

Training scientists and engineers as science and engineering teachers: the motivational factors of enrolees in the *Views* programme

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ABSTRACT: In view of the shortage of accomplished teachers specialising in teaching mathematics, science and engineering in high schools, the Technion - Israel Institute of Technology, launched a unique programme called *Views*. This two-year programme offers Technion graduates holding degrees in mathematics, science or engineering, an additional BSc degree in science and engineering education with a scholarship to cover tuition costs. Through the use of quantitative and qualitative tools, the study described in this article investigated the factors motivating Technion graduates to enrol in the *Views* programme. Eighty-nine graduates who enrolled in the programme over the 2014-2016 academic years participated in the study. According to the findings, by choosing to enrol in the programme, the graduates placed substantial weight both on intrinsic motivational factors, which reflect an interest in the study of education, and on extrinsic motivational factors (identified regulation), which express the future benefits they expect to derive upon completion studying in the programme.

INTRODUCTION

The ongoing shortage of engineers and scientists characterises many Western countries, including Israel [1][2]. This phenomenon may be partially attributed to the considerable difficulty in recruiting accomplished high school teachers specialising in teaching mathematics, science and engineering. In response to this, in the 2011-2012 academic year, the Technion - Israel Institute of Technology launched a programme called *Views* (Hebrew acronym for engineers/scientists in science and technology education). This two-year programme offers Technion graduates an additional BSc degree in science and engineering education with a full-tuition scholarship, in light of the Technion's social commitment to the community. It is important to emphasise that the programme is offered to Technion graduates with Bachelor degrees in mathematics, science or engineering, as well as to those with more advanced degrees in these fields.

A study characterising graduates of the Department of Computer Science participating in the programme was recently published [3]. Among other things, the study dealt with a qualitative analysis of the factors motivating these graduates to join the programme, and indicated their interest to return to the academic world and acquire an additional profession. The current study focused on a quantitative and qualitative data analysis, based on the self-determination theory [4], of the motivational factors among those enrolled in the programme in the 2014-2016 academic years (including the graduates of the Department of Computer Science mentioned above).

The article opens with a concise review of the self-determination theory. Further, the *Views* programme, the research framework and the main findings are presented. The article concludes with a discussion of the results and the conclusions that arise from them.

MOTIVATION AND THE SELF-DETERMINATION THEORY

According to the self-determination theory, the motivational factors driving an individual to invest resources in certain behaviour are situated on a continuum. Intrinsic motivation, expressed by the interest and pleasure the individual derives from the behaviour, is situated at one end of the spectrum [4].

Extrinsic motivation, situated at the opposite end of the spectrum, includes several types of regulation. For example, external regulation is derived from the hope of receiving an (immediate) reward for the behaviour or, alternatively, from the fear of punishment; introjected regulation originates from the desire to fulfil the expectations of the people who are important to the individual or from considerations of personal prestige; and identified regulation stems from identifying a value (other than interest and pleasure) embedded in the behaviour. The self-determination theory argues that the more the motivation stems from intrinsic factors, the higher its quality is.

The self-determination theory identifies three basic needs among individuals [5]: the need for autonomy is the individual's need to feel the behaviour has not been forced upon him/her; the need for competence is the individual's need to believe he/she is able to successfully uphold challenges he/she is faced with; and the need for relatedness is the individual's need to be accepted as part of a group. According to the theory, the fulfilment of these needs leads the individual to high-quality motivation.

Besides the self-determination theory, other key motivation theories, including the attribution theory of motivation [6] and the self-regulated learning theory [7], have been developed. The self-determination theory was used in the present study, since in its educational context [8], it has been used as the theoretical framework for studies on mathematics education [9][10], science education [11][12] and engineering education [13-15].

THE VIEWS PROGRAMME

As previously stated, the *Views* programme is designed for Technion graduates with degrees in mathematics, science or engineering, and gives those completing the programme an additional BSc degree in science and engineering education in one of the following tracks: mathematics, physics, chemistry, biology, environmental sciences, computer science, electrical engineering and mechanical engineering. Despite the fact that the programme's participants are eligible to a scholarship to cover the full cost of tuition, they are not obligated to work as teachers upon completing the programme. This decision was made in light of the recognition that the knowledge and skills the graduates acquire in the programme would accompany them on their professional path, whatever it maybe, and will contribute to their performance outside the formal educational system too.

