Model for Developing the Creativity of Future Engineers

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Abstract: The article presents factors and their interrelations that influence the development of engineers' creativity. The subject of the article is in the field of human resources management and was in-spired by the results of research related to the analysis of the competency potential of future employees. The main goals of this paper are: - How can competencies of future engineers in the area of creativity be developed and what does creativity depend on – internal and external factors. - Can a model of enhancing creativity of future engineers be worked out? The research was carried out between 2014-2020, on a group of 861 students. The survey method was used, and the research tool was a self-evaluation questionnaire. The research used regression analyses, Spearman's rank correlation coefficients, the power of interrelation between chosen variables (social competencies and forms of education) was evaluated. Hierarchical multiple regression was carried out to verify the objective of the research. The analysis of correlations was verified and visualised with principal components analysis PCA, as well with cluster analysis using Ward's method. The main value of the article is the developed graphic model that reflects the stages of creative development as a competence that is a very important competence resource of the company. A mathematical model that includes the analysis, based on hierarchical multiple regression, revealed that social competencies and forms of learning examined are strongly correlated with 'creative thinking' competence, and this correlation is statistically significant.

Keywords: Management competencies, Creativity, Engineers' skills, Competencies of the future

1. Introduction

The question related to creativity and innovation is of key importance for modern organizations (Audretsch et al. 2020). Market requirements and customers' needs motivate companies to improve their products and intensify activities in the area of innovation. That, in turn, requires creativity in designing new solutions – in other words: to go beyond what is known, common and obvious (Pinker, 2009). Another reason why more attention is paid to creativity is the shift from economy based on tangible assets that is end-product oriented, to economy based on intangible assets, knowledge and services (Georgiev et al., 2016). Employees' creativity of a company gives the basis for a creative organization and is the source of competitive advantage (Al-Ajlouni, 2020). Creativity has become one of the production factors, a non-material resource, unique and of great value.

Why is creativity a competency of such demand? According to The Future of Jobs Report 2020, 'creativity and social intelligence will probably be indispensable skills in case of most new jobs created before 2030. Because these skills give people a distinct advantage over machines and software' (World Economic …, 2020). Employees who can combine mathematical, technological skills with creativity will be indispensable in organizations of the future. Hopkins (Hopkins & Keown, 2005) claims that a creative engineer is able to find various solutions regarding the design of a new product or improvement of a product already designed in order to be more sustainable. Creativity and innovation within a technoeconomic perspective are becoming the major driving forces behind the sustainability of economic growth and competitive achievements (Badran, 2007). Creative thinking is therefore a very essential part of earning and sustainable development (Sandri, 2013). Creativity is an essential engineering skill, therefore engineers have a lot of scope to support the development of creative skills (Carbonell-Carrera, 2019].

What is the level of engineers' creativity? How do they develop this skill? Does university education ensure a high level of creativity of future engineers?

Research shows that although students believe creative thinking is an important aspect of engineering, they do not have the impression of having enhanced their creative skills during the course of studies (Cropley, 2015).

There is a lot of research in the area of acquiring creativity among students (Szafrański et al., 2017). Such research was also done within the project called „The acceleration method of development of transversal competencies in the students' practical training process", realised in four countries: Poland, Finland, Slovakia and Slovenia. Literature of the subject also presents modern models directly referring to creativity regarding innovative organizations (Amabile & Pratt, 2016), new service development (Han-Kuang, et al., 2018), organizational creativity (Anderson et al., 2014) or collective creativity (Hargadon & Bechky, 2006). This

research rarely takes into account the process of enhancing creativity during formal, informal and non-formal education, therefore the authors included such an approach in this paper.

Competency enhancement approaches should be adapted to the student's needs. It is necessary to evaluate the level of creativity competency of individual students, and then to prepare a programme of business knowledge and skills development. The main research aspects of this paper are:

- How can competencies of future engineers in the area of creativity be developed and what does creativity depend on – internal and external factors (e.g. age, chosen elements of non-formal education, place of residence, forms of enhancing creativity).
- Can a model of enhancing creativity of future engineers be worked out?

