

Factors influencing the engineering career aspirations of 15-year-old students

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ABSTRACT: This article presents the outcomes of an investigation to identify factors that inspire young people to pursue careers in engineering. In order to increase interest in engineering careers, it is necessary to know the factors on the basis of which young people decide to continue their education after completing elementary school. The study started from the existing social cognitive career theory (SCCT), which was developed further. Based on a sample of 779 students in the last grade of elementary school, the most important factors influencing career choice were identified as: *enjoyment of work* and *ability to work in a group*. Using regression analysis, it was found that the factor: *I will enter the profession as soon as possible* has a statistically significant influence on the choice of engineering professions, regardless of the level of education required, while the choice of an engineering profession requiring higher education is most strongly influenced by the factor: *the work takes place in a clean environment* and factors related to mentally demanding work and challenges. The results obtained revealed false stereotypes about engineering professions that need to be broken.

INTRODUCTION

The shortage of engineers and technical personnel (ETP) is a global problem [1] that must somehow be solved. To increase the number of ETP in democratic societies, it is not enough to raise public awareness of the problem or to delegate the solutions only to the education sector, families and employers. Due to the complexity of the problem, solutions need to be found by all stakeholders, such as international organisations, civil society, industry, chambers of commerce, the education sector, academic institutions, national governments, etc, who have the power to take evidence-based action to encourage enough young people to follow an educational path leading to ETP-related professions or other professions, where a shortage is foreseeable. At different points in their lives, young people have to make difficult decisions about their sometimes lifelong careers. However, their choices do not always match the problems faced by employers and society. Therefore, guidance and the removal of obstacles on the way to the goals desired by society should be a top priority. It is, therefore, in everyone's interest to know which factors should be addressed to steer young people towards engineering careers, and by whom, because not all tasks can be delegated to schools or left to a laissez-faire approach.

Career aspirations and decisions have always been of interest to researchers, but not equally along the entire educational path. As actual employment is still a long way off for most children in elementary school [2], most research focuses on the transition from secondary school to higher education and later during employment. Examples of studies on career aspirations leading to ETP occupations at the transition level between high school and university education are numerous [3-7]. Many of the studies also deal with gender differences in interest in engineering professions [8][9], which is by no means negligible, however, it is not the focus of the present study.

Young people's career aspirations change as they grow up [10], and one of the most important decisions for them should be made during the transition from elementary school (which is compulsory in most countries) to elective upper secondary school. Therefore, the study presented in this article involved an investigation of career-related opinions of students important in their career choice. The students were in the (last) 9th grade of Slovenian compulsory elementary school and were mostly 15 years old.

In the last grade, school students are probably facing the most important career decision of their life because they should make a decision about the beginning of their professional career. At this point, they have three possible options. Each student can: 1) drop out of formal education; 2) continue their education in an upper secondary school or vocational school; and 3) continue their education in high school, which allows them to postpone the decision about choosing a career in a specific entrepreneurial field or to fulfil their already known ambitions of obtaining a university degree. This decision can shape a person for life, as the career path taken at that point does not usually change significantly over the course of a lifetime [11].

According to social cognitive career theory, the most important factors influencing career choice behaviour are *outcome expectations*, *career interests* and *career self-efficacy* [12]. Gray and O'Brien later added the factors *achievement aspirations* and *educational aspirations* [13]. However, much of the variance remains unexplained, so the authors proposed an extended instrument in which they added Gray and O'Brien's constructs [13], Ajzen's *subjective norm* and *behavioural control* constructs [14], Liao et al's *attitudes* and *self-efficacy* constructs [15], and a factor from Šorgo et al [4] to Lent's model [12]. The constructs from Ajzen [14] and Liao [15] were not primarily developed for career choice research, so the authors adopted the items for career aspirations.

Therefore, with the means of descriptive statistics, principal component analysis (PCA) and multiple regression, the aim was to explore:

- the preferences of 15-year-old elementary school students for technical, technological and engineering careers, based on the required level of education (Table 1);
- the identification of factors (components) that influence, to a greater or lesser extent, the career preferences of 15-year-old students who opt for upper secondary education (Table 2); and
- the identification of factors (opinions) that are statistically significant predictors of 15-year-old students' career preferences in the fields of technics, technology and engineering, depending on the required level of education (Table 3).

METHODOLOGY

The opinions of 779 students of the (last) 9th grade of Slovenian compulsory elementary school (15-year-old students) were considered. The instrument used in this study consisted of two parts: 1) career preferences; and 2) factors that are important for students when choosing a career. In the first part, the students were asked about their career preferences in the fields of technics, technology and engineering, with all occupations classified according to their level of education. The response format was a 7-point scale in a range between *I do not want to do this at all* - 1 to *I really want to do this* - 7 and the additional choice *I do not know the profession*. In the second part, the authors asked for 26 items that might influence their career decisions. The response format was a 7-point scale ranging from *not true at all* - 1 to *completely true* - 7. The factors were adapted from previous studies [4][12-15].