The programme is comprised of thirty-six credit points spread over two years, for one day a week (or, alternatively, two half-days a week). This format allows the students participating in the programme to maintain their current jobs. The training is organised on a number of levels: the basic level, shared by all education tracks, focuses on educational psychology and general teaching methods (general pedagogical knowledge [16]); the intermediate level dealing with teaching methods specific to the relevant track, including high-school practicum (pedagogical content knowledge [16]); and the upper level of advanced elective courses in education and/or in the subject matter. As an example, the mandatory courses in the electrical engineering track are presented in Appendix A.

RESEARCH GOAL AND METHODOLOGY

The goal of the study was to characterise factors motivating Technion graduates to participate in the *Views* programme.

The research population included 44 Technion graduates (41% men; 59% women) who started the programme in the 2014-2015 academic year (hereinafter, Group A) and 45 Technion graduates (42% men; 58% women) who started the programme in the 2015-2016 academic year (hereinafter, Group B). The distribution of the education tracks among the participants is given in Table 1.

Table 1: Distribution of the education tracks among the participants.

Education track	Group A (%)	Group B (%)
Mathematics	14	29
Physics	18	15
Chemistry	18	18
Biology	11	16
Environmental sciences	0	4
Computer science	23	4
Electrical engineering	2	7
Mechanical engineering	14	7

The study made use of quantitative tools along with qualitative tools in order to present various aspects of the studied phenomenon and increase the findings' trustworthiness [17].

All the participants were asked to fill out a close-ended questionnaire before they started the programme. This Likert-type questionnaire (five levels) was based on the Situational Motivation Scale (SIMS) questionnaire [18] and the Self-Regulation Questionnaire - Academic (SRQ-A) questionnaire [19].

The questionnaire included 20 statements reflecting the motivational factors mentioned above. Thus, for example, the statement *...I enrolled in the Views programme because of my interest in the study of education*, expresses intrinsic motivation, the statement *...I enrolled in the Views programme because I shall be able to derive benefit from completing the programme*, reflects identified regulation, the statement *...I enrolled in the Views programme because people expect me to study teaching*, reflects introjected regulation, and the statement *...I enrolled in the Views programme because I had no choice*, reflects external regulation. A sample of the statements is presented in Appendix B.

The respondent was asked to state the degree in which each of the statements was relevant to him/her by choosing the most suitable option out of the five following ones: *very relevant*, *relevant*, *not sure*, *not relevant* and *not relevant at all*.

Additionally, prior to onset of studies in the programme, the participants were requested to answer the following open question: ...*Please state the two most significant motives for you when enrolling in the Views programme.*

The quantitative data were statistically analysed and the qualitative data underwent content analysis and were classified into categories. The self-determination theory served as the theoretical framework for the qualitative analysis.

FINDINGS

Figures 1 and 2 present the importance the members of the two groups attributed to the four motivational factors. The weight expresses the percentage of respondents who chose a particular possibility (among the five possible options stated above) for a given motivational factor, so the sum of the five weights for each motivational factor equals one.

