Longitudinal research of motivation for mechanical engineering study at the University of Zagreb

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ABSTRACT: The recent Croatian societal turn towards economic development based more on engineering and other science and technology fields encouraged an increase of enrolment quotas in engineering academic study programmes. Since previous Croatian research findings have indicated stable predominance of intrinsic motivation in Croatian students to enrol in engineering study, this article analyses possible changes in motivational structure at a time when Croatia was exhausted by a prolonged economic recession. The article is based on the findings of a longitudinal survey conducted with mechanical engineering students at the University of Zagreb in three consecutive years (2013-2015). The persistence of intrinsic motivation is singled out as a stable factor, mostly through general interest in the field of science and technology, notwithstanding job, pay and career being of important concern. Additionally, the structure of motivational factors seems to be significantly gendered. On the other hand, findings, which deal with variables of a family's educational features and household revenues seem to be mixed.

INTRODUCTION

Reports on the declining interest of young people to enrol in STEM academic programmes at the beginning of the 21th Century encouraged a real tide in research interest in corresponding students' motivational factors to study engineering and similar programmes [1]. The main insights can be covered through two topics, which refer to the most important features of the engineering profession and engineering study.

The first topic has connected variations of students' interest in engineering with the fluctuations in the socio-economic context of late industrial societies [1]. It was shown that the late 20th Century de-industrialisation, combined with an unstable and unpredictable job market, the rising precarious character of employment and a corresponding uncertainty of individuals' professional careers, could be considered to be a discouraging environment in which young people are less likely to enrol in engineering study programmes. However, it was also found that the beginning of the economic crisis in the 2000s and a clearly expressed orientation towards re-industrialisation, in combination with an intensified technological nature of late industrial societies, could mark a shift in a stagnating interest in engineering. It should be stated that most of these elements were anticipated in social theoretical literature much earlier [2].

As to the second topic, among the most discouraging features of existing engineering academic study programmes, research reports singled out an excessive focus on scientific abstraction and a corresponding disciplinary exclusiveness of the programmes, which resulted in obstacles in understanding engineering as a form of social conduct [1]. As in the previous case, theoretical and research insights indicated these features to be problematic even as early as the 1980s and 1990s [3-5]. For example, Bucciarelli and Kuhn stated that *...aspiring engineers' first year or so at university is mainly spent taking mathematics and science courses. These are typically taught in authoritarian ways, with the apparent intent of getting students to think, speak and act in terms of the theories and methods dispensed. The authority and hierarchy of knowledge presented are rarely open to question* [4]. Similarly, Johnston et al found that *…there can be little doubt that engineering education had become captive to the dominance of a discourse of engineering science, losing touch with the social context of engineering* [6]. Most of these remarks have been echoed in the 2008 OECD report on students' interest in science and technology and were covered mostly in curricular terms [1].

Thereafter, numerous research studies have focused on the motivational structure of engineering students. In a systematic review of the literature which, in one way or another, considered motivation of engineering students, Brown et al have selected more than 70 articles within the time frame of 2009-2012. Although most of the articles covered in their review focus on particular aspects of students' engagement in an ongoing learning process, a smaller number of articles, which deal strictly with motivation in enrolment in engineering studies, indicated socialisers' influence, interest in the field, as well as working autonomy, security, wages and social position, etc, as the most important

influencing factors [7]. This corresponds to some degree with the authors' own review of related research [8-11]. However, one of Brown et al key findings regarding reviewed articles points to an inconsistent use of motivation frameworks and relatively theoretically poor understanding of students' motivation to enter engineering study [7].

RESEARCH OBJECTIVES

The main objective of the present study is to analyse elements of extrinsic and intrinsic motivation used in the survey conducted with first semester students in undergraduate study in the Faculty of Mechanical Engineering and Naval Architecture (FAMENA) at the University of Zagreb. The survey covered three generations of freshmen in the time period 2013-2015, when the Croatian economy was deeply exhausted by a prolonged recession, and during which suggestions for the strengthening of science and engineering perspectives in higher education were strongly established, sometimes as a comprehensive remedy [12]. Enrolment quotas in the Faculty have been rising annually and are regularly filled by new students - contrary to the years before economic recession.