In order to realise these goals, research on creativity competencies of students of two technical universities (A and B) was done between 2014-2020. In total, 861 future engineers of various technical faculties were examined. Using the method of a survey, the authors of this article recognized factors that influence enhancing students' creativity. Next, each of them was analysed statistically in order to isolate the dominant factors of developing creativity of future employees, and based on literature and empirical research, a model of developing future engineers' creativity was drawn up.

2. Enhancing Creativity Competency of Future Engineers

Enhancing the competency of creativity is the process of continuous learning and a key factor of the organization's success. A student develops and perfects their competencies in a formal, informal and non-formal way (Straka, 2002). Formal learning is institutionalised, formalised education, realised in accordance with syllabuses that result in qualifications accepted in a given legal system. Informal learning is intentional (self-learning) and unintentional learning, occurring accidentally in situations of everyday life, as well as when someone gains experience while working, not during formal or informal training. This form of education is usually of disorganized and non-systematic character, and covers any method of obtaining knowledge and experience (figure 1).

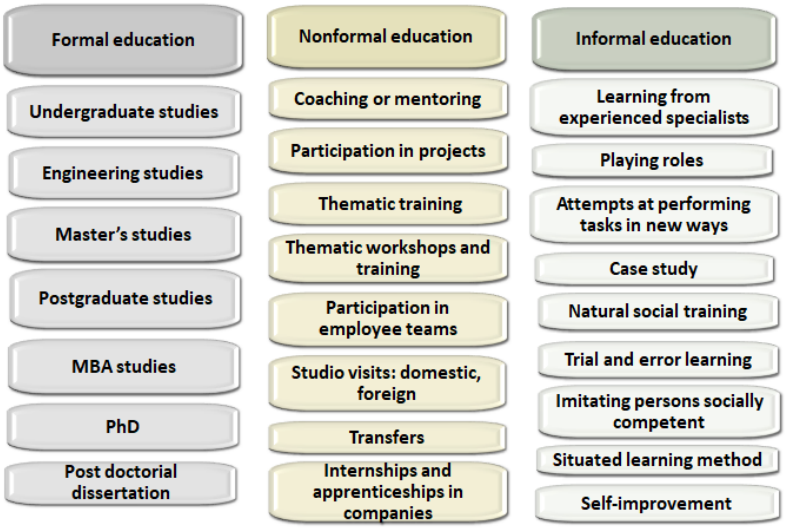

Figure 1: Formal, Non-Formal and Informal Learning of Creativity Competency of a Student - Examples (own Elaboration)

Figure 1 shows examples of a student's competencies development and improvement in a formal, informal and non-formal way (Spychała & Matejun, 2015).

The development and perfecting of a future engineer's creativity depend on many factors that, based on literature of the subject, were grouped into four categories and presented in the model drawn up:

- social and technical competencies that influence the development of creative thinking (Abrantes, 2020);
- characteristics of an employee and their environment (Sadłowska-Wrzesińska et al., 2017);

- forms of education realised throughout the professional career (2017; European Commission…2020);
- influence of the economic environment, including supply and demand for competencies of creativity, therein learning, knowledge and innovation (Hermawati, 2020).

3. Results

3.1 Research Assumptions

Statistical analyses for the research were carried out using TIBCO Software Inc. (2017). Statistica (data analysis software system), version 13. The research used regression analyses, Spearman's rank correlation coefficients, the power of interrelation between chosen variables (social competencies and forms of education) was evaluated. Only those factors that were correlated and whose correlation was statistically significant were used to build the statistical model. The analysis of correlations was verified and visualised with principal components analysis PCA, as well with cluster analysis using Ward's method.

The objective of the research was to create a hierarchy of chosen forms of formal, informal and non-formal education, which are evaluated by students and young employees who enter the job market as key forms in enhancing creativity, and to combine them with social competencies.

The research was carried out between 2014-2020, on a group of 861 students of day studies and extramural studies of two technical universities (A and B). The survey method was used, and the research tool was a self-evaluation questionnaire, where the creativity competency was expressed as synthetic measures based on three coefficients that allow evaluation of knowledge, skills and attitudes related to a given competence.