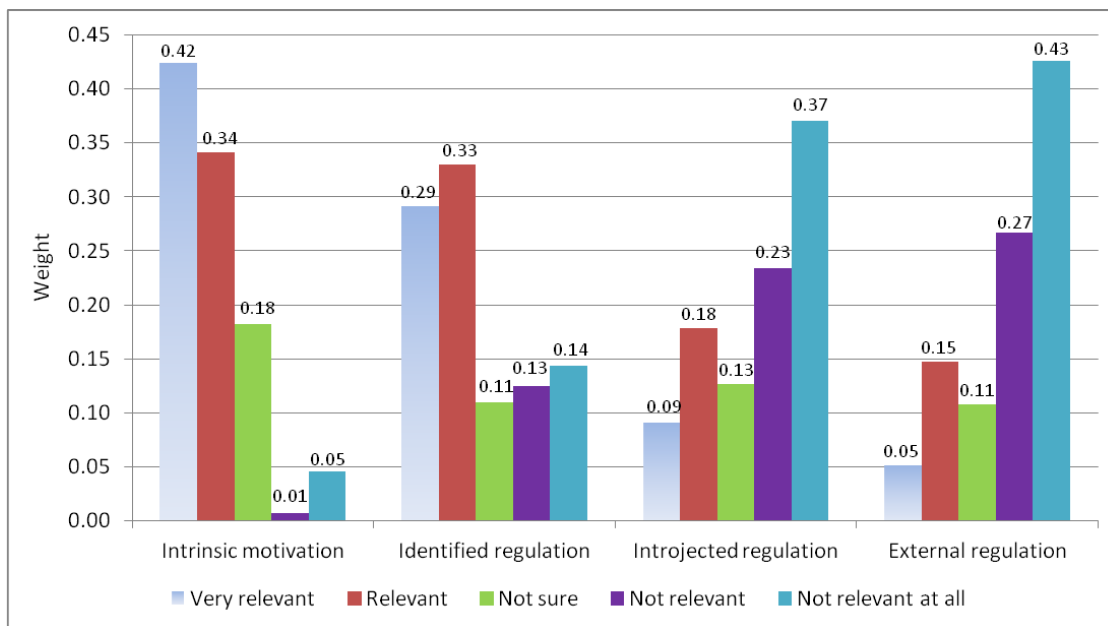


Figure 1: Motivational factors for enrolling in the *Views* programme - Group A.

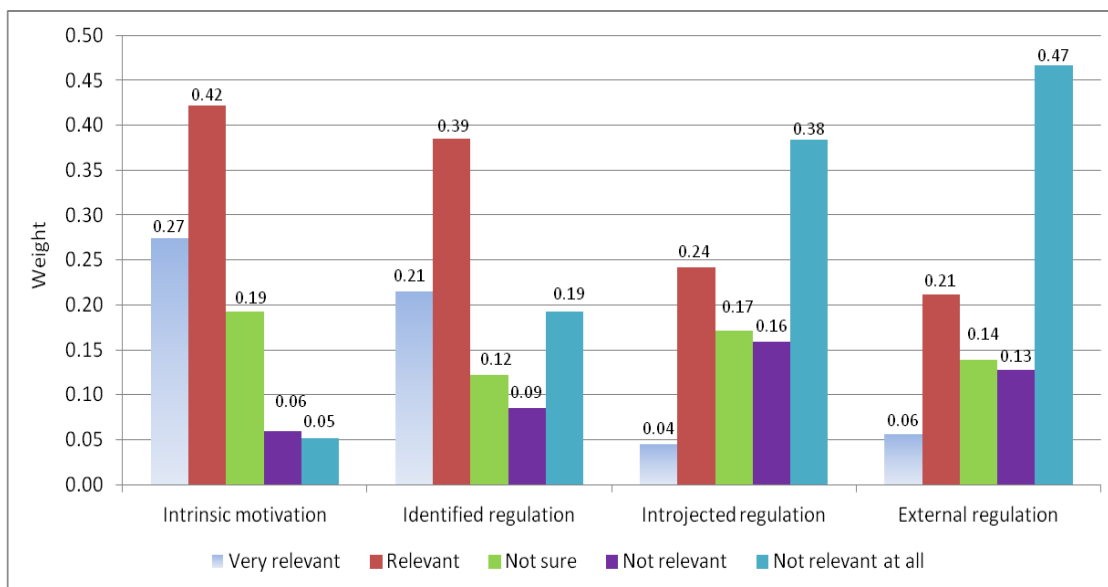


Figure 2: Motivational factors for enrolling in the *Views* programme - Group B.

The authors combined the weights of *very relevant* and *relevant* for each of the four motivational factors (hereinafter, P_A the sum of the weights in Group A and P_B the sum of the weights in Group B) and carried out a proportion test to see if there was a significant difference between the two groups. The results are presented in Table 2.

Table 2: Motivational factors for enrolling in the *Views* programme - comparison between the groups.

Motivation	Regulation	P_A	P_B	z	p -value
Intrinsic		0.76	0.69	0.74	0.46
Extrinsic	Identified	0.62	0.60	0.19	0.85
	Introjected	0.27	0.28	0.11	0.91
	External	0.20	0.27	0.78	0.44

Table 3 presents examples of the motivational factors for enrolling in the programme, identified in the analysis of the open question.

Table 3: Motivational factors for enrolling in the *Views* programme - examples (two groups).

