
CREATIVITY AND INNOVATION IN TECHNOLOGY AND OPERATIONS MANAGEMENT THROUGH BRAINSTORMING

CREATIVIDAD E INNOVACIÓN EN TECNOLOGÍA Y DIRECCIÓN DE OPERACIONES MEDIANTE BRAINSTORMING

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ABSTRACT

This research develops an exploratory study on the impact of brainstorming on students' creativity and innovation. Therefore, the purpose of this research study is to advance on: how much the creativity and innovation of students increases with the use of brainstorming; how contextual variables influence creativity and innovation when brainstorming is applied, and; how the legitimacy

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given by students to the brainstorming methodology influences the results achieved in creativity and innovation. The results show that the application of brainstorming, among a sample of 89 students of the technology and operations management course, leads to significant increases in creativity and innovation. They also show that there are no significant differences according to age, study background and gender. Finally, it demonstrates the importance of the degree of acceptability and desirability of brainstorming in the teaching and learning process to improve student outcomes. Having legitimacy is positive because it conveys confidence to students, encouraging learning. Future research could analyse the role of legitimacy of teaching methods on student outcomes.

KEYWORDS

brainstorming, creativity, innovation, legitimacy, students, teaching, soft skills

RESUMEN

En esta investigación se desarrolla un estudio exploratorio sobre el impacto del brainstorming en la creatividad y la innovación de los estudiantes. Nuestro propósito es avanzar sobre: cuánto aumenta la creatividad y la innovación de los estudiantes con la utilización del brainstorming; cómo influyen las variables contextuales sobre la creatividad y la innovación cuando se aplica el brainstorming y; cómo influye la legitimidad otorgada por los estudiantes a la metodología del brainstorming sobre los resultados alcanzados en la creatividad y la innovación. Los resultados evidencian que la aplicación del brainstorming, entre una muestra de 89 estudiantes de la asignatura de tecnología y dirección de operaciones, conduce a incrementos importantes de la creatividad y la innovación. También muestran que no existen diferencias significativas en función de la edad, estudios de procedencia y género. Por último, se demuestra la importancia del grado de aceptabilidad y deseabilidad del brainstorming en el proceso de enseñanza aprendizaje para mejorar los resultados de los estudiantes. Tener legitimidad es positivo porque transmite confianza a los estudiantes, favoreciendo el aprendizaje. Futuras investigaciones podrían analizar el papel de la legitimidad de los métodos de enseñanza sobre los resultados de los estudiantes.

PALABRAS CLAVE

brainstorming, creatividad, innovación, legitimidad, estudiantes, enseñanza, soft skills

INTRODUCTION

Identifying and generating new opportunities is an essential capability for business success. People can improve their ability to identify opportunities through creativity training. Creativity enables people to produce innovations, ideas, solutions and products that meet the needs of society (Zhu et al., 2021).

Creativity and innovation have been recognised as key competences for students in all fields of knowledge (Edwards-Schachter et al., 2015; Oluwalola & Awodiji, 2021). These are transversal competences that have been integrated into a large number of educational programmes throughout the European Union, because of their socio-economic importance in responding to social challenges and technological developments. Universities are increasingly aware that they must educate students to be: creative and develop new or improved products and services; able to identify opportunities; understand market forces and societal challenges. However, despite the key role of these competences, creativity and innovation are, in general, a superficial aspect of our education system (Rahimi & Shute, 2021). In fact, creativity is undermined by many classroom practices, such as test-based assessment or the discrediting of professors and students who choose to move away from socially accepted activities and develop more creative ones (Kaufman & Sternberg, 2007).

Creativity is a skill that can be trained. Techniques such as group discussion, brainstorming, cooperative learning, and debate to teaching practice have been proposed by higher education professors to enhance critical thinking (Lombardi et al., 2021; Zorrilla Calvo et al., 2020). Methodologies for promoting and assessing creativity and innovation are constantly evolving (Giancola et al., 2021; Sternberg, 2012). For example, great advances are being made in this type of teaching through the use of video games (Rahimi & Shute, 2021). However, brainstorming remains one of the main techniques to foster creativity among students (Al-Samarraie & Hurmuzan, 2018). It is a technique whereby spontaneous ideas and thoughts are shared among the members of a group in order to reach at practical solutions. The process of idea generation plays a key role in stimulating individuals to produce creative solutions and practical innovations (Schlee & Harich, 2014)..