Statistical Analyses

The items regarding the choice of factors that may or may not represent preferences related to technics, technology and engineering careers (Table 2) were analysed in the first phase using descriptive statistics. Means, standard deviations, median and mode were calculated to identify measures of central tendencies (Table 2). Tables with frequencies and primary data are available to interested parties on request from the authors.

In the second, exploratory phase, all items listed (N = 769) were subjected to PCA with direct oblimin rotation. The PCA was chosen to extract the components with which the authors could explain the maximum variance. The other option was confirmatory factor analysis (CFA) according to theoretical constructs from different theories [4][12-15]; however, this option was not chosen. The Kaiser-Meyer-Olkin (KMO) and Barlett's tests were performed prior to PCA, which allowed for further analysis. Cronbach's alpha was chosen to investigate the reliability of the extracted components. Parallel analysis [16] was an option to decide on the number of components to keep. In the third phase, multiple regressions (Table 3) were conducted with the predictor variables listed in Table 2, and the outcome variables listed in Table 1.

RESULTS

Results are provided in three tables as follows.

Table 1: Descriptive data on preferences for technical, technological and engineering careers, based on the required level of education (Cronbach's alpha: 0.76).

Required level of education	N	M	SD
University	746	4.3	2.1
Upper secondary or vocational	737	3.8	1.9
Lower secondary	726	3.4	1.8

Table 2: Factors that are important for students when choosing a career (N = 769, Cronbach's alpha = 0.86), sorted by mean value - descending. The table contains all items from the second part of the instrument.

I will choose a profession ... (construct/source of a factor)	M	SD	Me	Mo	PC1	PC2	PC3	PC4	PC5	PC6	PC7
... which requires group work [12]	6.4	1.0	7	7		-0.86					
... which I will enjoy [15]	6.3	1.0	7	7		-0.86					
... which will fulfil my life's ambitions [12]	5.6	1.3	6	7		-0.49					

... which offers challenges [12]	5.6	1.2	6	5		-0.47					
... which is well paid [14]	5.5	1.3	5	5				-0.70			
... which offers sufficient quality employment opportunities [14]	5.5	1.3	5	5				-0.70			
... with which I will help others [15]	5.4	1.4	5	7							0.59
... in which I will invest extra energy in further development [13]	5.4	1.3	5	5	0.46						
... for which I am willing to study hard [13]	5.4	1.5	5	7							
... which takes place in a clean environment [14]	5.1	1.4	5	5				-0.69			
... in which I will have to constantly improve myself [13]	5.1	1.4	5	5	0.56						
... for which I can easily complete the necessary training [12]	5.0	1.5	5	5			0.67				
... of which the people I respect have a good opinion [14]	4.9	1.6	5	5	0.42		0.41				
... which requires group work [12]	4.8	1.4	5	5					0.51		
... which is mentally challenging [15]	4.7	1.5	5	4a	0.71						
... which will enhance my reputation [14]	4.6	1.6	5	5	0.48						
... which offers employment in the hometown [14]	4.6	1.7	5	4			0.54				
... which will allow for much travel [14]	4.4	1.6	4	4							-0.52
... which requires special talents [15]	4.4	1.5	4	4	0.66						
... in which I will lead other employees [13]	4.4	1.5	4	4							0.86
... in which I will teach other employees [13]	4.3	1.5	4	4							0.89
... which I will take up as soon as possible [4]	4.0	1.6	4	4			0.69				
... which is performed outdoors [14]	3.9	1.6	4	4					0.79		
... which is physically demanding [15]	3.9	1.6	4	4					0.59		
... which will make me famous [14]	3.4	1.7	3	4							-0.60
... which others have advised me [14]	3.1	1.7	3	1							
% Variance					23.7	9.1	7.2	6.1	5.2	4.5	3.9
Eigenvalue					6.2	2.4	1.9	1.6	1.3	1.2	1.0
Cronbach's alpha					0.76	0.78	0.58	0.65	0.55	0.76	0.32

Note: Deleted items and components are coloured grey

Based on the criteria of the eigenvalue > 1 , seven components were extracted that explain about 60% of the variance. By applying a more rigorous parallel analysis [16], five components explaining 51% of the variance were retained (see PC1 - PC 5 in Table 2). It can be seen that Cronbach's alphas of three components are above the value of 0.7, which calls for the probable deletion of some items in the remaining components or the recognition that the factors influencing career aspirations are very diverse.

All the items listed in Table 2 were used as predictors for technical, technological and engineering careers. Careers in tertiary education were predicted by $R^2 = 0.13$, $F(26, 769) = 4.12$, $p < 0.001$; careers in upper secondary education were predicted by $R^2 = 0.14$, $F(26, 769) = 4.31$, $p < 0.001$, and careers in lower secondary education were predicted by $R^2 = 0.16$, $F(26, 769) = 5.07$, $p < 0.001$.

