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Emotional Intelligence of Engineering Students as Basis for More Successful Learning Process for Industry 4.0

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Abstract: The purpose of this paper is creating analyses for understanding the personality characteristics related to emotional intelligence and how can this define the development program of personal characteristics in the processes of education for Industry 4.0. The main research goal is to measure dimensions of emotional intelligence in the student population based on a quantitative survey (Emotional Competence Inventory) through dimensions of emotional intelligence: self-regulation, self-awareness, and attitude towards changes. Since the student population was the research target, a group of 338 engineering students was selected. The group was characterized by highly diversified geographic origin, having previously completed school and achieved success. The results show that there are statistically significant differences between all three dimensions of emotional intelligence. Namely, self-regulation and attitude towards changes (both directly and indirectly through self-regulation) are positively affected by self-awareness, while attitude towards changes is positively affected by self-regulation. Developing student emotional potential is one of the most important actuators of business for Industry 4.0, especially in countries with low educational attainment and low social and economic indicators.

Keywords: learning process; emotional intelligence; Industry 4.0; students; engineering studies.

1. Introduction

The transformation of the economic structure and the ever-increasing link between the process of de-industrialization and globalization represent today's reality and also represent a milestone on the business horizon in the direction of reindustrialization and the creation of conditions for Industry 4.0. A prerequisite for a new approach to business is the existence of appropriate technical and production potential, especially human potential, since the transformation we want is not possible without competent employees. Competencies relate to the personal characteristics of employees that can be verified (knowledge, emotional intelligence, skills, or working methods) and enable employees to achieve work results.

Industry 4.0 opens up many problems, especially those related to personal competencies and their optimal use. In conditions in which Industry 4.0 involves the technical integration of cyber-physical systems into manufacturing and logistics, as well as the use of the Internet in industrial processes [1],

the most important resource for work is human resources. The role and importance of employees in Industry 4.0 in the future will be based on transformation business models of companies, as well as models of work organization. Big changes must be seen as a chance but also as a challenge for companies and individuals [2].

One of the most important concepts in human development is emotional intelligence. Goleman consolidated previous beliefs and expanded Salovey and Mayer's model of cognitive abilities, offering an integrated matrix concept of a total of 20 emotional competence indicators which he classified into self-awareness and self-regulation, social skills, empathy, motivation, and attitudes towards changes [3–5]. The trait model represents emotional intelligence as a disposition that develops and that we consider important for complete behavior, especially in young people. Goleman furthermore emphasizes that emotional intelligence is more important for jobs on a higher organizational level, because at these levels, technical skills are less important. Emotional intelligence is a much better predictor of business performance in jobs that require positive emotions, or in jobs that require high levels of emotional labor [5].

Emotional intelligence basically describes the ability to perceive and understand emotions and to manage emotions [6]. Emotional intelligence can help a person to use their emotions to improve the processing of information about challenges, threats, and problems and can contribute to finding ways of overcoming ambiguous and conflicting situations [7].

Among the emotional-intelligence-related abilities for engineering studies, in this paper, we have chosen self-awareness, self-regulation, and attitude towards changes as most important.

Self-awareness implies a multitude of different psychological and social dimensions, such as feelings, thoughts, personality traits, preferences, goals, attitudes, perceptions, and intentions [8], encompassing the sense of continuity of seeing yourself in a social setting. Self-awareness is not only the ability to become the object of your own attention but, above all, the active state of identification, processing, and preservation of data about yourself [9]. Goleman defines self-awareness as knowing your own strengths, weaknesses, drives, values, and impacts on others. Self-awareness is the ability to recognize ourselves, our own identity, and to be aware of our strengths and weaknesses, needs and motives. For emotional intelligence, awareness of our own feelings is extremely important. People with clear self-awareness are not exceedingly critical to others, nor are they irrationally optimistic. They are open and honest both to themselves and to others, they are self-confident, aware of their limits and abilities, and, consequently, they are much more aware of when it is time to seek help. They are ready to accept criticism, which ensures committing changes necessary for reaching success. Self-awareness is one of the most important dimensions of emotional intelligence in the processes of managing one's emotions and managing other people, and it is considered crucial to the attitude towards change [10].