Motivation	Regulation	Category	Examples	Interpretation
Intrinsic			I always loved teaching. (Group A)	Teaching is interesting and enjoyable
			I have been interested in teaching mathematics in school for several years and decided to study it properly. (Group B)	
Extrinsic	Identified	Promoting careers	I would like to learn new things that will help develop my career [in high-tech]. (Group A)	Participation in the programme promotes careers (outside of teaching)
		Contribution to society	I acquired a lot of experience in senior jobs in high-tech and the time has come to contribute to society and teach the younger generation. (Group B)	Participation in the programme enables to contribute to society
	Introjected	Placating relatives	My husband really wanted me to enrol in the programme. (Group B)	Participation in the programme is designed to placate relatives
		Prestige	The <i>Views</i> programme is a prestigious programme. (Group A)	Participation in the programme provides prestige
	External		I cannot find work in my profession and have to change profession. (Group A)	Participation in the programme is due to lack of choice
			I could not get work in engineering. (Group B)	

DISCUSSION AND CONCLUSIONS

According to the quantitative findings, despite the different distribution of the education tracks, there is no significant difference between the groups with respect to any of the four motivational factors. In both groups, the relevance of intrinsic motivation is the highest, with identified regulation situated just below. Introjected regulation and external regulation have a similar relevance and are situated at the lower end of the scale, long behind intrinsic motivation and identified regulation.

The results indicate that in the decision to enrol in the programme, Technion graduates gave greater weight to intrinsic motivational factors, which reflect an interest in the study of education, and to the identified regulation factors, which express the future benefits they expect to derive upon completion of the programme. According to the qualitative findings, the future benefits may be expressed in acquiring skills that would promote careers or help promote education in Israel.

It is interesting to note that a similar ranking of motivational factors was found in studies examining the motivation of sophomore electrical engineering students to study electrical engineering [20] and of outstanding high-school students participating in an engineering design course to study science and engineering [21].

The theoretical contribution of the study is in the identification of the factors that motivate students to enrol in this *Views* programme. The practical contribution may be expressed in applying the findings to improve the existing

programme and develop additional programmes. These contributions are of particular importance in view of the lingering shortage of engineers and scientists in Israel and the Western world [1][2].

In the future, by interviewing the participants, the authors intend to gain an in-depth understanding of the reasons leading to the aforementioned ranking. In addition, the authors will monitor the motivational factors of the students, dependent on the various stages of the programme and see whether they have undergone a change during the course of the programme.

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APPENDIX A: VIEWS PROGRAMME (ELECTRICAL ENGINEERING TRACK) - MANDATORY COURSES

The following list contains mandatory courses included in the electrical engineering track of the *Views* programme. The first five courses provide general pedagogical knowledge and are common to all tracks of the programme. The other courses provide pedagogical content knowledge and are designated for the electrical engineering track.

General Pedagogical Knowledge

1. Introduction to Social Psychology (2.0 credit points);
2. Introduction to Developmental Psychology (2.0 credit points);
3. Introduction to Cognitive Psychology (2.0 credit points);
4. Philosophy of Education (2.0 credit points);
5. Teaching Methods and Skills (3.0 credit points).

Pedagogical Content Knowledge

1. Methods of Teaching Electrical Engineering 1 (3.0 credit points);
2. Methods of Teaching Electrical Engineering 2 (3.0 credit points);
3. Selected Problems in Electrical Engineering (2.0 credit points);
4. Selected Problems in Electronics (2.0 credit points);
5. Practicum in Electrical Engineering Education (2.0 credit points).

APPENDIX B: MOTIVATIONAL FACTORS QUESTIONNAIRE - SELECTED STATEMENTS

Below is a sample of the statements included in the questionnaire that assesses motivational factors driving students to enrol in the *Views* programme. Statements 1, 4 and 12 reflect intrinsic motivation, statements 2, 3, 8 and 9 express identified regulation, statements 5, 7 and 10 reflect introjected regulation, and statements 6 and 11 reflect external regulation.

1. I enrolled in the *Views* programme because of my interest in the study of education.
2. I enrolled in the *Views* programme because completing the programme will enable me to contribute to promoting Israeli society.
3. I enrolled in the *Views* programme because it is good to acquire an additional profession.
4. I enrolled in the *Views* programme because I feel good when I teach.
5. I enrolled in the *Views* programme because people expect me to study teaching.
6. I enrolled in the *Views* programme because I had no choice.
7. I enrolled in the *Views* programme because *Views* is a prestigious programme.
8. I enrolled in the *Views* programme because I shall be able to derive benefit from completing the programme.
9. I enrolled in the *Views* programme because completing the programme will enable me to contribute to promoting education in Israel.
10. I enrolled in the *Views* programme because it will bring me appreciation.
11. I enrolled in the *Views* programme in order to enjoy the benefits of being a student (e.g. discount on travelling in public transportation).
12. I enrolled in the *Views* programme because I think it is fun to study in this programme.