Generally, the evaluation of brainstorming focuses on the number of creative ideas generated. In fact, it is one of the most commonly used techniques to stimulate students' production of ideas (Al-Samarraie & Hurmuzan, 2018). Beyond the generation of ideas, it is not clear from previous studies how much the use of such techniques enhances creativity and innovation among students. The acceptability of the technique applied by the students may explain these discrepancies. To some extent it seems reasonable that greater legitimacy of the methodology applied may lead to better results among students. This follows from Institutional Theory which has been demonstrated in other contexts, for example on the acceptability of subjects in higher education settings (Thomas, 2005). Context can become a key determinant of the outcomes of teaching methodologies (e.g. Al-Samarraie et al., 2020). Thus, the use of the same technique in different contexts may generate different results on creativity. From the literature, it is evident that there is still a lack of studies analysing the different effects of creativity techniques, such as brainstorming on students' creativity generation under various conditions and contexts. Previous research suggests that application across different disciplines may involve different requirements, content, criteria and approaches to learning (Al-Samarraie & Hurmuzan, 2018). It follows that some methods used successfully in one discipline may fail when applied to other disciplines.

Based on these observations, the objectives of this research are as follows: (i) determine how much students' creativity and innovation increases with the use of brainstorming; (ii) analyse how contextual variables influence creativity

and innovation when brainstorming is applied; (iii) analyse the degree of legitimacy of brainstorming among students and its influence on students' creativity and innovation. These objectives will increase our knowledge on the use of brainstorming for the generation of creativity and innovation among students.

In the following sections, a review of the literature on creativity and innovation in higher education is developed. It points out the role of brainstorming as an enabler of creativity and it is suggested that legitimacy and context can influence the implementation of brainstorming. The methodology used and the results achieved are described below. Finally, the research results, limitations and future research directions are discussed.

LITERATURE REVIEW

Creativity and Innovation

En general, se entiende por creatividad la capacidad de generar ideas novedosas y potencialmente útiles (Woodman et al., 1993). For an idea to be considered creative it must contain both characteristics. There are multiple ways to enhance creativity. These have been explained through three schools of thought: Inspirationism (a), Structurism (b) and Situationism (c) (Rahimi & Shute, 2021). Thus, creativity emerges: (a) by moving away from conventional and familiar structures and towards less usual thoughts, networks, associations and even problems; (b) going through a series of pre-established stages in an orderly manner, for example through Amabile's (2016) model of creativity; c) social activity through social relations between people. "Creativity does not only lead to societal progress through notable inventions and discoveries, it does so also (if not primarily) by changing the way people relate to the world, to others, and to themselves, making them more flexible, more open to the new and, at least in principle, to differences in perspective" (Glaveanu et al., 2020, p. 743).

Creativity is different from innovation. Creativity is the generation of new and useful ideas by individuals, whereas innovation involves the successful implementation of creative ideas. In other words, it is implementation of ideas into practice (Zhou & George, 2001). Creativity is therefore considered to be a precursor to innovation. Innovation involves acting on creative ideas to generate value for the market or society. The innovation process involves evaluating the quality and effectiveness of creative ideas (Bjørner et al., 2012).

Brainstorming, context and legitimacy

In higher education, the teaching of creativity and innovation is confronted with disparate conceptions on the part of professors. Some professors consider that students have a certain degree of creativity, with which they enter their studies, which cannot be changed through education. On the contrary, other educators believe that students' level of creativity and innovation can be enhanced through educational methodologies (Edwards-Schachter et al., 2015).

Brainstorming is the most common strategy in teaching and learning processes to promote the generation of ideas. In a review of the literature on creativity support tools, the authors pointed out that almost half of the tools used some form of brainstorming (Frich et al., n.d.). This method has proven to be effective in generating a wealth of original ideas in both group and individual

sessions. This may be due to factors such as free association and the constant collision of opinions among students, which allow for the free flow of ideas among group members and the interrelation of ideas. However, previous research indicates that while in some contexts, when using certain brainstorming techniques, students can generate a large number of ideas, in other contexts, these techniques can generate few ideas (Levine et al., 2015).

The context in which teaching and learning tools are developed can influence learning outcomes. Context is a strong determinant of individuals' perceptions (Cachón-Rodríguez et al., 2021). It therefore has a direct influence on legitimacy, i.e. on the acceptability of the actions carried out. Socio-demographic characteristics or the context of uncertainty may influence legitimacy assessments (Francisco Díez-Martín et al., 2022). Institutional theory suggests that when an organisation's actions are perceived as more desirable and appropriate by society, the likelihood of success increases. This has been analysed in multiple areas of research (Francisco Díez-Martín et al., 2021). In the case of higher education, stakeholder satisfaction increases when the institution is perceived as having more legitimacy (Cruz-Suárez et al., 2020; Miotto et al., 2020).