People who are open to constructive criticism are able to change, develop, and learn, which enables them to manage their job and life more easily. Self-awareness is also related to our own ability to engage in a mental component of social knowledge, related to goals, intentions, beliefs, desires, thoughts, and feelings [11], and leader self-awareness has been linked to performance. One of the areas where increased emotional competencies are necessary is in constant interaction through personal contact and through the Internet patterns of the organization, which was investigated by Molnár et al. in their work [12] to describe a new approach to generating contact patterns using text analytics. One of the most important adaptive functions of self-awareness is self-regulation, which involves changing one's behavior, resisting temptation, or changing one's mood by selecting responses from various options and filtering irrelevant information. Self-regulation in the educational process can be viewed from the aspect of voluntary participation in the educational process through the management of behavioral, emotional, and cognitive resources in the service of achieving desirable learning goals [13]. Attitude towards change is the main characteristic of a leader, which is reflected in an openness to the new, balanced resistance to changes, and tendency and propensity to change and be in continuous development. Measuring dimensions of students' emotional intelligence would contribute to the

perception of their personality traits considered important for the job, development of which during their educational training would create preconditions for the successful execution of tasks.

Since emotional intelligence is significant in academic achievement, it was pointed out that emotional knowledge, skills, and intelligence are the key to improving education and helping students acquire higher levels of achievement, leadership, and personal well-being [14]. The results revealed that there is a positive relationship between self-esteem and emotional intelligence among students [15]. The results of these studies showed that students with high scores of emotional intelligence attain greater academic achievements, and they concluded that emotional intelligence has a significant impact on performance, and in addition, there is a positive relationship between emotional intelligence and motivation for academic achievement [16]. Also, research has shown the positive role of emotional intelligence in students' academic success and their adjustment and roll in positive education [17]. Celik and Storme, in their research, showed that emotional intelligence is positively associated with academic satisfaction and career adjustment abilities [18]. Longitudinal research in Hong Kong confirmed the positive predictor role of emotional intelligence in student engagement and key learning outcomes in higher education, including student grades and satisfaction with the university experience [19].

2. Materials and Methods

The starting point of this research is that students with higher emotional intelligence scores will adopt new knowledge easier, their development will be more sustainable in the future, they will adapt faster to new working conditions, and they will take more responsibility in new jobs. In accordance with the research scope and objectives, this paper addresses a basic research question: what is emotional potential, and how does it affect the development of a student? The goals of this research are focused on analyzing the traits of successful students and the connection between the measured dimensions of emotional intelligence and certain personal characteristics.

Based on the objectives of the research, the following hypotheses were defined:

Hypothesis 1 (H1). *Dimensions of emotional intelligence—self-awareness, self-regulation, and attitudes towards change—are highly recognized in engineering students' behaviour.*

Hypothesis 2 (H2). *The statistical correlation of the examined dimensions of emotional intelligence supports the idea of the role of engineering students' emotional intelligence in their personal development.*

The research was carried out between 1 October and 1 December 2018, on a student population of the University Novi Sad—Faculty of Technical Sciences. The study included 338 questionnaires that were properly completed. The research was conducted on the faculty premises. Students participated voluntarily, with great interest in the test outcomes. Age and gender were taken into account in sample selection.

2.1. Measures and Research Instrument

The questionnaire consisted of 19 questions. The general demographic section consisted of 5 questions, while the section related to the research subject consisted of 14 questions. The instrument for collecting data from respondents in this study was an adapted and shortened version of the Emotional Competence Inventory (ECI).

The Emotional Competence Inventory (ECI), which originally included four dimensions of emotion-based behavior—self-awareness, self-management, social awareness, and social skills—served as a basis for our research, explaining self-awareness (arising from emotional awareness, self-assessment, and self-confidence items) and self-regulation (attitudes toward changes arising from self-assessment items) for initiating or managing change [20]. Boyatzis, Goleman, and Rhee consider the ECI questionnaire to be based on competencies that measure emotional intelligence [21].

Further, the development of questionnaire measures was operationalized in accordance with relevant literature recommendations [21]. Therefore, measures with substantial theoretical backbone and previous empirical validation were included to constitute the research dimensions of this study. Then, a face validity check was conducted by a group of Faculty professors. Due to linguistic differences between English and Serbian vocabulary, and with the professors' recommendations, minor corrections were made. For the purpose of a pilot test, minor groups of students were selected to assess the questionnaire. Generally, the questionnaire items were understandable, and there were no major complaints related to the meaning or clarity of the written text [22]. Finally, to acquire respondents' subjective estimates, a five-point Likert-type scale was used, with agreement degrees ranging from "completely agree" to "strongly disagree". After that, the questionnaire was administrated to responders in their classrooms.