- K1 – knowledge regarding techniques of creative thinking
- K2 – ability to use techniques of creative thinking
- K3 – ability to think in a way that leads to original solutions, create new concepts or new connections with existing ideas.

These coefficients were described in detail and were evaluated by students on a scale 1-8, according to rules presented in Table 1.

The level of creative competency was set as the arithmetic mean of the battery of coefficients.

Cronbach's alpha was used to evaluate the reliability of the measurement. This coefficient allows to evaluate the conformity between various components (coefficients) of defined synthetic measures (Hair et al., 2006).

This coefficient defines with its value to what extent a set of coefficients describes the same theoretical constructs, represented by a given measure. According to the rules of methodology, it was accepted for this paper that the battery of coefficients represents acceptably reliable measure with Cr. > 0,7 (Sarstedt & Mooi, 2014).

Further in the paper, we presented the results of research on creativity level of students depending on various factors of one of the university A (594 respondents), where the arithmetic mean of results was analysed. Next, a model was drawn up, based on the correlation coefficient for all students surveyed of universities A and B.

Table 1: Description of Competency Levels

Level	Description
1	Competency is not acquired. No behaviour shows its acquisition and use in actions undertaken.
2	Basic acquisition of competence. It is used irregularly. Supervision and support from more experienced persons are required.
3	Sufficient acquisition of competence, hence it may be used in practice, independently. At times supervision of experienced persons is required.
4	Satisfactory acquisition of competence, hence it may be used indepentenly when performing professional tasks.
5	Good acquisition of competence, which enables adequate fulfilment of tasks in a given area.
6	Very good acquisition of competence, which enables very good fulfilment of tasks in a given area, and to pass own experience to others.
7	Excellent acquisition of competence. Ability to creatively use and develop knowledge and attitudes in a given area of tasks.
8	Expert level, ability to creatively share knowledge and skills with other managers and employees.

Source: own elaboration based on the research result

3.2 Questionnaire Research Analysis

The results of the research combine data from questionnaires that facilitated presentation of:

- students' age compared to self-assessment of creativity,
- internships and work used as a chosen element of non-formal education compared to creativity,
- work position during internship (manual, technical, administrative, managerial) compared to creativity,
- place of residence compared to creativity,
- forms of creativity development (formal: classes at university; non-formal: professional work, internships and apprenticeships, workshops and training, social organizations; informal: social life, family life).

Regarding the research results calculated with the arithmetic mean, it may be stated that:

- students (48 persons) who gave highest scores (7 and 8 out of 8) to three elements: presence in formal classes at university, initiative in class and results in education – average of competencies regarding creativity of these students is 4.49 (scale 1 – 8 see…);
- slightly lower – at 4.3, were placed students (55 persons) who gave high scores (7 and 8) only regarding their initiative in class;
- students (70 persons) who were placed at 4.01 gave high scores (7 and 8) regarding their average grade at university;
- the lowest self-assessment of creativity (3.48) was among students (306 persons) who gave high scores (7 and 8) only regarding one area, i.e. presence in clas-ses.

The arithmetic mean of self-assessment of all students surveyed at university A (total of 594) is 3.48 (on an eight-point scale).

The older the students, the higher the score of creativity self-assessment. Creativity self-assessment among 19-year-olds was 3 (38 students), 20-year-old – 3.18 (63 students), 21-year-olds – 3.24 (115 students), 22-year-olds – 3.47 (108 students), 23-year-olds – 3.59 (111 students) 24-year-olds – 3.69 (87 students), 25-year-olds – 4.01 (28 students), for students aged 26 and older – 4.1 (33 students).

Another factor analysed that enhanced creativity is internship. Average creativity self-assessment score (3.65) of students who did an internship (372 persons) was high-er by 0.17 compared to the arithmetic mean of creativity self-assessment score of all students. This difference was even bigger for students doing an internship or working for up to 4 years (by 0.59 – average creativity self-assessment score of 15 students was 4.07), up to 5 years (by 1.06 – average creativity self-assessment score of 8 students was 4.54) and above 5 years (by 0.93 – average creativity self-assessment score of 23 stu-dents was 4.41). The difference decreased as the length of internship or work de-creased. For 35 students doing an internship or working for up to 3 years, creativity self-assessment score was 3.93 – 0.45 higher than the arithmetic mean of creativity self-assessment score of all students surveyed. For 63 students doing and internship or working for up to 2 years, creativity self-assessment score was 3.47 – 0.01 lower than the average; for 228 students doing an internship or working less than a year creativity self-assessment score was 3.65 – 0.17 higher than the average.

