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Analysis of the Factors Motivating Students at a Two-Year Technological College to Study Electronics*

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Two-year technological colleges provide practical engineering training, allowing their graduates to become directly integrated into the employment market. Similarly to students at community colleges, students at technological colleges are usually from the socio-economic periphery or students with relatively low academic achievements. Using quantitative and qualitative instruments, the study described in this paper characterized the factors motivating students to study electronics at a leading two-year college in Israel. Fifty second-year electronics students took part in the study. According to the findings, the students are primarily motivated by interest in the studies (intrinsic motivation) and by recognizing their inherent value (identified regulation). However, an additional factor that should be taken into account is external regulation, according to which, some of the students are studying electronics at the two-year college for lack of any other option. The external regulation's relatively high weight could possibly be explained by the findings, according to which, the need for competence and the need for relatedness are only partially met in those students during their studies.

Keywords: electrical engineering education; two-year colleges; motivation

1. Introduction

Numerous countries, including Israel, have a tertiary technological education system. This training places more focus on the practical side of the profession and less on its theoretical side, and its intention is to allow direct integration into the employment market [1].

Upon the completion of two years of study, a graduate of a technological college in Israel will receive a Practical Engineer degree (hereinafter: "PE degree") in one of the following professions: electronics, mechanical engineering, biotechnology, architecture and others, similarly to a community college graduate in the United States, who receives an Associate Degree in his/her field of study [2]. Other than the similarity between two-year technological colleges and community colleges in regards to the duration of the studies and their practical nature [3], there is also a similarity in the characteristics of the students studying in these institutions: students from the socio-economic periphery or students with relatively low academic achievements [1, 4].

In Israel, there is a marked lack of practical engineers in general and of practical electronics engineers in particular. This lack stems partially from the continued decline in the number of those expressing an interest in studying practical engineering [5]. Nonetheless, the relevant literature is relatively meager and focuses on a general description of the development of technological colleges and their impact on the social diversification and stratification [1], or on specific pedagogical aspects, such as project-based learning [6, 7] and animation-based learning [8–10] among practical engineering students.

The research described in the paper is the first, to the best of our knowledge, to characterize the motivational factors driving students to study electronics at a two-year college. Other than the study's theoretical contribution to the limited body of knowledge on the subject, its practical importance is likely to be reflected in the identification of problems inherent to this course of study and in finding ways to increase its attractiveness. The study's results and the conclusions rising from them may be relevant in the many countries that have a tertiary technological education system.

The paper opens with a concise review of self-determination theory—a leading motivation theory—which served as the theoretical framework for this study. This is followed by a description of the training course for practical electronics engineers and a presentation of the research goal and methodology. The paper ends with a description of the primary findings and the conclusions rising from them.

2. Motivation and self-determination theory

Motivation theories attempt to understand the processes leading an individual to choose a particular behavior from a number of possible behaviors. The literature offers diverse theoretical explana-

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tions for the sources of motivation [11–15]. Reinforcement theory [16], which emphasizes the reward (either positive or negative) the individual receives for his/her behavior, and the two-factor theory [17], which differentiates between extrinsic factors (e.g., rewards) and intrinsic factors (e.g., interest and pleasure embodied in the behavior), are among the most classic explanations.

Modern approaches to motivation, such as self-determination theory [18] which we shall focus on below, describe a more complex picture. According to self-determination theory, the motivational factors are situated on a continuum between two extremes, extrinsic motivation on one hand and intrinsic motivation on the other (Fig. 1). Intrinsic motivation stems, as aforementioned, from the interest and pleasure the individual derives from the behavior. As opposed to intrinsic motivation, extrinsic motivation stems from sources other than interest and enjoyment, and includes various types of regulation. The most important types are specified below:

- External regulation is the most extreme regulation on the continuum, and stems from the desire to receive a reward for the behavior, on alternatively, from a fear of punishment (as claimed by the reinforcement theory mentioned above);
- Introjected regulation is situated more internally on the continuum in comparison to external regulation, and stems from the desire to fulfill the expectations of people who are important to the individual or from reasons of personal prestige;
- Identified regulation is a more internal regulation in relation to introjected regulation, and it originates from identifying a value (which is not interest or pleasure) inherent to the behavior.

It is important to stress that the more intrinsic the sources the motivation stems from—the more the individual's quality of motivation is high. According to self-determination theory [19], the individual can be brought to a state of a high-quality motivation by fulfilling his/her three needs:

- The need for autonomy—the need to feel that the individual's behavior has not been forced on him/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 a relationship with others and be part of a group.

