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Motivational factors for studying science and engineering in beginning students: the case of academic preparatory programmes

Aharon Gero & Gershon Abraham

Technion - Israel Institute of Technology
Haifa, Israel

ABSTRACT: Academic preparatory programmes offer candidates who did not achieve high enough grades during their secondary education, an opportunity to improve their chances of being accepted by universities and colleges. Using quantitative and qualitative tools, the study described in this article characterised the motivational factors for studying science and engineering among sixty beginning students in an academic preparatory programme in Israel. According to the findings, the students are motivated primarily by interest in studying science and engineering (intrinsic motivation) and by recognition of the value inherent to these studies (identified regulation). Nevertheless, alongside these factors, introjected regulation, according to which some of the students have undertaken these studies in order to fulfil the expectations of those who are important to them or for reasons of personal prestige, also bears considerable weight.

Keywords: Engineering education, academic preparatory programmes, motivation, beginning students

INTRODUCTION

Academic preparatory programmes were first initiated in the 19th Century by colleges in the United States. These institutions began to offer secondary level programmes focusing on core subjects, such as mathematics and English to candidates without a sufficient academic background [1]. Nowadays, similar programmes also exist in Europe [2] and in Israel [3].

The programmes offer an opportunity to improve the chance of being accepted by higher education institutions to candidates who did not obtain sufficiently high achievements during their secondary education. There are numerous academic preparatory programmes in Israel; some are offered by universities and others by colleges. In this article, the authors focus on the programme offered by the Technion - Israel Institute of Technology (hereinafter: *the Technion*), and intended primarily for students interested in studying engineering. In the programme, the students spend two semesters intensively studying secondary level mathematics, physics and English.

Considering the students' weak academic background on one hand and the programme intensity on the other, motivation plays a central role in the learning process in programmes of this kind [4]. Nonetheless, the research literature hardly deals with the motivation of students in academic preparatory programmes interested in studying engineering, but rather focuses on characterising the motivational factors of undergraduate engineering students [5-9] or of high school students engaged in engineering activities [10].

To the best of the authors' knowledge, the study described in this article was the first to characterise the motivational factors for studying science and engineering in beginning students in an academic preparatory programme. The importance of this study is further pinpointed in view of the inadequate literature in the field and considering the ongoing shortage of engineers in Israel and in the Western world [11].

MOTIVATION AND THE SELF-DETERMINATION THEORY

The concept of motivation refers to the individual's desire to invest time and effort in a certain activity, even when it involves difficulties and failures. The research literature offers a diversity of explanations for the processes driving a person to choose a particular behaviour. These explanations focus, *inter alia*, on personality factors [12], behavioural factors [13] or social-cognitive factors [14].

The self-determination theory [15], which served as the theoretical framework for this study, is currently one of the leading motivation theories. According to the self-determination theory, the factors motivating a person's behaviour can be positioned on a continuum. Intrinsic motivation, stemming from the interest and the pleasure a person derives from the behaviour is situated at one end of the continuum, and extrinsic motivation, which includes several types of regulation, is positioned at the other end of the continuum. The most important types of regulation are specified bellow:

- External regulation, which stems from the desire to receive (immediate) compensation for the behaviour or alternatively, from the fear of punishment.
- Introjected regulation, which originates from the desire to fulfil the expectations of people who are important to the individual or by considerations of personal prestige.
- Identified regulation, which stems from the identification of a value (other than interest and pleasure) inherent to the behaviour. The behaviour is the means through which another pleasurable or interesting behaviour is made possible or alternatively, the behaviour has moral value.

According to the self-determination theory, the more intrinsic the sources of the motivational factors - the higher the quality of the individual's motivation. As part of the humanistic approach, the theory claims that it is possible to raise the quality of the individual's motivation by fulfilling three of his or her innate needs [16]:

- The need for autonomy - the need to feel that the behaviour stems from the individual's needs and was not forced upon him or her.
- The need for competence - the need to feel that the individual is capable of achieving challenging goals.
- The need for relatedness - the individual's need to be in touch with others and to be part of a group.