2.2. Research Sample and Data Collection

As mentioned earlier, the study included 338 respondents comprising a random sample with the share of male respondents being approximately twice that of female respondents (68.6% vis-à-vis 31.4%). The majority of respondents were approximately the same age—19 (66%), 18 (24.6%), or 20 (9.5%). The sample consisted of first-year students from the following departments: Electrical Engineering (29.73%), Industrial Engineering and Management (20.62%), Transportation (17.43%), Mechanical Engineering (12.87%), Civil Engineering (12.19%), Mechatronics (5.69%), and Environmental Protection (1.48%). Questionnaires were filled in during the breaks between lectures, and students were free to choose whether they wanted to participate in the research.

For the purpose of this study, students from three different regions were included in the sampling design. Most of the responses were from Vojvodina (255, or 75.4%), with the minority of cases from south Serbia (53, or 15.7%) or Serb Republic (30, or 8.9%). When it comes to sample structure by age, for the age of 18, there were 83 respondents (24.6%); for the age of 19, there were 223 respondents (66%); and for the age of 20, there were 32 respondents (9.5%). By achievement in schools, the sample structure was Excellent, 178 students (52.7%); Very Good, 55 students (16.3%); and Good, 105 students (31.1%).

3. Results

3.1. Results of Reliability and Validity Tests

Even though the questionnaire was developed on the premise of previous literature and studies, still, reliability and validity tests were conducted to confirm its factor structure. This was done because, to the best of authors' knowledge, previous similar studies in the context of the research population were rather scarce. Hence, it was necessary to conduct empirical validation of the measures used within the questionnaire.

First, the reliability of the research instrument was tested using Cronbach's α . Accordingly, the α coefficient should be at least 0.7 [23]. All the factors met this criterion (Table 1). Further, the validity was assessed by confirmatory factor analysis (CFA). For this purpose, the average variance extracted (AVE), maximum shared variance (MSV), and average shared variance (ASV) were calculated [24]. Accordingly, if Cronbach's α is greater than the AVE and the AVE is above 0.5, convergent validity is established [24]. Also, discriminant validity is established if the MSV and ASV are lower than the AVE, which was the case for all constructs [24]. This is shown in Table 1.

Table 1. Cronbach's α , values of AVE, MSV, and ASV, and correlation coefficients.

Factor	No. of Items	Standardized Factor Loadings	α	AVE	MSV	ASV	1	2	3
1 Self-regulation	5	0.763 *–0.834 *	0.896	0.621	0.465	0.370	1		
2 Self-awareness	5	0.669 *–0.780 *	0.854	0.540	0.465	0.410	0.682 **	1	
3 Attitude towards changes	4	0.662 *–0.871 *	0.863	0.601	0.355	0.315	0.525 **	0.596 **	1

AVE, average variance extracted; MSV, maximum shared variance; ASV, average shared variance; α , Cronbach's α ,

* Standardized factor loadings significant at 0.01, ** Correlation between constructs (significant at 0.01).

Additionally, factor loadings for each item should be at least 0.65–0.7 and statistically significant ($p < 0.05$) [24]. Empirical validation of the model showed that all of the factor loading coefficients of manifest variables with presumed factors were statistically significant. Moreover, the lowest and highest values of the factor loading coefficient were 0.662 and 0.871, respectively. Therefore, it can be said that the manifest variables build their presumed factors well, and the CFA solution was adopted as satisfactory and acceptable [24].

3.2. Descriptive Statistics

Self-regulation had an average score of 0.814, self-awareness had an average score of 0.839, and change ratio had an average score of 0.846, out of 1000 as the highest possible rating. The central value according to the processed data is 44.952, while the standard deviation is 50.374 and the median is 45.

3.3. Common Method Bias (CMB) Analysis

Since the responses were collected from a single site and predictor and criterion variables were provided by the same person without introducing time-lag between those two, it was necessary to test the CFA model for potential common method bias (CMB). Thus, Harman's test with a single-factor unrotated solution was analyzed [25]. The results show that the greatest part of the variance is not explained with one general factor (eigenvalue = 6.765, 48% of variance explained). Further, a single-factor solution was also checked by confirmatory factor analysis.