The third factor analysed was the work position of internship or work. The highest scores of self-assessment of the surveyed group were among 42 persons who did an internship or worked in managerial positions (arithmetic mean of creativity self-assessment score – 4.24, 0.76 higher than the average of all surveyed students). Creativity self-assessment score of students doing an internship or working in technical positions was below the arithmetic mean of all students surveyed (arithmetic mean for a group of 107 students was 3.33, 0.15 lower than the average), and in manual positions (arithmetic mean for a group of 84 students was 3.3, 0.18 lower than the average of all persons surveyed).

The data analysed suggests that place of residence has an influence on creativity self-assessment done by students. 271 persons with above-average score of creativity self-assessment live in a big city of population >500 thousand inhabitants (arithmetic mean of creativity was 3.62 – 0.14 higher than the arithmetic mean of all persons surveyed). Students from small towns – 151 persons – were below the arithmetic mean of creativity self-assessment (arithmetic mean of the score – 3.46, 0.02 lower than arithmetic mean of all persons surveyed). The same applies to inhabitants of villages (167 persons, arithmetic mean of score – 3.29, 0.19 lower than the average of all scores).

Formal education, which includes classes at university (lectures, practical and laboratory classes and projects) is the most common source of developing creativity of the students surveyed (87% of indications). On the other hand, the lowest number of the surveyed (14%) evaluated this form as most useful in development of creativity competencies. The biggest influence on developing knowledge, skills and creativity attitudes is professional work, included in the category of non-formal education. This form is of key importance for the development of creativity competencies, as was indicated in 35% of cases, but also by a high assessment score of 5.28. Charities were evaluated by students as a poor form of developing competencies (average score 3.82). The fewest respondents (15%) indicated its key role in the process of improving creativity skills. Internships and apprenticeships, as well as workshops and training were given a higher score for their role in developing creativity competencies.

The last form of learning is informal learning: family and social life. Situations in social life were deemed by 23% of students as those that develop creativity competencies to the largest extent, with a high average score of 4.92. Importance of this form of learning is thus high and in the hierarchy it takes the second place, following professional work. Situations in family life were evaluated on a similar level to workshops and training – average score was 4.49, with a slightly higher percentage of respondents attributing those situations with a key role in the process of developing creativity.

3.3 Drawing up the Model Based on the Correlation Coefficient

In view of the above conclusions and aiming at realisation of the research objective, a path of developing creativity may be drawn (fig. 2). Individual stages of developing creativity result from both literature analysis and the analysis of survey research among students. 861 students took part in the research, but due to the completeness of data for calculating the correlation coefficient, surveys of 841 respondents were used.

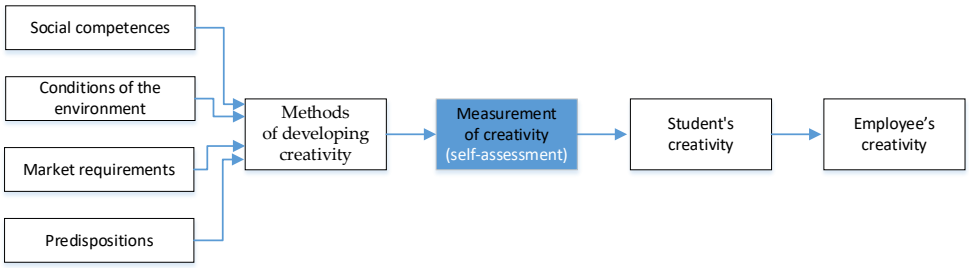

Figure 2: Chosen Factors That Influence the Path of Competency Development With an Impact on Employee's Creativity

Stages of developing creativity presented in fig. 2 were examined in detail through questionnaires, and results thus obtained were subjected to statistical research. The analysis, based on hierarchical multiple regression, revealed that social competencies and forms of learning examined are strongly correlated with 'creative thinking' competence, and this correlation is statistically significant.