In this way, students' perceptions of the methodology used in the teaching process could become barriers to learning creativity and innovation. On the contrary, positive perceptions of teaching methodology would increase motivation and the likelihood of success (Plaza-Casado et al., 2020). Therefore, it is to be expected that when a teaching methodology has more legitimacy, it is more desirable, it will enhance the students' abilities to a greater extent, because they will feel more motivated and will be able to reach the flow state (Catalán Gil & Martínez Salinas, 2018; Sundararajan, 2019). When you experience the state of flow, you lose track of time, enjoy the experience and produce better performances (Catalán Gil & Martínez Salinas, 2018; Sundararajan, 2019).

METHODOLOGY

Sample and data collection

Data for this research was collected at two points in time, before and after the brainstorming activity, by means of surveys.

Before starting the brainstorming activity, data related to the level of creativity and innovation was collected from 89 students, second and third year undergraduate students of Technology and Operations Management, from four different fields of knowledge: Science and Technology, Social Sciences, Humanities, Arts and Humanities (Table 1).

This was followed by an explanation of how the brainstorming activity would work. The objective of the session was for the students to have their team choose a business idea. This business idea would be implemented by each working team during the academic year. The "nominal brainstorming" (NBS) method was used for this activity (Al-Samarraie & Hurmuzan, 2018), where: (i) each individual generates ideas individually; (ii) ideas are shared and discussed among the working team; (iii) the business idea that will be implemented during the rest of the course by the team is chosen.

One week after the activity, data was collected from the 89 students regarding their level of creativity, innovativeness and their perception of the acceptability and desirability (legitimacy) of the methodology used.

Table 1. Sample data

Sample	89
Gender	
Female	43
Male	46
Age	
18-19	25
20-21	36
22-23	17
>24	11
Study Field	
Arts	36
Science and Technology	28
Humanities	5
Social Sciences	20

Variables

L Creativity was measured using the 13-item scale of Zhou and George (2001). The evaluation of each item was done using a seven-point Likert scale, where 7 represents a higher level of creativity.

The students' level of innovation was measured by means of the Hurt-Joseph-Cook questionnaire (Hurt et al., 1977). It is a list of 20 items, each of which is assessed on a seven-point Likert-type scale. Thus, innovation levels can range from 20 to 140 points, with the theoretical mid-point being 80 points. In this way, students would be placed on a continuum between a more or less innovative type of behaviour.

The legitimacy of the brainstorming technique was measured by asking students whether: (i) whether they felt that the activity had been useful to them and (ii) whether they felt that the activity was good and should continue to be used next year. These questions are based on the legitimacy measurement process of Díez-Martín et al. (2021). Previous authors have used similar questions to measure legitimacy (Chung et al., 2016).

In addition, three variables like age, gender and background studies were used to take into account the effect of context on brainstorming results.

RESULTS

Brainstorming, creativity and innovation

The results of the application of brainstorming on creativity and innovation of the students of the Operations Management and Technology course are shown in Table 2.

Table 2. Variations of creativity and innovation with brainstorming

	Before BS		After BS			Var.	
	Media	Desv	Media	Desv	BS Leg		
Creativity	5,002	1,369	5,460	1,057		📉 9,15%	
Innovation	4,628	1,466	5,475	1,214		📈 18,31%	
Legitimacy			5,640	1,194			
	Creat	Innov	Creat	Innov	BS Leg	Var.Creat	Var. Innov
Age							
18-19	4,938	4,540	5,250	5,125	🟢 5,540	📉 6,32%	📈 12,90%
20-21	4,782	4,578	5,710	5,500	🟢 5,545	📈 19,42%	📈 20,15%
22-23	5,344	4,762	5,500	5,890	🟢 5,945	📉 2,92%	📈 23,70%
>24	5,327	4,789	5,335	5,500	🟢 5,585	📉 0,15%	📈 14,86%
Origin of studies							
Arts	5,063	4,654	5,875	6,125	🟢 6,045	📈 16,04%	📈 31,62%
Science & Tech	4,917	4,557	5,265	5,235	🟢 5,635	📉 7,08%	📈 14,89%
Humanities	5,015	4,740	5,100	4,875	🟢 5,000	📉 1,69%	📉 2,85%
Social Sciences	5,004	4,654	5,565	5,250	🟢 5,375	📈 11,21%	📈 12,82%
Gender							
Femenine	4,908	4,517	5,500	5,555	🟢 5,780	📈 12,07%	📈 22,98%
Masculine	5,095	4,740	5,430	5,175	🟢 5,520	📉 6,57%	📉 9,18%

N=89

BS=brainstorming, Var.= Variation, Creat= Creativity, Innov=Innovation, Desv=Deviation

The average level of creativity and innovation of the students before the brainstorming was 5 and 4.62 points. Showing above-average levels in both indicators. After the application of the brainstorming methodology the average of both skills increases by 9.15% and 18.31% respectively.

