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Factors Enhancing Creativity in Technical Higher Education

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Abstract

Extended experience and knowledge need creativity as a third component to create a base for any innovative endeavour or advancement. Transdisciplinary approach and an opening for creative integration of the information are crucial in any educational endeavour. This paper reports correlation analyses performed on the results of a quantitative and qualitative study based on five dimensions (creativity components, personal, interpersonal, equipment and conjectural), aiming to determine the incentive and inhibitor factors of creativity in the activity of the engineering student work groups. Strong liaison between creativity components and personal, alternate experiences were detected, while inertial approaches in learning and dependence to guidance and equipment were identified as deterring creativity.

Keywords: Innovative thinking, correlation analyse, transdisciplinarity, creative integration

1. Introduction

The modern society needs specialists that can undertake non-standard decisions and actions in solving technical and economic problems. Above strict and rather narrow qualification stands the social need for persons to be able to enrol high-tech solution for accomplishment of human needs, under various social, cultural and feasibility constraints.

An assessment presented in 2007 by the Institute of Directors [1] grouped the skills and qualities that employers seek as items in four sets: employability, people, social and personal qualities.

In the employability set, creative and innovative thinking was considered quite important by 51% and very important by 40% of employer respondents, after advanced oral communication

skills, appreciated as quite important by 46% and very important by 42% of the employers. Decision-making skills received, correspondingly 51 and 38%, while problem-solving skills were considered quite important by 37% and very important by 59% of the employers, positioned on the third place after ability to meet deadlines (29 and 60%, correspondingly) and attention to detail (34 and 61%). As it appears, half of the employers appreciate creativity, in strong liason with problem solving.

A recent survey conducted by the Millennial Branding [2] reveals that, in the engineering fields, effective communication skills are crucial to success. The second soft skill found crucial in an engineer's career is creativity, defined as the driving force behind innovation and increasingly gaining recognition as the new capital in the actual economic conditions. As a consequence, creativity should be treated like a skill that needs to be identified, cultivated and trained. One effective way to do that is to foster a creative culture during the educational process and many authors propose some turning keys to develop a culture for innovation and creativity [3].

In conclusion, extended experience and knowledge need creativity as a third component to create a base for any innovative endeavour or advancement.

2. Triggers of the innovation

Although creativity can be considered as extremely subjective, its main output, the innovation is strictly monitored and considered an important indicator of progress and development. In general, the innovation is distinctly defined as technological and non-technological innovation. An insight at the innovation would lead to very pragmatic results and conclusions, all linked to the internal mechanism of the enterprise and its economic status. Behind the drivers and goals of the innovations resides the creative thinking and the capacity to access and correlate holistic information regarding the economical units, its competitors, social and economic environment. This can be done only with a transdisciplinary approach and an opening for creative integration of the information.

The primary driver of the innovation is the improvement of the quality of goods and services and the second is the increasing of the range of goods and services [4]. In 2012, approximately 40% of the enterprises in EU-27 were found technologically innovative and over 42% reported non-technological innovation. New methods of organising work responsibilities and decision making were the leading innovation in 20 countries, followed by new business practices and reorganisation of external relations. Enterprises more often are motivated to reduce the reaction time to customers' needs or by the need to improve the communication and sharing together with the ability to develop new products or processes.

In Romania, the innovative enterprises attained last year 20.7%, with the types of innovation described in Figure 1. In Europe, in general, among the triggers of change, the increase in turnover seems the most important, as described in Figure 2.

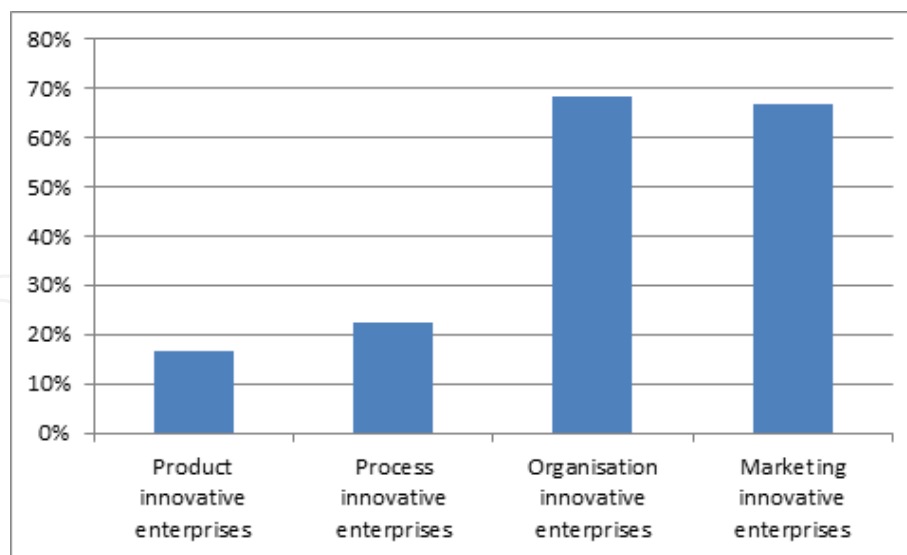


Figure 1. Types of innovation in Romania, 2015.