Over recent years, self-determination theory has become the leading theory in the field of motivation in general and educational motivation in particular [20]. The theory served as a theoretical framework for studies focusing on the characterization of motivational factors of high-school students [21–23] and university students [24–28]. In light of its importance—it constituted the theoretical framework for this study.

3. Practical electronics engineer training

As stated at the beginning of this paper, a practical engineer is a technologically-oriented professional, positioned between a technician and an engineer in terms of his/her education.

In Israel, there are two educational frameworks for studying toward a PE degree: the first is for younger people, who continue to post-secondary studies directly from high school, and the second is for older students, who have taken some time out from their schooling. The first track is supervised by the Israeli Ministry of Education, whereas the second is supervised by the Ministry of Economics as part of the Institute for Training in Technology and Science. The curricula for both the younger and the older students are similar in content, last two years, take place at technological colleges and

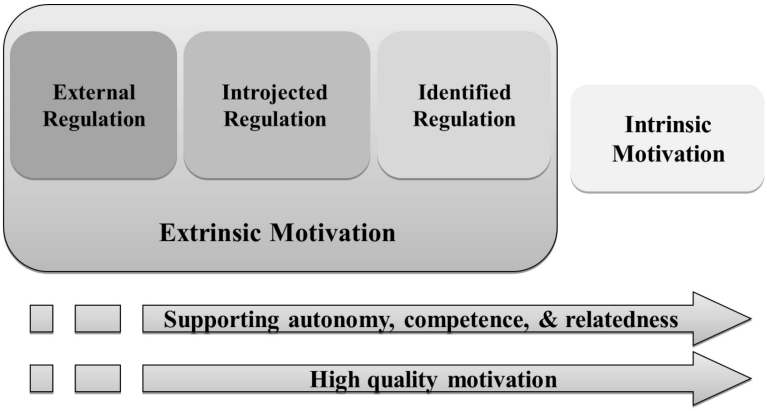

Fig. 1. Primary motivational factors (self-determination theory).

provide their graduates with a PE diploma in their field of study [5]. We shall focus on the electronics program below.

The electronics curriculum provides the student with knowledge and skills in analyzing and designing analog and digital electronic circuits, in writing and developing software, and in designing embedded computer systems.

The first year is dedicated to basic courses in electronics, from both theoretical and practical aspects, and includes experience in electronics and computer laboratories. During the second year, the students take more advanced courses and execute their final project. In the final project, the student is required to solve a technological problem, based on the knowledge he/she has obtained so far during the course of his/her studies at the college. The project includes three stages: designing an electronic system, implementing the system and documenting the design and implementation stages [29]. The curriculum is detailed in Appendix A.

4. Research goal

The study examined the factors motivating students to study electronics at a two-year technological college.

5. Methodology

5.1 Participants

Fifty second-year electronics students (39 men; 11 women) at a leading two-year technological college in Israel participated in the study. The students were studying in a program supervised by the Ministry of Education.

5.2 Method

The study made use of quantitative and qualitative instruments. The students were asked to fill out an anonymous questionnaire, designed to assess the motivational factors leading them to study electronics. The first part of the questionnaire was close-ended and its second part was open-ended. In addition, seven semi-structured interviews were held with students, with the objective of expanding and deepening the information gained from the questionnaires.

The quantitative data were statistically analyzed. By content analysis, based on self-determination theory, the qualitative data were classified into categories. Only information brought up at least three times in the various research instruments was included in this analysis.

5.3 Instruments

The questionnaire used for assessing the factors motivating the students to study electronics consisted of two parts. The first part was a five-level Likert-like questionnaire based on the SIMS (Situational Motivation Scale) questionnaire [30] and the SRQ-A (Self-Regulation Questionnaire—Academic) questionnaire [31]. The questionnaire included twenty statements which reflected the four motivational factors mentioned in Section 2. Thus for example, the statement "I am studying electronics because I think the studies are interesting," expresses intrinsic motivation; the statement "I am studying electronics because this will benefit me in the future," reflects identified regulation; the statement "I am studying electronics because my parents want me to study electronics" and the statement "I am studying electronics because I want people to think I am smart," reflect introjected regulation; and the statement "I am studying electronics because I do not have a choice," expresses external regulation. The statements were validated by two experts in engineering education. Cronbach's alphas indicate good internal consistency: 0.84 (intrinsic motivation), 0.80 (identified regulation), 0.78 (introjected regulation) and 0.86 (external regulation). A sample of the statements is provided