Table 2. shows correlation coefficients between chosen independent variables self-assessing the level of social competencies and the used forms of learning, and the most significant competency related with creativity – 'creative thinking'. The strongest correlation was shown by the group of social competencies (SC - 02 Managing a team, SC – 03 Conflict resolution, SC - 04 Organizational skills, SC - 05 Negotiation skills, SC - 06 Internal communication skills, SC - 07 Communicating with the environment, SC - 08 Strategic thinking, SC - 09 Managing information). Weaker correlation was shown by FE - 01 Professional work, FE - 02 Internship/ apprenticeship, FE - 03 Workshops/ training (simulations), FE – 04 University classes (e.g. practical classes), FE – 05 Out-side work (e.g. organizing events), FE – 06 Family life (e.g. parents), FE – 07 Social activity (voluntary work)).

Table 2: Spearman's R Correlation Coefficient Between 'Creative Thinking' and Other Social Competencies and Forms of Learning. Basic Statistics

No.	Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14	15.	16.
1.	SC - 01 Creative thinking	-															
	SC - 02 Managing a team	0.59*	-														
3.	SC - 03 Conflict resolution	0.55*	0.69*	-													
4.	SC - 04 Organizational skills	0.35*	0.50*	0.50*	-												
5.	SC - 05 Negotiation skills	0.52*	0.60*	0.68*	0.45*												
6.	SC - 06 Internal communication skills	0.46*	0.59*	0.65*	0.45*	0.64*	-										
7.	SC - 07 Communicating with the environment	0.44*	0.59*	0.61*	0.47*	0.57*	0.77*	-									
8.	SC - 08 Strategic thinking	0.46*	0.59*	0.56*	0.55*	0.53*	0.56*	0.60*	-								
9.	SC - 09 Managing information	0.42*	0.45*	0.49*	0.30*	0.4*	0.41*	0.39*	0.38*	-							
10.	FE - 01 Professional work	0.24*	0.25*	0.21*	0.19*	0.23*	0.17*	0.24*	0.22*	0.29*	-						
11.	FE - 02 Internship/ apprenticeship	0.19*	0.18*	0.16*	0.11*	0.21*	0.14*	0.16*	0.11*	0.18*	0.37*	-					
12.	FE - 03 Workshops/ training (simulations)	0.26*	0.27*	0.25*	0.19*	0.24*	0.24*	0.23*	0.21*	0.19*	0.34*	0.41*	-				
13.	FE – 04 University classes (e.g. practical classes)	0.11*	0.17*	0.14*	0.08*	0.17*	0.15*	0.15*	0.09*	0.10*	0.08*	0.15*	0.30*	-			
14.	FE – 05 Outside work (e.g. organizing events)	0.16*	0.20*	0.20*	0.14*	0.24*	0.18*	0.18*	0.13*	0.15*	0.16*	0.20*	0.33*	0.33*	-		
15.	FE – 06 Family life (e.g. parents)	0.13*	0.17*	0.18*	0.12*	0.20*	0.16*	0.17*	0.15*	0.12*	0.24*	0.21*	0.26*	0.28*	0.46*	-	
16.	FE – 07 Social activity (voluntary work)	0.10*	0.17*	0.14*	0.17*	0.15*	0.15*	0.15*	0.11*	0.10*	0.20*	0.30*	0.44*	0.19*	0.33*	0.30*	
	Median	3.7	4.0	4.3	3.0	4.0	4.4	4.3	4.0	3.5	0.5	0.4	0.4	0.4	0.5	0.4	0.2
	Q1-Q3	2.7-4.3	3.0-4.8	3.3-5.0	2.5-4.5	3.0-5.0	3.6-5.2	3.7-5.3	3.0-5.0	0-5.0	1-7	1-6	1-5	3-6	2-6	1-6	0-5
	SE	0.04	0.04	0.04	0.05	0.05	0.04	0.04	0.05	0.08	0.10	0.09	0.09	0.07	0.09	0.09	0.09