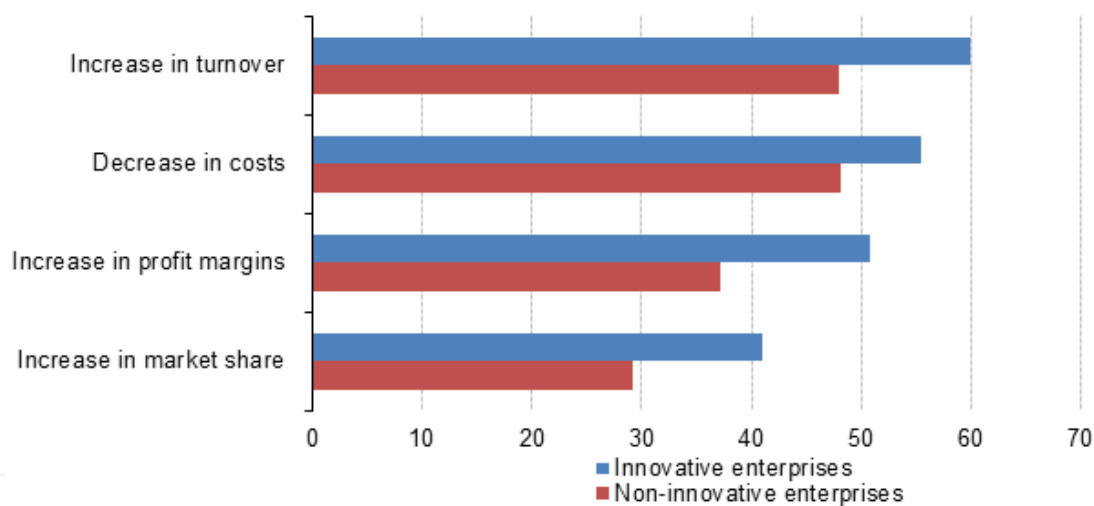


Figure 2. Highly important goals in innovative and non-innovative enterprises, EU-28, 2010–2012 [5].

3. Argument

Starting with creative teams established in the 1970s in France, nowadays is more and more obvious that lonely thinkers who produce relevant contributions to science and technology, even if extremely talented, are *rara avis*. Plethora of information and the complexity of technological, time and social constraints require effective groups of specialists with various points of views. For obvious reasons, young people are preferred as sources of ideas and creative specialists and attracted in research projects at various levels. As a consequence,

nurturing creativity is a crucial task for education at all levels. In polytechnic higher education the challenge is to adapt the syllabi and curriculum as a holistic approach to the real-world problem solving. Creative student groups are one of the solutions closest to the day-by-day engineering challenges.

Even though student creative teams are not easy to establish and sustain, they follow the same group rules as enterprise or any real-world research teams and can provide the precious output of experience and innovation: small groups of people linked by trust thrive on the associative functioning. This concept is underused in Romanian polytechnic universities, which suffer from scarce financing, lack of efficient policies regarding the research quality management and are rather rigid regarding the new pedagogy behind a learning context where temporary “chaos” of questioning and doubting is encouraged and evaluation rules change. Naturally, one might imagine the extent of the outcome of more flexible education methods, where personal experience is mostly considered and personal point of view encouraged. It is characteristic for technical and applied sciences domains the validation and augmentation of one’s personal point of view in a group or peers. Student groups are one of the closest approaches to the real world of engineering, but still, they are far from being used in teaching and examination due to the ill-functioning bridging with the so-called objective evaluation. On-going standardised testing is restraining the ability to see and present reality from different angles. Even so, each and every one reports learning and education, in general, as a personalised experience, the resulting knowledge being always the integration of the “standard academic package” in own frame of beliefs and practical experience.