RESEARCH GOAL AND METHODOLOGY

The study was intended to characterise the motivational factors for studying science and engineering in beginning students in an academic preparatory programme.

Sixty students who began their studies in Technion's academic preparatory programme in 2016 took part in the study. On the first day of the programme, the students were asked to fill out an anonymous, closed-ended questionnaire intended to evaluate the motivational factors driving them to choose science and engineering studies. The questionnaire was a five level, Likert-like questionnaire, based on the situational motivation scale (SIMS) [17] and the self-regulation questionnaire - academic (SRQ-A) [18].

The questionnaire included 20 statements, which reflected the four motivational factors mentioned in the previous section. Thus, for example, the statement …*I am interested in studying science and engineering because I think the studies will be interesting…* expresses intrinsic motivation; the statement …*I am interested in studying science and engineering because this will benefit me in the future…* reflects identified regulation; the statement …*I am interested in studying science and engineering because my parents want me to study these subjects…* and the statement …*I am interested in studying science and engineering because I want people to think I am smart…* express introjected regulation; and the statement …*I am interested in studying science and engineering because I have no choice…* represents external regulation. The statements were validated by two experts in engineering education. Cronbach's alphas are given in Table 1 and show good internal consistency.

Table 1: Cronbach's alphas.

Motivation	Regulation	Cronbach's α
Intrinsic		0.84
Extrinsic	Identified	0.80
	Introjected	0.78
	External	0.86

In addition, in order to expand and deepen the information gleaned from the questionnaires, soon after the beginning of the programme, six semi-structured interviews were held with students, in which they were asked about the reasons for them being interested in science and engineering studies.

The quantitative data were statistically analysed. The qualitative findings were categorised by content analysis based on the self-determination theory.

FINDINGS

Figure 1 presents the mean score (between 1 and 5) the academic preparatory programme participants (AP) gave each of the four motivational factors. In addition, the figure also shows the mean score given by outstanding 12th grade high school students majoring in science and engineering (HS). These students filled out the same questionnaire (with the necessary adjustments) as the study participants [10]. One can see a similar distribution in both cases, according to

which intrinsic motivation is the highest of the motivational factors, identified regulation is ranked second, introjected regulation is in the third place and the score for external regulation is the lowest.

Table 2 shows the score (mean *M* and standard deviation *SD*) given by both groups to the various motivational factors. The *t*-tests revealed that there is no significant difference between the two groups regarding the identified regulation and external regulation's scores. On the other hand, there are significant differences between the two groups in intrinsic motivation ($p < 0.05$) and introjected regulation ($p < 0.01$). For intrinsic motivation the negative effect size is medium ($d = -0.47$) and for introjected regulation the positive effect size is large ($d = 0.83$).

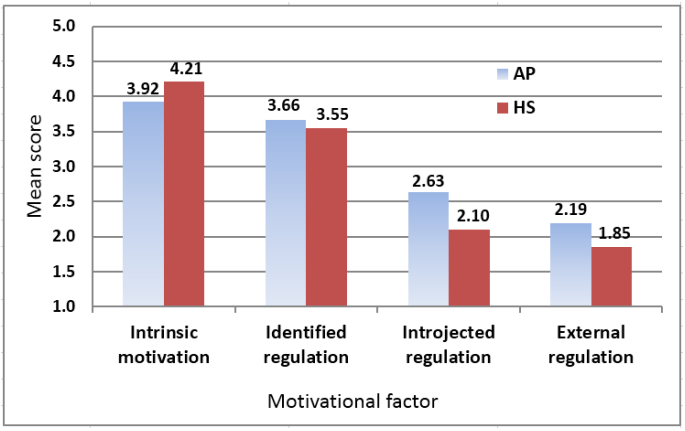

Figure 1: Mean motivational factor scores - academic preparatory programme students (AP) and high school students (HS).

Table 2: Motivational factor scores.