* $p<0.05$ statistically significant value, $p\geq0.05$ statistically insignificant value. Source: own elaboration based on the research result

In order to describe the dependency model based on hierarchical multiple regression, all independent variables that showed a significant correlation with creative thinking were analysed (tab. 3). The model drawn up covered six steps, but since in the last step the variable did not enhance the description, it was not included in the description of the model. In the first step, the variable (SC – 02 Managing a team) described the model largely and was statistically significant ($R2 = 0.35$, $p \leq 0.001$), where-as further variables improved the correlations of the model. Finally, the description of the model was based on four variables from the area of social competencies (SC – 02 Managing a team, SC – 05 Negotiation skills, SC – 03 Conflict resolution, SC – 08 – Strategic thinking) and one variable regarding the form of education (FE – 03 Work-shops/ training (simulations)). This model described significantly – in 43% - the phenomenon of correlating creative thinking with qualities examined in the survey ($R2 = 0.43$, $p \leq 0.001$, $F = 13,27$).

Figure 3 shows graphic correlations between qualities analysed that have an influence on creative thinking. Factors appearing in the model describing the phenomenon statistically analysed were also marked in the chart (social competencies SC – 02, SC – 05, SC – 03, SC – 08 and the form of education FE – 03). The chart presented is also the idea reflection of factors related with competencies significant in the job market, as well as the reflection of the model for developing creativity of future engineers.

Additionally, while looking for the correlations between the examined qualities, an analysis of variance was used to estimate the distance between clusters as well as Ward's method. (fig. 4.) The choice of this method was justified with the analysis of variance relating to the data set while obtaining a high effectiveness with examining small clusters.

Internal similarities and external differences may be observed based on the tree diagram, an example of which may be a separate accumulation of social competencies from SC – 01 to SC – 08 and a separate accumulation of forms of education from FE 01 to FE 07. A very distinct similarity of social competencies SC – 01 and SC – 08, while simultaneously discarding SC – 08 should be noted. It shows a lack of group connection with a very distinct individual similarity.

Table 3: Analysis of Backwards Stepwise Regression – Establishing the Model Of Dependencies

Variable	R^2	β	F	p value
Step 1	**0.35**		**461.32**	**<0.001**
SC - 02 Managing a team		0.59		<0.001
Step 2	**0.39**		**278.51**	**<0.001**
SC - 02 Managing a team		0.43		<0.001
SC - 05 Negotiation skills		0.27		<0.001
Step 3	**0.41**		**196.86**	**<0.001**
SC - 02 Managing a team		0.35		<0.001
SC - 05 Negotiation skills		0.18		<0.001
SC – 03 Conflict resolution		0.19		<0.001
Step 4	**0.42**		**152.99**	**<0.001**
SC - 02 Managing a team		0.31		<0.001
SC - 05 Negotiation skills		0.16		0.0001
SC - 03 Conflict resolution		0.16		0.0001
SC - 08 Strategic thinking		0.12		0.0003
Step 5	**0.43**		**125.5**	**<0.001**
SC - 02 Managing a team		0.29		<0.001
SC - 05 Negotiation skills		0.15		0.0001
SC - 03 Conflict resolution		0.16		0.0002
SC - 08 Strategic thinking		0.12		0.0004
FE - 03 Workshops/ trainig (simulations)		0.09		0.0015
Step 6	**0.43**		**107.13**	**<0.001**
SC - 02 Managing a team		0.29		<0.001
SC - 05 Negotiation skills		0.12		0.0026
SC - 03 Conflict resolution		0.15		0.0005
SC - 08 Strategic thinking		0.12		0.0005
FE - 03 Workshops/ trainig (simulations)		0.08		0.0025
SC - 09 Managing information		0.09		0.0038

* p<0.05 statistically significant value, p≥0.05 statistically insignificant value. Source: own elaboration based on the research result