Technological innovation is strongly connected with creative approach to practical problems. The methods to nurture technological creativity were described by G.S. Altshuller in the so-called Theory of the Solution of Inventive Problems (original TRIZ) with the related Algorithm of Solution of Inventive Problems (original ARIZ) [6], but the steps approached there do not fully apply for students groups enrolled in a creative quest. The students in creative groups need to learn to organise their work and the methods of research in technology and engineering. Also, the motivations are different and instable and conduct to absenteeism or discouraging attitudes and drop-out. The leaking pipe phenomenon depletes the initial enthusiastic groups of students of those who lack proper motivation, despite their aptitudes for investigation and knowledge.

This paper is the result of a research aiming to find the triggers for creative thinking in groups of engineering students. This study came as a need to identify ways to stimulate students to succeed during preparation of their final exams and thesis, enhancing their ability to produce original work. In fact, as Sir Ken Robinson emphasised, “...everyone has huge creative capacities as a natural result of being a human being. The challenge is to develop them. A culture of creativity has to involve everybody not just a select few” [7].

4. The method

This paper reports correlation analyses performed on the results of a quantitative and qualitative study, aiming to determine the incentive and inhibitor factors of creativity in the activity of the engineering student work groups.

4.1. Study set-up

The following groups of items (dimensions) were considered: creativity components, personal, interpersonal, equipment and conjectural. The creativity components acknowledged for this study were: the interest for paradox, curiosity, originality, the ability to question and doubt, fantasy, the ability to make associations, conceptual representation, intuition, aesthetic perception, willingness to take risks and openness. They were appreciated for each student by the supervisor of the student groups and correlated with other components of the dimensions. As research instruments a questionnaire and semi-structured interviews, enhanced with direct observations, were used. Supervisor, sophomore students and master students enrolled at Mechanical Engineering Faculty from Ovidius University filled in the multi-item questionnaire and their answers were registered in a data base for further analysis. The response rate was 93.5%, with an error of 4.3%.

4.2. Sampling

Sampling parameters for the respondents are presented in Tables 1 and 2. It is obvious the majority of urban respondents (69,64%) and the gender asymmetry of the group (56,25% male and 43,75% female respondents). The age of the respondents was not a criterion, as all of the students were in the 20–25 years old group.

Masculine	63	56.25%
Feminine	49	43.75%
Total	112	100.00%

Table 1. Gender structure of the sample

Urban	78	69.64%
Rural	34	30.36%
Total	112	100.00%

Table 2. Respondent provenience

4.3. Methodology

The supervisor and the student surveys aimed to capture the levels of intensity for each response. The student questionnaire aimed to capture the amount of agreement or disagreement on a six-point Likert scale. An even Likert scale intensity ranking was preferred to enforce clear delimitation of the responses. The survey was built on the dimensions presented in Table 3:

Creativity components	Personal	Interpersonal	Equipment	Conjectural
The interest for paradox, curiosity	Existence of role model(s)	Supervisor support	Quality of the research equipment	Mission clarity
Originality	Existence of a mentor in any filed	Team members support	Research premises	Balanced tasks
The ability to question and doubt	Experience in crafting, manufacturing, repairing things	Communication	Access to information	Visibility of the results
Fantasy	Theoretical/ scientific knowledge on specific subject	Challenging team	Support to access materials, consumables or special equipment	Organization risk policy
The ability to make associations	Theoretical/ scientific knowledge on alterne subjects	Team cohesion		Any kind of benefit, rewarding
Conceptual representation	Sport, dancing, scenic movement experience (hobby)	Degree of individual freedom within the team		Future usage/ applicability of the work
Intuition	Musical and visual art experience (hobby)	Personal contribution recognition		
Aesthetic perception	Literature/ poetry experience (hobby)			
Openness	Awareness of personal development goals			
Not being afraid to take risks	Awareness of professional goals			
	Awareness of personal social goals and achievements			
	Ability to stand-up/ have own say			

Table 3. Grouped items of the survey dimensions

Additional data acquired from the interviews and design practical activities were used by the supervisor to characterise each student creativity components, as listed in the first column of Table 3. Each group of students were supervised during a semester. At the end, students were interviewed with concern to the survey dimensions.

Each group of students was formed by the students themselves, based on affinities to each other and to the design mission. The design mission was formulated by each group, from the

prerequisite research and real needs in specific engineering domain. All the initial design themes were presented in front of four large groups, commented and selected by the students, voting the importance, relevance and attractiveness. Around the design themes portfolio, the student groups were formed and the mission statements were defined. A project calendar was set and compulsory deadlines and milestones were agreed between the members of each group.

Correlation analysis was performed in order to track down any connection between the creativity components with personal, interpersonal, conjectural and endowments set of items. As such, motivating factors and barriers in expressing one’s creativity were identified, at the level of the group studied.

