronger positive change from educational efforts than their BS, and provides further details of the distribution of the data on which the analysis is based.

Table I. *Pearson correlations, means, standard deviation, skewness, kurtosis, minimum and maximum for BS pre and post, BTM pre and post, differences in BS pre and post, differences in BTM pre and post and differences in pre and post for BS versus BTM.*

Measure		**1**	**2**	**3**	**4**	**5**	**6**	**7**
BS_pre	1							
BS_post	2	.239						
BTM_pre	3	.665 ***	.134					
BTM_post	4	.480 *	.684 ***	.415 *				
BS_diff	5	-.731 ***	.488 *	-.504 **	.050			
BTM_diff	6	-.249	.449 *	-.634 ***	.441 *	.539 **		
B_diff	7	.566 **	-.104	-.056	.371	-.582 **	.370	
Mean		4.58	4.25	3.57	3.78	-0.33	0.21	0.53
Std. Dev.		1.17	0.92	1.13	0.97	1.30	1.14	1.18
Skewness		-0.50	0.36	0.87	-0.29			
Kurtosis		0.11	-0.44	1.31	0.84			
Minimum		1.75	2.75	1.80	1.20	-2.63	-3.20	-1.38
Maximum		6.63	6.13	6.60	5.80	3.00	2.80	3.18

* indicate p≤.05, ** indicate p≤.01, *** indicate p≤.001

A paired sample t-test with bootstrapping was used to explore the extent to which education can modify and enhance students' creativity. T-tests are sensitive to non-normal distributed data (Field, 2013). Pallant (2013) recommends paired sample t-tests when the sample size is small. In cases where the data are non-normally distributed, differences in means can be tested by performing permutations or running a Wilcoxon test. Wilcoxon t-tests and Student's t-tests, including permutations, were performed. Bootstrapping also underpins conclusions based on tests of small samples. Table I shows that the tested measures are normally distributed, as the skewness and kurtosis measures are within the –1 to 1 bounds recommended by Hair *et al*. (1998).

These tests did not reveal any significant differences in the BS or BTM measures between the pre- and post-test groups. The differences between the groups in the creativity measure were not sufficiently significant to indicate changes in creativity occurring as a result of the course. A paired samples t-test for the BS measure comparing pre- and post-test measures was not significant ($p = .214$), nor was a similarly paired sample t-test for the pre- and post-test scores on the BTM ($p = .363$).

As the direction of these non-significant changes differed, a paired samples t-test indicated a difference between the two measures in terms of the influence of the course. A paired samples t-test in SPSS (version 22) revealed significant differences between the effects reported by students of the classroom activities relating to the BTM and BS (Pallant, 2013). The difference between BSdiff and BTMdiff (Bdiff) was significant (.53), at $p = .030$. Bootstrapping ($n = 1000$) the paired samples t-test confirmed the indicated difference, at $p = .035$.

This finding indicates that education can modify and enhance students' creativity. The creative abilities of the 26 students showed a stronger positive change than their enjoyment of or willingness to be creative.

Conclusion and discussion

The analyses showed that students' willingness to be creative decreased, whereas their creative ability increased, during the one-semester course. These changes were partly consistent with our assumptions; however, we did not expect students' willingness to be creative to decrease during the course. It was assumed that the course would affect students' willingness to be creative and their creative ability positively, but that the effect would be stronger for students' ability than for their willingness to be creative. Therefore, the results support our assumption that education can modify and enhance students' creativity, but the effect of education is stronger on the development of creative ability than on willingness to be creative.

We used a pre- and post- longitudinal survey design to explore the extent to which education can modify and enhance students' creativity. Only non-significant differences in changes were found in the two measures between the pre- and post-test. Even so, a difference was found in how these two measures changed during the course. As we assumed, the students' ability to engage in creative tasks increased. The data indicate that their willingness to engage in creative tasks and their enjoyment thereof decreased as a result of the course.

Some suggestions can be made based on the results, which show differences in the effects between students' abilities and their enjoyment of the activity. The findings indicate a stronger positive influence on students' creative problem-solving abilities (BTM) than on their intrinsic enjoyment and willingness (BS) to perform creative tasks. This suggests that entrepreneurship education with creativity tools is more likely to affect students' creative abilities than their willingness to be creative. We assume that performing a practical task, such as developing a business plan, would require only slight changes in personality, underlying preferences and disposition.