Motivation	Regulation	Group	*M*	*SD*	*p*-value
Intrinsic		AP	3.92	0.63	<0.05
		HS	4.21	0.60	
Extrinsic	Identified	AP	3.66	0.47	n.s.
		HS	3.55	0.78	
	Introjected	AP	2.63	0.62	<0.01
		HS	2.10	0.68	
	External	AP	2.19	0.84	n.s.
		HS	1.85	0.66	

Content analysis of the interviews allows the identification of three out of four motivational factors in the study participants:

- Intrinsic motivation:

  It [science and engineering] *is interesting… I was always attracted to it and it was obvious to me that that is what I wanted to do.*

- Identified regulation:

  [Soon,] *I will reach the age at which I will have to support a family and this* [engineering] *is a field in which one can make a lot of money.*

- Introjected regulation:

  My father is an engineer… my parents have directed me towards this [engineering studies] *for my entire life.*

It should be noted that during the interviews, external regulation was not mentioned as a motivational factor.

DISCUSSION AND CONCLUSIONS

According to the findings, academic preparatory programme students are primarily motivated by interest in studying science and engineering (intrinsic motivation) and by recognition of their inherent value (identified regulation). Nonetheless, alongside these factors introjected regulation, according to which some of the students are studying in order to fulfil the expectations of other people and for considerations of personal prestige, also bears notable weight.

A comparison of the findings to the distribution of motivational factors among outstanding 12th grade students majoring in science and engineering [10] reveals that there is no significant difference between the two groups as far as the

identified regulation and the external regulation scores go; the members of both groups are well aware of the high wages characterising science and engineering professions, and most of them are not interested in these professions for a lack of other options. On the other hand, there is a significant gap in intrinsic motivation between the two groups. This gap, in favour of the latter is characterised by a medium effect size. In addition, there is a significant gap in introjected regulation in favour of the academic preparatory programme students - a gap characterised by a large effect size. These gaps could possibly be explained by the different backgrounds of the members of the two groups.

While the high school students are outstanding students engaged in engineering, the students in the academic preparatory programme have a weak academic background and have yet to be exposed to engineering studies. It is possible, therefore, that the high school students' exposure to engineering, as opposed to the lack of exposure among the students in the academic preparatory programme, caused the gap between the scores given to intrinsic motivation. It may also be possible that the lack of success the students in the academic preparatory programme experienced in their secondary studies, caused them to attribute greater importance to the expectations of the people close to them or give greater weight to personal prestige considerations - which might explain the gap between the scores for introjected regulation.

Considering the findings, it is important to enhance the intrinsic motivation in the academic preparatory programme students, since the studies in this programme require higher order thinking skills and intrinsic motivation plays a central role at this level of study [19].

The main limitation of the study is the relatively low number of participants. In order to overcome that limitation and with the intention of increasing the trustworthiness of the findings, both qualitative and quantitative tools were put to use.

The contribution of the study is in the characterisation, for the first time to the best of the authors' knowledge, of the motivational factors for studying science and engineering in beginning students in an academic preparatory programme. The importance of this research is further enhanced considering the limited literature in the field and in light of the ongoing lack of engineers in Israel and in the Western world [11]. In future research, the authors intend to monitor possible changes in the students' motivation during the course of their studies in the academic preparatory programme.

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BIOGRAPHIES

Aharon Gero holds a BA in Physics, a BSc in Electrical Engineering, an MSc in Electrical Engineering, and a PhD in Theoretical Physics, all from the Technion - Israel Institute of Technology. In addition, he has an MBA from the University of Haifa, Israel. He is a faculty member at the Department of Education in Technology and Science of the Technion. His research focuses on electrical engineering education and interdisciplinary education that combines physics with electronics, such as electro-optics and microelectronics education.

Gershon Abraham holds a BSc in Biomedical Engineering and a BSc in Technology and Science Education from the Technion - Israel Institute of Technology. He is a graduate student at the Department of Education in Technology and Science of the Technion.