5. Data analysis

The median values for the answers regarding interpersonal, were rather high in what concerns the supervisor role ($M=5.4$), perceived as a mediator and important professional guide. During the interviews, occurred the fact that students, at least at the beginning of the work in student groups, have low self-confidence in what concerns their ability to bring to the end the design mission, mostly because they lack practical experience, also lack experience to apply in specific situations the theoretical knowledge. Median scores presented in Table 4 show that respondents consider the team support and good communication as very important creative incentives, but show certain disregard to the degree of liberty within the team (Table 4). During the interviews, this appeared to be linked to a certain fear to liable for any/some aspects of the project. Also, this was linked with the rather low availability to undertake risky decisions regarding the engineering design or project management.

The own contribution recognition reached high scores, and shows a delicate balance between the team-work values and personal contribution delimitation, often source for abandoning the project or rejection of critics.

Interpersonal	Median values
Supervisor support	5.4
Team members support	4.35
Communication	5.4
Challenging team	3.2
Team cohesion	4.4
Degree of individual freedom within the team	2.8
Personal contribution recognition	4.6

Table 4. Interpersonal dimension scores

Conjectural dimension scores are shown in Table 5 and reveal that respondents do not link the creative endeavour to its immediate applicability, while balanced tasks, clear mission received high scores. In our opinion this might reveal a dependence on clear, standardised framework, schematic thinking, which might stand against creative approach. An interesting low received organisational risk policy shows that the students do not necessary link this component to the creativity-simulative environment.

Conjectural	Median values
Mission clarity	4.25
Balanced tasks	5.4
Visibility of the results	4.35
Organization risk policy	2.65
Any kind of benefit, rewarding	5.27
Future usage/ applicability of the work	2.23

Table 5. Conjectural dimension scores

Equipment components were recognised as very important, with high scores, showing one more time that the students are reliant on material support for creative design, in spite of conceptualisation and initiative (Table 6).

Equipment	Median values
Quality of the research equipment	4.43
Research premises	5.23
Access to information	5.65
Support to access materials, consumables or special equipment	4.85

Table 6. Equipment dimension scores

In what concerns the creativity components, they were strongly correlated with the personal experience, in the first place, followed by interpersonal and conjectural components. The ability to question and doubt was correlated ($r = 0.5713$, $P < 0.0001$) to the experience of having a mentor in any filed and with the theoretical/ scientific knowledge ($r = 0.3801$, $P < 0.0001$). The ability to make associations was correlated with any previous experience in arts ($r = 0.39801$, $P < 0.0001$) and not being afraid to take risks is correlated at the 0.01 level (two-tailed), with the awareness of personal development goals sub-item ($r = 0.4302$, $P < 0.0001$), with the visibility of the results ($r = 0.5608$, $P < 0.0001$) and with any kind of benefit, rewarding ($r = 0.3907$, $P < 0.0001$). During the interviews, this was confirmed, as respondents linked their

boldness in approaching risky design or management alternatives with the incentives or recognition of their work.

6. Conclusions

The correlations revealed a strong liaison between creativity components showed during student group work sessions and personal, alternate experiences. This might bring, once more, the need of more flexible curriculum, where students should be able to benefit from alternative activities.

Even sophomore students and master students are strongly dependent on directions given by tutors or supervisors, and hesitate to challenge them. One of the issues in student's creative groups is the balance between the creative thinking and critical thinking within the group. The tension created at the frontier of those two is the source for advancement in solving inventive problems. Due to the lack of information on the objectives of the groups, as a whole, the critical thinking is not paid enough attention in common educational approaches and is often perceived as destructive when applied during group meetings. Overall, good communication within the team and team support were appreciated as very important but few interviewees knew how they could be accomplished. The need for efficient communication strategies activities in the curriculum might fill-in this obvious gap.

The students supervised during this research seem to perceive creative effort as a supplementary one, somehow extracurricular, and rather few of them engage voluntarily in creative endeavours. Even if most of them agree that creativity is important, and recognise the intrinsic value creativity brings to artefacts and technologies, they are, at the beginning, reluctant to manifest components of creativity, and remain attached, for learning, expressing their contribution and examination, to standardised engineering calculus described step-by-step in design guides. This inertia is identified as an important barrier in learning with and for creativity and origins much far backwards in the education flowline. In exchange, they perceive up-to-date lab endowments as crucial for a creative design.

A general conclusion of this study is that flexible thinking, autonomous thinking and self-criticism are the key creativity components that need to be paid special attention to in technical, scientific higher education.

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