Table 3: *P*-values of items representing opinions that are statistically significant predictors of technical, technological and engineering occupations, according to the level of education required (UNI - tertiary level, USE - upper secondary level and LSE - lower secondary level).

I will choose a profession ...	<i>p</i> (UNI)	<i>p</i> (USE)	<i>p</i> (LSE)
... which I will take up as soon as possible	0.028	0.048	0.001
... which is physically demanding	0.773	0.002	< 0.001

... which takes place in a clean environment	<i>0.003</i>	<i>0.006</i>	0.144
... which is mentally challenging	< <i>0.001</i>	0.606	0.796
... with which I will help others	<i>0.001</i>	0.295	0.059
... for which I am willing to study hard	0.140	<i>0.005</i>	0.064
... which offers sufficient quality employment opportunities	<i>0.007</i>	0.338	0.273
... which is performed outdoors	0.095	<i>0.009</i>	0.104
... which others have advised me	0.913	0.749	<i>0.014</i>
... which will fulfil my life's ambitions	0.076	<i>0.023</i>	0.085
... in which I will lead other employees	<i>0.052</i>	0.369	0.461

Note: Statistically significant results are in italic

DISCUSSION AND CONCLUSIONS

Interpretations of the results and conclusions can be made on three levels as follows.

The first level is based on item analysis based on mean scores (Table 1 and Table 2). Table 1 shows that preferences for technical, technological and engineering occupations are low. However, there is a difference between the occupations in terms of the level of education required in favour of university education, the only mean value which is slightly above neutral.

According to the decreasing mean values in Table 2, the highest perceived reason for career attractiveness is fun and group work, followed by two items denoting ambition and challenges (the difference between the first two and the two following is $d = 0.6$, which can be recognised as a medium effect in Cohen's sense). At the bottom of the list is an item about the importance of advice from others, with both median (3) and mode (1) below the neutral median, followed by an item about celebrity status. Given the nature of many technical and technological occupations, it is unfortunate (especially if less education is required) that working outdoors and doing physically demanding work suppresses career ambitions.

The second level of conclusions can be formed on the basis of the PCA. The first component includes (23.7%) three items (mentally challenging, requires special talents and needs constant improvement) with factor loadings above 0.5 and slightly above the neutral position of the mean.

The third level is based on a regression analysis. The interpretation of the results of the three regression analyses is as follows. Of the 26 items included in the regression analysis, only eleven items have a predictive power $p < 0.05$ levels. Among them, only one item: *a profession which I will take up as soon as possible* is a predictor in all three regressed levels, with the most significant value for occupations requiring only the lowest level of education.

The item about occupation being physically demanding is the strongest predictor for the lower secondary level of education and slightly weaker for the upper secondary (and vocational) level of education, but not for the tertiary level of education. On the other hand, the next item that predicts careers at two levels (UNI and USE) is *clean working conditions*.

In addition to the two mentioned, UNI is predicted by the items: *which is mentally challenging*, < 0.001; *where I will help others*, 0.001; *which provides sufficient quality employment opportunities*, 0.007; and *where I will lead other employees*, 0.052. On the other hand, unique predictors of USE are: *for which I am willing to study hard*, 0.005; *which is pursued outdoors*, 0.009; and *which will fulfil my life goals*, 0.023. For LSE, the unique predictor is *which others have advised me to do*, 0.014.

In the present study, the factors that were found to influence the career aspirations in engineering professions of 15-year-old students after completing lower elementary school differ significantly from the factors identified at a secondary educational level by other researchers [5-7].

The three most important factors identified in a sample of 624, 19-year-old students in their final year of general high school were self-interest, employability and school grades [5]. Research on the same sample confirmed that career aspirations were explained by out-of-school-generated opinions on technical topics and not by school-related factors [7]. The results of the study to investigate the influence of teachers, parents and friends on STEM interests and career choice intention among 230 secondary school students in Malaysia showed that parents had a significant influence on both students' STEM interests and career choice intention, while teachers did not [6].

The only discovery that the current research on a sample of 15-year-olds has in common with the studies on samples of 19-year-olds [5-7] is that the choice of STEM occupations is not influenced by school-related factors (such as the content of the technical school course or related school experiences). This finding strengthens the awareness that the promotion of technical professions must take place outside the school walls.

Proposed solutions

Based on the conclusions, the authors suggest that to increase the attractiveness of technical, technological and engineering professions, action should not be left exclusively to the school system or families. The authors also recognise that there are many personal factors that are perceived as important and that schools cannot change. However, schools can help to break the stereotypes that apply to technical, technological and engineering professions.

Limitations of the Study

The problem addressed in this article is very broad and consequently requires an extensive questionnaire to find solutions. Students at the age of 15 hardly maintain the concentration and motivation to seriously complete the questionnaire to the end. The number of factors included in the questionnaire is therefore limited and as such does not allow for exploration of all the factors that could potentially be important.

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