Additionally, in regard to the importance of social context in examining extrinsic and intrinsic motivation, the present research considers this subject not strictly in terms of the immediate social setting in the Faculty, but more in terms of gender, household income and parental education as selected students' sociodemographic features. Finally, given that previous research implied a predominance of intrinsic motivation in young people's enrolment in engineering studies in Croatia [13-14], the authors' intention was to see whether this kind of motivation was sustained in times of economic crisis, paired with a promotion of engineering as lucrative profession at the societal level or was it simultaneously accompanied or even overshadowed, by elements of extrinsic motivation.

THEORETICAL BACKGROUND

Extrinsic and intrinsic motivation represent two broad orientations, which rely on differentiating decisions to enrol in engineering studies based on whether they are made on generally utilitarian terms, be they understood in terms of financial issues, career, social status and the like or whether they are based primarily on a personal interest in the field of science of technology and corresponding motivators. These concepts are not only a long-standing theoretical stream, established mostly through psychological research in the field of education [15], but are also highly debated and updated since theoretical models, such as the self-determination theory, the expectancy theory or the theory of value assignment, differ in research goals, methodology, target population, sample and setting [16].

Furthermore, the relationship between extrinsic and intrinsic motivation seems to be more complex than their ideal-typed, antagonistic conceptualisation would imply. Thus, for example, the self-determination theory [17][18], in which elements of choice were introduced as regulatory process of someone's behaviour, outlines the extrinsic and intrinsic motivations in terms of a continuum in which each variant indicates a different level of transformation from external contingencies into agency regulated by internal processes. Adjacent variants of extrinsic motivation differ in nuances. Moreover, the most sophisticated type of extrinsic motivation - integrated motivation - comes close to intrinsic motivation for the differences between the two are sometimes not clear at the sight.

However, even then, extrinsic and intrinsic motivation differ from each other depending on the kind of stimulus for an activity. Intrinsically motivated individuals would engage with an activity for their sheer interest its corresponding sense of enjoyment. They do so …*freely, with a full sense of volition and without the necessity of material rewards or constraints* [18]. On the other hand, extrinsic motivation represents an activity determined primarily by external and utilitarian goals, be it attainment, reward, success, etc. In essence, extrinsic motivation indicates behaviour which is assumed to be *instrumental for some separable consequence*. In short, intrinsic and extrinsic motivation represent two general orientations, although the former is conceptualised almost in its ideal-type form, and the latter involves a number of variations. Therefore, extrinsic and intrinsic motivation continue to present important factors which, in an implied mutual tension, determine real-life human activities and related decisions.

In regard to other variables covered in terms of extrinsic and intrinsic motivation by the present research, the issue of gender reflects engineering as a predominantly male domain. Since the middle of the 20th Century, numerous initiatives worldwide have been made toward increasing women's representation in engineering studies. Nevertheless, as recent reports suggest, although the number of female students in tertiary education in OECD countries has increased more rapidly than that of males, women still constitute less than 25% of engineering students [1].

In previous research, numerous reasons for this longstanding underrepresentation of women in engineering were considered. Focusing on the USA, Sax et al have summarised these reasons through a number of predictor variables, generating eight stable categories: personal inputs, background characteristics, learning experiences, self-efficacy, outcome expectations, interests, contextual influences and choice goals [19].

On the basis of a comparative literature review, Kolmos et al singled out structural barriers, contradiction in core female and core engineering values, curriculum issues including contextualised content and pedagogical approaches, personal

motivation factors and socio-demographic explanations considered to be influential [20]. In their research on motivational factors behind male and female respondents' choice of enrolling in an engineering education programme, they found intrinsic motivation, social good, financial motivation and parental motivation to be significantly more important for male students than for female students, while mentor motivation turned out to be significantly more important for female students [20]. Within the Croatian educational context, Jugović's research indicated that, although there were no differences between boys and girls when it comes to personal importance and the assessment of their own abilities in physics, significant educational aspirations in selection of future study programme had risen with respect to gender [21].