Furthermore, the research indicates that it is difficult to modify and enhance students' fundamental creative dispositions and trigger intrinsic enjoyment in a one-semester course. Creativity research may partly explain this finding, claiming those individuals' basic creative dispositions are most likely developed from their early years, influenced by family background and individual histories of interests and circumstances (Amabile, 1983; Simonton, 2000; Sternberg, 2006). Furthermore, the fact that the education system has long favoured analytical skills and convergent thinking (Runco, 2004; Sternberg, 2006) may also clarify our findings. In general, students are marginally exposed to pedagogical content encompassing divergent and creative thinking in their schooling. Students' first encounters with creativity tools encouraging them to act and think creatively can occur at the age of 22 years (bachelor's degree level). Consequently, this situation may make them feel uncomfortable and unsecure, as suggested by McFadzean (1998). Hence, unfamiliar creative tools 'imposing' creative thinking may create negative emotions in students and decrease their willingness to be creative. To the researchers' knowledge, few other courses at the focal university offer practice-based learning with creative elements to undergraduate engineering students.

Students who are pushed to perform creative acts through unfamiliar creativity tools may also have problems internalizing the new abilities and skills. When pedagogy and learning arrangements impose practical (creative) tools on students, the learning outcomes may not last for long, which may raise questions about how and when the desired learning outcomes of entrepreneurship education should be evaluated and measured.

Implications for entrepreneurship education

Our research findings may inform educators in the field of entrepreneurship education. In particular, they inform practice-based learning courses aiming to develop students' abilities and skills as important learning outcomes. Some of these abilities and skills may be related to students' dispositions and learning preferences that are more basic and hence need a long time to grow (Simonton, 2000). It is therefore important to consider that even young bachelor's students developing their personalities already possess a basic personality and exhibit inclinations in their thoughts and actions (Kubberød and Pettersen, 2018).

Therefore, as educators, we need to discuss how to teach entrepreneurship and creativity (in terms of pedagogy) and to decide which learning outcomes we can and should develop in our students. Should we as educators emphasize more superficial and potentially malleable abilities and skills? Should creativity training be adapted to individual personalities and basic dispositions? Are educators entitled to change students' behaviour, personal dispositions and preferences, and is it possible?

Developing and enhancing creative and divergent thinking is critical in today's complex and shifting world. Creativity is central in entrepreneurial behaviour, and engineers are well placed to contribute to creative problem-solving by finding new technological solutions. Therefore, creativity should be further integrated into curriculums and assessments, enhancing its value in university education. Moreover, educators should advance their competence in creativity training and improve learning designs that facilitate creative thinking. To familiarize students with creative tasks, creative learning elements should be introduced early in higher education, in both curricular and extra-curricular learning arrangements. If students are exposed to creative learning throughout their university education, negative emotions may diminish with continual exposure.

Creativity tools and techniques abound in organizations and business life, so educators should learn and gain inspiration from successful companies with creative cultures. Educators also need to experiment with and improve creativity training and tools in curriculums, and carefully select appropriate pedagogy that facilitates and secures students' learning experiences. It is essential to respect individual students, as well as their dispositions and preferences.

Therefore, our pedagogy should strike a balance between encouraging and 'pushing' students' learning and securing individual students' learning experiences.

Limitations and future research

This study reports results from one course, examining changes in creative abilities and willingness to be creative among only 26 students. The low *n* invites further studies involving new cohorts and contexts, as well as other creative elements in teaching. Another limitation of this study relates to the specific course and its pedagogy, which includes creative elements and students' learning context, which may limit the external validity of our findings. Our findings are obviously connected to the chosen course, specific creativity tools and the learning context, as well as to the specific cohort of engineering students. Consistent with other creativity research, the social context surrounding the creative act is influential (Amabile, 1983; Runco, 2004; Simonton, 2000). In education, the specific pedagogy, curriculum and assessments affect creative acts and outcomes (Sternberg, 2006), so future studies should include various pedagogies and learning arrangements, possibly with control groups, to explore how creativity may be developed and enhanced in educational settings. Furthermore, new research should adopt a qualitative longitudinal approach, using interviews (with individuals and teams) combined with observations of the creative process. New qualitative studies will add in-depth and multi-faceted knowledge to expand and enrich the research field.

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References

Amabile, T.M. (1983), "The social psychology of creativity: a componential conceptualization", *Journal of Personality and Social Psychology*, Vol. 45 No. 2, pp. 357-376.

Åmo, B.W. (2012), *Entreprenørskapsutdanning i endring [Entrepreneurship Education in Change]*, Cappelen Damm Akademisk AS, Oslo.