Brainstorming in different contexts

We explored the influence of context on the results of brainstorming by observing age, educational background and gender.

Depending on age, it is observed that after brainstorming, younger students experience greater increases in creativity, and older students experience greater increases in innovation levels. According to the origin of studies, the students who experience the greatest increases in their levels of creativity and innovation are those from the Arts, followed by those from the Social Sciences. The effect is small among Humanities students. By gender, the increase in levels of creativity and innovation is significantly higher among women.

The observation of the results on the effect of the contextual variables on creativity and innovation led us to consider contrasting the existence of significant differences between the different groups for each variable. In this

way we carried out an ANOVA analysis on each of the contextual variables used in the research. The results indicated that there were no significant differences between the groups analysed.

Brainstorming and legitimacy

Brainstorming has proven its legitimacy. The results of the legitimacy assessment are above average (5.6 points out of 7), suggesting that this tool is considered desirable, useful and should continue to be used in the teaching process. Students have positively evaluated the use of brainstorming as a teaching and learning tool.

Furthermore, the results show that the legitimacy of the teaching and learning tool (in our case brainstorming) is positively related to students' levels of creativity and innovation (Table 3).

Table 3. Correlations between creativity, innovation and brainstorming legitimacy

	Creativity	Innovation	Legitimacy
Creativity	1	.513**	.557**
Innovation	.513**	1	.702**
Legitimacy	.520**	.755**	1

** $p < 0.01$

CONCLUSION, LIMITATIONS AND FUTURE RESEARCH LINES

This research develops an exploratory study on the impact of brainstorming on students' creativity and innovation. The results show significant increases in both skills in the students.

In addition, it analyses how the context influences on the results from the application of brainstorming in the classroom. The results suggest that there are no significant differences in students' creativity and innovation by age, study background and gender.

Finally, we analyse whether the legitimacy of the teaching and learning tool, in our case brainstorming, is correlated with the levels of creativity and innovation achieved by the students. The results indicate a significant correlation between the three variables. Therefore, it demonstrates the importance of the degree of acceptability and desirability of the tool used in the teaching and learning process to improve student outcomes. Having legitimacy is positive because it transmit confidence to students, which is favouring to learning.

However, this research shows some limitations that lead to future research lines. One of the main limitations lies in the sample size. The results should be taken as exploratory because with such a small sample size there is a loss of significance. For example, in the multi-group significance analysis, the study groups were very small.

Thus, future research would have to be based on larger samples, in which statistical techniques that offer greater significance can be applied. Further more, it would also be of great interest to see whether the results obtained are replicated when using other methodologies for teaching creativity and innovation. In the field of higher education and legitimacy (Cruz-Suárez et al., 2020; Díez-de-Castro, 2020), future research could analyse whether the legitimacy of other teaching and learning methodologies enhances better outcomes among students.

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APPENDIX

Scales and Items

Creativity

1. Suggests new ways to achieve goals or objectives.
2. Comes up with new and practical ideas to improve performance.
3. Searches out new technologies, processes, techniques, and/or product ideas.
4. Suggests new ways to increase quality.
5. Is a good source of creative ideas.
6. Is not afraid to take risks.
7. Promotes and champions ideas to others.
8. Exhibits creativity on the job when given the opportunity to.
9. Develops adequate plans and schedules for the implementation of new ideas.
10. Often has new and innovative ideas.
11. Comes up with creative solutions to problems.
12. Often has a fresh approach to problems.
13. Suggests new ways of performing work tasks.

Innovation

1. My peers often ask me for advice or information
 2. I enjoy trying out new ideas
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3. I seek out new ways to do things
 4. I am generally cautious about accepting new ideas
 5. I frequently improvise methods for solving a problem when an answer is not apparent
 6. I am suspicious of new inventions and new ways of thinking
 7. I rarely trust new ideas until I can see whether the vast majority of people around me accept them
 8. I feel that I am an influential member of my peer group
 9. I consider myself to be creative and original in my thinking and behaviour
 10. I am aware that I am usually one of the last people in my group to accept something new
 11. I am an inventive kind of person
 12. I enjoy taking part in the leadership responsibilities of the groups I belong to
 13. I am reluctant about adopting new ways of doing things until I see them working for people around me
 14. I find it stimulating to be original in my thinking and behaviour
 15. I tend to feel that the old way of living and doing things is the best way
 16. I am challenged by ambiguities and unsolved problems
 17. I must see other people using new innovations before I will consider them
 18. I am receptive to new ideas
 19. I am challenged by unanswered questions
 20. I often find myself sceptical of new ideas
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