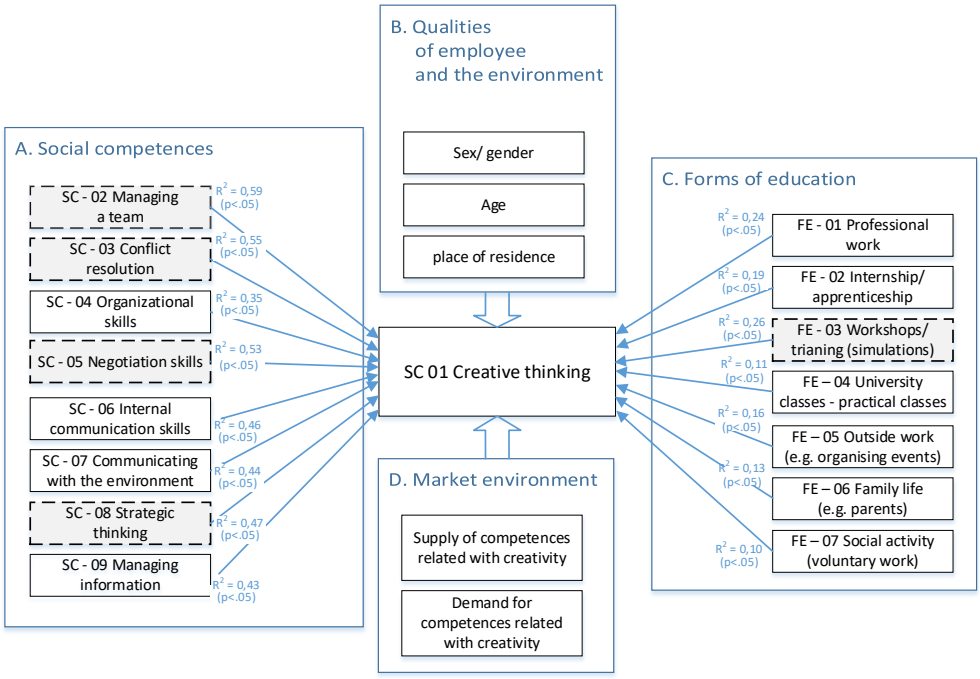

Figure 3: Graphic and Statistical Model for Developing Creativity of Future Engineers

Within the scope of expanding search for correlations indicating general regularities in relationships between variables taken into account in the examination of social qualities that influence creativity, principal component analysis (PCA) was done – figure 5. The component, corresponding to the first (biggest) eigenvalue, explains as much as 61.9% of total variability, the second one – 9.7%, which explains 71.6% of random variable. Vectors representing the analysed variables reach almost the edges of the unit circle, thus they are well represented by the first two components. Five components show a positive flow direction and confirm, previously proved in other research and literature analysis, a stronger correlation between social qualities

connected with communication (managing a team, internal communication skills, communication with the environment) and coordinating managerial competencies (organizational skills, strategic thinking). Managing in-formation is also characterised by a bigger angle inclination, which proves a weaker correlation among other variables. The distribution of other variables indicates a significant correlation of primary variables – their angle inclination from the second principal component does not exceed 900 (α < 450).

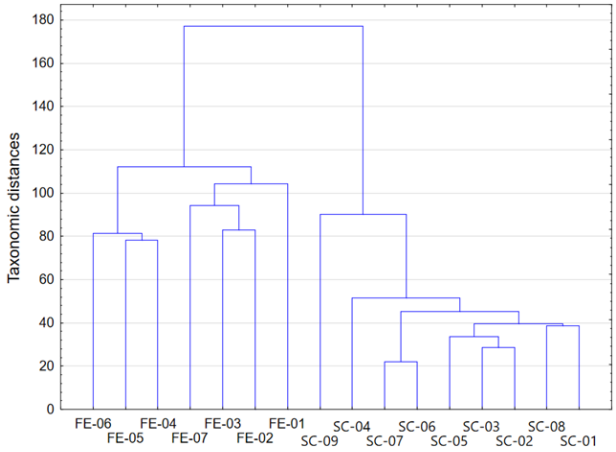

Figure 4: Tree Diagram - Ward's Method – Accumulation of Qualities Related with Creative Thinking