Bakhshi, H., Downing, J.M., Osborne, M.A. and Schneider, P. (2017), *The Future of Skills: Employment in 2030*, Pearson, London.

Bourgeois-Bougrine, S., Buisine, S., Vandendriessche, C., Glaveanu, V. and Lubart, T. (2017), "Engineering students' use of creativity and development tools in conceptual product design: what, when and how?", *Thinking Skills and Creativity,* Vol. 24, pp. 104-117.

Bulut, C., Eren, H. and Halac, D.S. (2013), "Which one triggers the other? Technological or social innovation", *Creativity Research Journal,* Vol. 25 No. 4, pp. 436-445.

Colette, H., Hill, F. and Leitch, C. (2005), "Entrepreneurship education and training: can entrepreneurship be taught?", Part I, *Education + Training,* Vol. 47 No 2, pp. 98-111.

Couger, J.D. (1995), *Creative Problem Solving and Opportunity Finding (Decision Making and Operations Management),* Thomson Learning, London.

De Jong, J.P.J., Bruins, A., Dolfsma, W. and Meijaard, J. (2003), "Innovation in service firms explored: what, how and why?", Strategic study B200205, *EIM Business & Policy Research*, pp. 1-73.

Dubitzky, W., Kötter, T., Schmidt, O. and Berthold, M.R. (2012), "Towards a creative information exploration based on Koestler's concept of bisociation", in Berthold, M.R. (Ed.), *Bisociative Knowledge Discovery. An Introduction to Concepts, Algorithms, Tools and Applications*, Springer, Berlin, Heidelberg, pp. 11-32.

Field, A. (2013), *Discovering Statistics Using IBM SPSS Statistics,* 4th edition, Sage, New York, NY.

Giordani, D.S. and Moraes, J.C. (2015), "An experience of the use of project-based learning to simulate a business environment in a discipline of chemical engineering course", *Proceedings of the 43rd SEFI Annual Conference 2015—Diversity in Engineering Education: An Opportunity to Face the New Trends of Engineering, SEFI 2015*.

Genova, G. and Gonzalez, M.R. (2017), "Educational encounters of the third kind", *Science Engineering Ethics,* Vol. 23 No. 6, pp. 1791-1800.

Guilford, J.P. (1950), "Creativity", *American Psychologist,* Vol. 5, pp. 444-454.

Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C. (1998), *Multivariate Data Analysis,* 5th edition, Prentice Hall, Upper Saddle River, NJ.

Hamidi, D.Y., Wennberg, K. and Berglund, H. (2008), "Creativity in entrepreneurship education", *Journal of Small Business and Enterprise Development*, Vol. 15 No. 2, pp. 304-320.

Higgins, D. and Galloway, L. (2014), "Refocusing—building a future for entrepreneurial education and learning", *Industry and Higher Education*, Vol. 28 No. 6, pp. 449-457.

Hubro Education (no date) *Hubro Business Simulation*. Available at: <https://hubro.education/en/hubro-business-simulation> [accessed 12 June 2019].

Hytti, U. and O'Gorman, C. (2004), "What is 'enterprise education'? An analysis of the objectives and methods of enterprise education programmes in four European countries", *Education + Training*, Vol. 46 No. 1, pp. 11-23.

Ireland, R.D., Hitt, M.A. and Sirmon, D.G. (2003), "A model of strategic entrepreneurship: the construct and its dimensions", *Journal of Management*, Vol. 29 No. 6, pp. 963-989.

Jabri, M.M. (1991), "The development of conceptually independent subscales in the measurement of modes of problem solving", *Educational and Psychological Measurement*, Vol. 51 No. 4, pp. 975-983.

Ko, S. and Butler, J.E. (2006), "Prior knowledge, bisociative mode of thinking and entrepreneurial opportunity recognition", *International Journal of Entrepreneurship and Small Business*, Vol. 3 No. 1, pp. 3-16.

Ko, S. and Butler, J.E. (2007), "Creativity: a key link to entrepreneurial behavior", *Business Horizons*, Vol. 50 No. 5, pp. 365-372.

Koestler, A. (1964), *The Act of Creation*, Hutchinson, London.

Kubberød, E. and Pettersen, I.B. (2018), "Entrepreneurial identity matching through cross-cultural learning", *UNIPED*, Vol. 41 No. 1, pp. 54-67.

Lai, C., Chen, S., Hwang, R. and Huang, H. (2015), "Influence of integrating creative thinking teaching into project-based learning courses to engineering college students", *Proceedings of the 43rd SEFI Annual Conference 2015—Diversity in Engineering Education: An Opportunity to Face the New Trends of Engineering, SEFI 2015*.