3.4. Structural Model

The structural equation model (Structural Equation Modelling) fit was analyzed based on several coefficients, following the recommendations of several authors [25–28]. The values of fit indices show that the hypothesized model is adequate [28]. This is shown in Table 2.

Table 2. The fit of the structural model.

Statistic of Model Fit	Structural Model	Recommended Coefficient Values
χ^2	122.873	the lower, the better ^{a,c}
Df	72	-
$\chi^2/(df)$	1.707	<2.0–3.0 ^{a,c}
RMSEA	0.046	<0.08 ^{a,c,d}
PCFI	0.776	>0.50 ^b
PNFI	0.755	>0.50 ^b
GFI	0.952	>0.90–0.95 ^{a,c,d}
CFI	0.980	>0.90–0.95 ^{a,c,d}
TLI	0.975	>0.90–0.95 ^{a,c,d}
IFI	0.980	>0.90–0.95 ^{a,c,d}

^a Kline (2005), ^b Mulaik et al. (1989), ^c Sun (2005), ^d Hu and Bentler (1999). df, degrees of freedom; RMSEA, root-mean-square error of approximation; CFI, comparative fit index; PCFI, parsimony adjustment to the CFI; PNFI, parsimony adjustment to the NFI (Normed Fit Index); GFI, goodness of fit index.

Additionally, the normality of manifest variables was examined. All of the values were under the literature recommendations [27,28]. Hence, kurtosis values did not exceed the recommended values (kurtosis = 0.508, <8, skewness = −0.189, <3). Thus, it could be said that normality was not the issue.

The research results indicated the possibility of considering the problem through modeling, which resulted in the model presented in Figure 1.

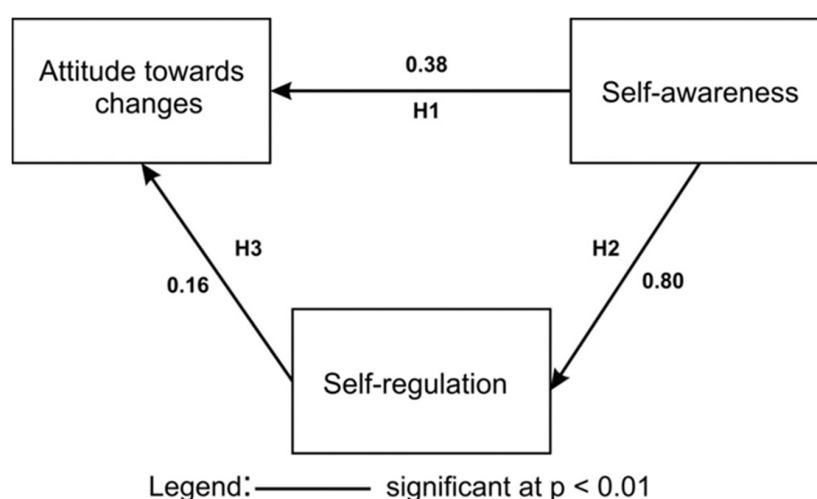


Figure 1. Empirically confirmed research model.

Mediation of the factor of self-regulation between self-awareness and attitude towards changes was tested based on the recommendations provided, using the bootstrapping method on 5000 subsamples and a 95% confidence level. The results of mediation are shown in Table 3.

Table 3. Mediation results of two-tailed significance of direct and indirect effects, at 95% confidence.

Effect from	To	Direct Effects	Indirect Effects	Total Effects
Self-awareness	Self-regulation	0.793 *	-	0.793 *
Self-awareness	Attitude towards changes	0.510 *	0.128 **	0.510 *
Self-regulation	Attitude towards changes	0.379 *	-	0.379 *

Note: Structural Coefficients; * $p < 0.01$; ** $p < 0.05$.

Self-regulation suggests that individuals consciously attempt to control their own behavior in an effort to mediate outcomes, so self-regulation abilities could potentially facilitate the aspects of the behavior change process. In conjunction with self-awareness, motivation, empathy, and social skills, self-regulation is a central component of emotional intelligence [29].