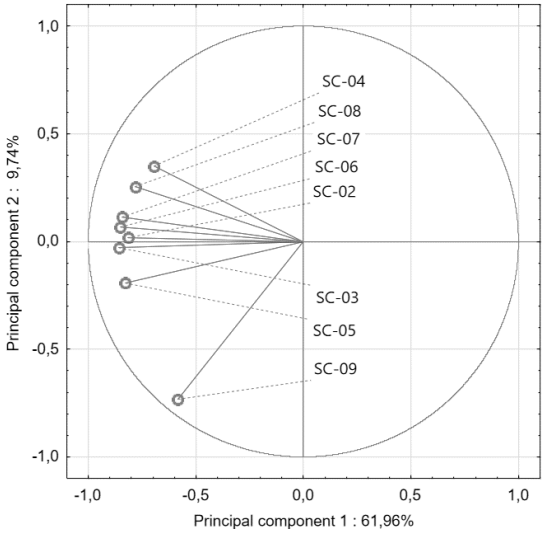

Figure 5: Principle Component Analysis of Social Competencies Related With Creative Thinking

The choice of analyses presented and the results was an attempt at showing opportunities of managing employees' competencies in effective business management. The use of activities described in the presented model should result in improving the quality of developing key competencies during the learning process, and their agile use and development at work.

4. Discussion

The objectives stated at the beginning of this paper referred to two areas: a) factors that influence the development and perfecting competencies of future engineers regarding creativity, and b) a proposal of a model for developing creativity of future engineers, that would encompass factors showing the higher influence on social competencies. Looking for the appropriate method of developing students' competencies, first their level should be recognised and adapted to their needs. It is necessary then to first examine the level of creativity competency of individual students, and next to create a programme of developing knowledge and business skills. Main research aspects of this paper, related with the opportunity for development and perfecting competencies of future engineers regarding creativity were included in the model. A large number of future engineers who provided information for the construction of the model is the reliable premise for implementation of the model obtained.

Having analysed our results, we may state that limiting development of factors most closely correlated with creative thinking (Managing a team, Negotiation skills, Conflict resolution, Strategic thinking or the form of education based on Workshops and training) may be the effective approach to the development of necessary competencies. In the research two areas were confronted – practical and theoretical – students' self-assessment of their own competencies in connection with factors included in the questionnaire, which were resulting from the literature analysis. The results obtained also confirmed the thesis that the university plays an important role in developing students' creativity, which is in line with research of other authors, e.g. (Tawil, & Dahlan, 2017; Tawil & Dahlan, 2017).

Factors present in examined models of creativity published by other authors were included in the model drawn up, e.g. (Awan et al., 2019). Taking into consideration the results of other authors and in order to increase the usefulness of the model used, further re-search could extend it by factors connected with internal motivation of the surveyed and conditions enabling implementation of innovation in the environment.

5. Conclusions

The importance of creativity among employees in the job market is emphasised (Abrantes, 2020). Human capital is currently the most valuable resource of modern businesses. Due to the great variability of the surroundings and the necessity to continuously increase competitive advantage and to be distinguished in the market, creativity may be the key competency in many work positions. It seems to be one of the key factors that influence the success of a business.

This paper emphasises the necessity of extensive description of competencies, which reflect knowledge and skills of employees and their connections with interrelations on managing human capital. Research results are based on data obtained from a large group of students, i.e. the group most involved in the development of managerial skills. Conclusions presented regarding the importance of creative thinking and including this social competency in the group of various forms of education are coincident with the perception of an employee as the most important 'resource' expressed as human capital (Bortolotti et al., 2015]. Such a view of social competencies and their development is also an important aspect of preventive management. Research shows that future engineers, while still at university, must develop their potential, investing in various forms of education for their future jobs. The significance of the influence of various forms of education on creative thinking is also presented in scientific papers discussing the ways of increasing the effectiveness of the educational process (Carayannis et al., 2017). Justification and practical use of the model presented in this paper is also shown in other research carried out by the authors (Goliński & Miądowicz, 2019; Goliński & Szafrański, 2019; Graczyk-Kucharska, 2019).

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