Lazar, L. (2018), "The cognitive neuroscience of design creativity", *Journal of Experimental Neuroscience*, Vol. 12, pp. 1-6.

Lin, J. and Nabergoj, A.S. (2014), "A resource-based view of entrepreneurial creativity and its implications to entrepreneurship education", *Economic and Business Review*, Vol. 16 No. 2, pp. 163-183.

McFadzean, E. (1998), "The creativity continuum: towards a classification of creative problem-solving techniques", *Creativity and Innovation Management*, Vol. 7 No. 3, pp. 131-139.

Pallant, J. (2013), *SPSS Survival Manual*, 5th edition, McGraw-Hill, London.

Rodrigues, A.P., Jorge, F.E., Pires, C.A. and Antonio, P. (2019), "The contribution of emotional intelligence and spirituality in understanding creativity and entrepreneurial intention of higher education students", *Education + Training*, https://doi.org/10.1108/ET-01-2018-0026.

Runco, M.A. (2004), "Creativity", *Annual Review of Psychology*, Vol. 55, pp. 657-687.

Runco, M.A. and Chand, I. (1995), “Cognition and creativity”, *Educational Psychology Review*, Vol. 7 No. 3, pp. 243-267.

Runco, M.A. and Chand, I. (1994), “Conclusions concerning problem finding, problem solving, and creativity”, in Runco, M.A. (Ed.), *Problem Finding, Problem Solving, and Creativity*, Ablex Publishing, Norwood, NJ, pp. 217-290.

Runco, M.A. and Acar, S. (2012), “Divergent thinking as an indicator of creative potential”, *Creativity Research Journal*, Vol. 24 No. 1, pp. 66-75.

Scott, G., Leritz, L.E. and Mumford, M.D. (2004), “The effectiveness of creativity training: a quantitative review”, *Creativity Research Journal*, Vol. 16 No. 4, pp. 361-388.

Scott, S.G. and Bruce, R.A. (1994), “Determinants of innovative behavior: a path model of individual innovation in the workplace”, *Academy of Management Journal*, Vol. 37 No. 3, pp. 580-607.

Simonton, D.K. (2000), “Creativity: cognitive, personal, developmental, and social aspects”, *American Psychologist*, Vol. 55 No. 1, pp. 151-158.

Smith, K.G. and Di Gregorio, D. (2002), “Bisociation, recognition, and the role of entrepreneurial action”, in Hitt, M.A., Ireland, R.D., Camp, S.M. and Sexton, D.L. (Eds.), *Strategic Entrepreneurship—Creating New Mindsets*, Blackwell, London, pp. 129-150.

Sternberg, R.J. (2006), “The nature of creativity”, *Creativity Research Journal*, Vol. 18 No. 1, pp. 87-98.

Sung, S.Y. and Choi, J.N. (2012), “Effects of team knowledge management on the creativity and financial performance of organizational teams”, *Organizational Behavior and Human Decision Processes*, Vol. 118 No. 1, pp. 4-13.

Ward, T.B. (2004), “Cognition, creativity, and entrepreneurship”, *Journal of Business Venturing*, Vol. 19 No. 2, pp. 173-188.

Appendix 1

The measures applied in the study

Bisociative thinking mode (BTM) (Ko and Butler, 2006). I totally disagree–I totally agree (1–7)

BTM1 I can link up previously unrelated ideas to create a novel business model.

BTM2 I can relate two seemingly unrelated things to produce that "aha" sensation in the marketplace.

BTM3 I can combine idea elements from two or more entirely unrelated domains.

BTM4 I spot new business ideas subconsciously.

BTM5 My new ideas are largely unrelated to one another.

Bisociative scale (BS) (Jabri, 1991). Is not likely to enjoy–is likely to enjoy (1–7)

BS1 Being confronted with a maze of ideas which may or may not lead me somewhere

BS2 Pursuing a problem, particularly if it takes me into areas I do not know much about

BS3 Linking ideas that stem from more than one area of investigation

BS4 Being fully occupied with what appear to be novel solution methods

BS5 Making unusual connections about ideas even if they are trivial

BS6 Searching for novel approaches not required at the time

~~* BS7 Struggling to make connections between apparently unrelated ideas~~

BS8 Spending time tracing relationships between disparate areas of work

BS9 Being "caught up" in more than one concept, method or solution

* BS7 was omitted from the study as the students in the validation sample reported not understanding the question.