Since education itself began to be shaped along the lines of token economies with external rewards prevailing over intrinsic motivation to learn and study [16], socioeconomic variables, such as parental education level and household disposable income are shown to be valuable predictors of high-school major choices, as well as college enrolment. In their research, Svoboda et al found significant effects of parental education on high school STEM course taking and college course taking, with children of higher educated parents enrolling in both more often [22]. Such a finding accords with that of numerous other authors showing that …*parents of women engineers have higher educational levels than parents with daughters in other fields* and positively linking parental education to engineering degree completion [23]. Not only is parental educational level important, so is their income, with research showing students from higher income families having better results in mathematics achievement and engineering degree completion [23].

On the other hand, although high family socioeconomic status (SES) does seem to be a positive influence on technical degree achievement, as engineering careers are often defined as lucrative ones, Ma found that …*students coming from lower SES families are more likely to major in technical, business, and life/health fields …considering higher education more as an instrumental means for achieving upward social mobility* [24]. Such a prospect could drive students from lower SES families to enrol more often in engineering and other technical fields, while high SES family students, being financially situated, could see themselves free to pursue the *riskier* fields of humanities and social sciences. As can be seen, although socioeconomic status plays an important part in college enrolment motivation, results can be mixed. While students from high SES families have the financial and cultural capital facilitating their academic success, and giving them freedom to be intrinsically motivated to enrol in STEM fields, students from low SES families could be more extrinsically motivated, seeing STEM as their ticket do the upper classes.

SAMPLE AND METHODOLOGY

As aforementioned, this study has had a longitudinal character, surveying freshmen in three consecutive years and gathering a total of 814 responses by implementing a convenience sampling method. The survey, containing 10 statements measuring intrinsic and extrinsic motivation (Table 1) and six sociodemographic variables (gender, high school grade point average (GPA), household income, parental education, professional reproduction and preferred field of study), has been administered during sociology classes, mandatory to all students of the first semester. Intrinsic and extrinsic items were evaluated on a five-point Likert type scale with grades varying from 1 - completely disagree to 5 - completely agree.

Table 1: Motivators averages through the observed years.

I enrolled this study because:	2013	2014	2015	Average
INT - I am primarily interested in the fields of science and technology	4.31	4.46	4.40	4.39
EXT - I want to find a well-paid job	4.07*	3.44	3.52	3.69
INT - When I see device, I immediately want to know how it works	3.63	3.79	3.61	3.67
EXT - I want to advance in my career	3.75*	3.60	3.49	3.61
INT – I would rather deal with devices than with people	3.41	3.22	4.07**	3.60
INT – I have always shown a tendency to fix devices	3.33	3.56	3.72	3.54
EXT - I want to find a job easily	3.41	3.53	3.60	3.51
INT - I love solving mathematic problems	2.99*	3.75	3.63	3.44
EXT - I want a pay above average	3.81*	3.08	3.13	3.35
EXT - Engineers enjoy a high status in society	3.16*	3.38	3.40	3.31

* 2013 is statistically different (p <.05) from 2014 and 2015
** 2015 is statistically different (p <.05) from 2013 and 2014

The respondents were predominantly male (81%), half of them had excellent grades in high school (50%), and FAMENA was their university of choice in 80% of the cases. Almost half of the respondents (44%) came from families that were economically above average (with ~ HRK11.200 (~€1.500)) being the average disposable income for two-income households in the observed years [25]) and had at least one highly educated parent (48% of the cases). Even though there is no frame of reference, it seems professional reproduction (with progenies following the educational footsteps of their parents) is considerably high in the engineering sector with more than a third (34%) of respondents having at least one engineer in their immediate family.

As testing extrinsic and intrinsic motivational factors and their correlation with the social setting of the respondents was this study's main goal, the methodology is mainly focused on descriptive and inferential statistics methods, such as χ^2 tests, *t*-tests for independent samples and ANOVA. Scheffé's method was used as a *post-hoc* comparison since group sizes are most often unequal and Tamhane's T2 method was applied in cases where equal variances could not be assumed. All tests are performed at the statistical value of $p < 0.05$.