Self-regulated learning is a process of self-regulation, such as perceptions of self-efficacy, which is considered in this study further on, and involves the adoption of strategies aimed at optimizing such processes, such as, setting intermediate objectives or the intrinsic task itself. Regulation contributes to successful mediation between oneself and others, and it has proved necessary to develop and stimulate self-centered processes, by which mental abilities can be transformed into skills related to certain activities [30].

The results suggest that self-regulation is a significant factor of mediation between self-awareness and attitude towards changes, and that self-awareness, in addition to its direct effects on attitude towards changes, also has a significant indirect effect through self-regulation, so there is a partial mediation.

4. Discussion

Correlation between self-awareness and attitudes towards change can be considered a logical connection, and a mediating role of self-control gives the relationship a cognitive sense. Attitudes towards change are the basis of personality development and are one of the main factors of personal dynamics, which is an important indicator of leadership potential, as obtained in the research. The results are consistent with the theoretical assumptions of Salovey and Mayer, according to which one of the roles of emotions is to increase the motivation to solve problems that require rational reasoning. The theoretical model of self-control [31] highlights several important aspects of the social dimension of self-control. Identifying these aspects is important for initial self-confidence, connecting with others,

and social interaction that contributes to improving self-discipline. Also, the results of some theoretical approaches to the study of emotional intelligence indicate the possibility of better understanding and perhaps future improvement of cognitive tasks [32–34]. The role of emotional intelligence in the relationship between cognitive ability and academic performance shows that students with high emotional intelligence are less likely to have future unjustified absences or expulsions from school. The main characteristics of emotional intelligences can essentially be summarized as a link between self-perceived abilities and emotion-related dispositions [35,36]. In their study from 2002 [37], it was found that managers with higher emotional competence scores, as measured by the ECI questionnaire, received higher marks in other employees' evaluations of them. The need for a more comprehensive approach to students' success and behavior during their studies has directed researchers to research certain psychosocial indicators, such as self-efficacy, emotions, belonging, and well-being, which are associated with student engagement and success [38]. Zimmerman, in his research, questioned how self-regulated learning depends on the social and physical parameters of the environment and how students can acquire self-regulatory skills during the learning process. The results showed that the formation of specific strategies or responses that occur as a result of self-regulatory learning requires serious preparation and time [39]. Our the results of this study showed that the dimensions of emotional intelligence exist in the surveyed respondents, and the correlation between them is statistically significant, which confirms the proposed hypotheses. The result that stands out is that the dimension of self-control has a mediating role between the dimensions of self-awareness and attitude towards change, therefore the development of investigated dimensions should be further researched. From a methodological point of view, it is very difficult to compare the results of our research herein with those of similar research in different cultural and economic conditions.

5. Conclusions

As indicated by the results, self-regulation and attitude towards change (both directly and indirectly through self-regulation) are positively affected by self-awareness, while attitude toward changes is positively affected by self-regulation.

However, not all studies positively assessed the importance of emotional intelligence. Some shortcomings are recognized in the concept of emotional intelligence, such as the variability of the concept, certain contradictions in the definition, and ambiguity in interpretation [40], but undoubtedly, the concept of emotional intelligence has lately proved useful in analyzing employees and their effects in business. In any case, engineering education, too, in modern working conditions implies the adoption of diverse knowledge and skills that would contribute to a better understanding of problems in engineering work [41], selection of investment strategies, and application of new technology [42].

One of the basic assumptions of self-directed learning is emotional intelligence, which includes the ability to regulate one's own emotions and create positive emotions. Results have shown that emotional intelligence has an impact on independent learning and is associated with student satisfaction with studying [43].

Students with clear knowledge of their own emotions are able to regulate feelings and emotions and use them in personality development. They are also able to concentrate on solving problems, which contributes to an increase in cognitive abilities. Concepts of business models and their various characteristics play a major role in the service economy, for which personal characteristics are also important [44]. The new employee profiles for Industry 4.0 require greater effort from educational institutions related to the development of the personal characteristics of employees.

Consequently, it is suggested to incorporate knowledge and research of emotional intelligence into official curricula [45]. The shortcomings of our this research are reflected through the choice of theoretical basis of the paper, the choice of questionnaire, and the sample, which could (and should) be overcome in future research. Personal development must take place within formal education because the development of value and personal integrity is one of the preconditions in sustainability programming.

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