THE RESULTS

Somewhat in line with previous research, over the analysed time period, respondents do seem to slightly favour intrinsic over extrinsic motivators, with their choices of enrolment being dictated by a mixture of both (Table 1). While their interest in the fields of science and technology is by far the most prominent motivator and they have an intrinsic need to understand the inner workings of devices, the wish to find a well-paid job, just like having the opportunity to advance in their careers are all extrinsic factors that push respondents to enrol in the engineering field. Although definitely keen on having a successful career, engineering students do not seem to be driven by *fame and fortune*, considering motivators like an above-average pay and enjoying a high status in society (granted by their *engineer* title) neither important nor unimportant factors in deciding their academic path.

Factors of extrinsic and intrinsic motivation do seem to vary in relevance depending on the state of the economy. Analysing motivators by year, it can be clearly seen (Table 1) that during 2013 (in which the number of unemployed culminated [26], somewhat marking the end of the recession) students tended to favour extrinsic over intrinsic motivators. In 2013, two thirds of the statements marked as *somewhat important* were extrinsic motivators, such as finding a well-paid job, having an above average pay or advancing one's career, all the three of which were statistically significantly higher rated when compared to their average of 2014 and 2015. Although not marked as important on average, enjoying high status in society was rated significantly lower in 2013 than in the succeeding years, accentuating the material connotation of the extrinsic factors during the recession, which were much more focused on *liquid* than on *potential* economic assets. The importance of such financial stability is something all respondents have in common throughout the years, regardless of the disposable income of their households, as there are no statistically significant differences between income groups in regard to financial motivators.

As a recurring theme in all social research undertaken in engineering fields, gender differences in motivation to enrol are explored in order to try to understand the reasons, such a low percentage of the student body is comprised of women. Although both genders seem to be generally motivated by the same factors; interests in the fields of science and technology being again the most prominent one, there are three statistically significant differences in the ranking of their motivators. While male students seem to value more a *hands-on* approach, rating statements like curiosity for the inner workings of devices and their previous tendencies to fix them significantly higher, women are significantly more inclined to approach engineering from more of a theoretical point, saying they enjoy solving mathematical problems. Such a difference could be attributed to the significantly higher-grade average female students had at high school, rating on average *excellent*, with their male counterparts being *very good* on average.

Although the differences in motivation are few, students' university of choice differs between genders, with a $\chi 2$ showing that more male students than expected have FAMENA as their first choice, while the opposite holds true for the female students. Such a difference could not be explained by means of professional reproduction, since more female students than expected have engineers in their immediate family, while the opposite is true for male students, indicating more research on gender expectations and structural barriers should be undertaken. On the other hand, while based on literature, one would expect FAMENA to be a primary choice of enrolment in years marked by economic recession, which that does not seem to hold true, with a $\chi 2$ test showing a lack of statistical significance between observed years and changes of university of choice.

Family members seem to influence students' motivation to enrol in other ways though, whereas students with secondary educated parents tend to value extrinsic, career-oriented motivators more than students with tertiary educated parents. Considering the mean results (all higher than those of secondary educated parents), the same would probably be true for students with not formally educated or only primary educated parents. Unfortunately, the number of such respondents is too low for analysis.

Regardless of whether the one to hold a secondary education diploma is the mother or the father, their progenies are statistically more likely to be motivated by the expectation of finding a job easily, finding a well-paid job or even one with an above-average pay. Additionally, students whose mothers are secondary educated are statistically more likely to be motivated by the ability to get promoted quickly, while those whose fathers are secondary educated are statistically more likely to be internally motivated by their interest in the field of science and technology. Such findings seem to uphold a common view of engineers finding jobs easily and being well paid, which could very well motivate students from less educated, and consequentially less financially stable households, (which is corroborated by chi square results on household income and parental education attainment) to enrol in STEM fields, which seem to promise exactly that kind of career.

Contrary to what would be expected, household income does not seem to affect enrolling motivators, with the ANOVA showing no statistically significant differences in neither extrinsic nor intrinsic factors between examined household income groups. The results hold true even when analysed by year, while one would expect respondents coming from lower-income households to be more motivated by extrinsic and materialistic factors during the recession, variabilities in means are not statistically significant. In the last-year cohort, however, respondents differ significantly on two variables: members of average-income households value the possibility of finding a job easily more than those pertaining to the high-income households, additionally, high-income respondents value the status, which comes with being an engineer significantly less than respondents coming from average and below-average income households.

DISCUSSION AND CONCLUSIONS

Since the first objective of the research has been to analyse specific elements of extrinsic and intrinsic motivation in FAMENA students for three consecutive years, findings indicate the interest in the field of science and technology as the most influential intrinsic indicator. This indicator is followed by a combination of other intrinsic and extrinsic variables, indicating that the importance of intrinsic motivation should not overshadow extrinsic motivation, especially since other research emphasised the concurrent importance of both [10].

Overall, highly rated intrinsic variables tend to be more of a practical nature given that focus on working with devices prevailed over a more theoretical interest in mathematics. Nonetheless, the overall value of mathematics is strongly impacted by its low importance in 2013, which increased in the following years allowing attribution of specific findings to the fact that choice of study can be of highly contingent character [8].

Finding a well-paid job, finding it easily and being able to advance one's career represent explicit extrinsically led considerations of enrolment at FAMENA, a well-paid job being of the highest importance, and just next to the intrinsic interest in the field of science and technology. Also, a well-paid job is followed by advances in career in 2013, when the economic crisis in Croatia culminated, resulting in its mean values being significantly higher than in the succeeding years.

Although it would be possible to assume some sort of correlation between all of the extrinsic variables and the societal context of recession, the importance of intrinsic motivation, be it reflected in general or in more of practical inclination toward technological topics, seems persistent and is consistent with the findings in previous research in Croatia [13][14].

Findings also suggest some differences with selected variables of extrinsic and intrinsic motivation and corresponding decisions to enrol in engineering studies being significantly gendered. Female students reported significantly higher interest in mathematics, they come from families with close relatives being engineers more often, and FAMENA is much less their first academic choice. Since female students continue being underrepresented at FAMENA, these findings concur with earlier research on the highly gendered nature of educational and career pathways in Croatia suggesting that, for a large number of high school girls, an inclination towards natural and technical sciences is not a sufficiently valid predictor of their future study enrolment, and has to be strongly supported by family members and other informal and formal socialisers [21].

Finally, exploration of socioeconomic status as a motivational factor seems to add to its variable nature. While Svoboda et al [22], as well as numerous authors cited by the AWE review [23], found that children coming from higher SES families were more successful in both enrolling and obtaining engineering degrees, this study's results seem to uphold Ma's [24] findings, in which it was reported that students from lower SES families (at least when SES is measured in educational attainment) see the field of engineering as a means of vertical mobility, enrolling more often than those of higher SES.

Although finding a lucrative job and finding it as easily as possible were statistically more frequent motivators for students with secondary educated parents, no significant difference between households of differing incomes on those variables was found. Taking into account that $\chi 2$ tests between household income and parental education are significant (with higher educated parents more often pertaining to higher income households), such results could indicate that respondents are differently motivated by specific SES variables, where their parents' educational status impacts on their decisions more than their financial status.

In conclusion, the main limitation of the present study can be seen as the fact that it has been conducted with students of a single engineering faculty, and does not cover other engineering studies in Croatia. Additionally, the structure of motives for enrolment should be upgraded and better understood through qualitative research. However, this being the first longitudinal research on motivation for enrolment in engineering studies in Croatia, and the findings being consistent with corresponding one-time research on student motivation, it could prove to be useful to future researchers. Differences in variants of extrinsic and intrinsic motivation are singled out in some details, which could be verified in new research and noticed by national educational policy makers, given the lack of engineers in upcoming Croatian industrial perspective.

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