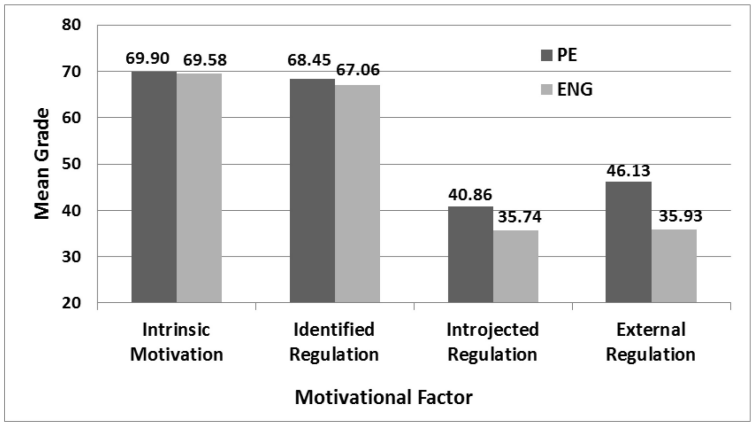

Fig. 2. Mean motivational factor grades (practical engineering students and engineering students).

Table 1. Motivational factor grades (practical engineering students and engineering students)

Motivation	Regulation	Group	*M*	*SD*	*t*	*p*-value
Intrinsic		PE	69.90	14.65	0.09	n.s.
		ENG	69.58	17.13		
Extrinsic	Identified	PE	68.45	12.05	0.45	n.s.
		ENG	67.06	15.08		
	Introjected	PE	40.86	13.63	1.68	n.s.
		ENG	35.74	12.44		
	External	PE	46.13	16.37	2.59	<0.05
		ENG	35.93	18.12		

Table 2. Effect sizes

Motivation	Regulation	*ES*
Intrinsic		0.02
Extrinsic	Identified	0.10
	Introjected	0.39
	External	0.60

in Appendix B. The second part of the questionnaire included the following open-ended question: ''State the two main reasons because of which you are studying electronics''.

A sample of the interview questions is provided in Appendix C.

6. Findings

Fig. 2 shows the mean grade (between 20 and 100) which the participants in the study (PE) gave to each of the four motivational factors. The findings indicate that intrinsic motivation received the highest grade among the motivational factors, identified regulation was ranked a very close second to intrinsic motivation, the grade for external regulation is third and introjected regulation's grade is the lowest.

In addition, the figure shows the mean grade sophomore electrical engineering students from a leading university in Israel (ENG) gave the motivational factors. It is important to stress that the engineering students filled out the same questionnaire as the participants in the study. This data was extracted from [32]. The figure shows that among electrical engineering students, intrinsic motivation and identified regulation grades lead the ranking, with a slight advantage to intrinsic motivation and that introjected regulation and external regulation are situated at the bottom of the ranking together.

Table 1 details the grade (mean *M* and standard deviation *SD*) given by the practical engineering students and by the engineering students to the various motivational factors. The *t*-tests indicate that there is no significant difference between the two groups in terms of the grades for intrinsic motivation, identified regulation and introjected regulation. On the other hand, there is a significant difference ($p < 0.05$) in external regulation between the two groups.

Table 2 shows the corresponding effect size (*ES*) for the various motivational factors. According to the table, the effect sizes characterizing intrinsic motivation and identified regulation are negligible, the effect size for introjected regulation is small-medium and that of external regulation is medium-large.

Content analysis of the qualitative data (Table 3) identifies the four motivational factors among the practical engineering students mentioned in the above quantitative analysis. The relatively high weight of external regulation could possibly be attributed to a partial satisfaction of the basic needs in some of the students, as specified in Table 4. It is important to note that the findings did not indicate partial satisfaction (or the lack of satisfaction) of the need for autonomy.

7. Discussion

According to the qualitative findings, electronics students at the two-year college are motivated both by intrinsic factors, which reflect the interest and pleasure found in the studies, and from extrinsic factors. These factors are identified regulation, expressing the value the students identify in the studies; introjected regulation, stemming from the desire to placate the people who are important to the students; and external regulation, according to which the students are studying for lack of another choice. The conclusion of the quantitative analysis is that the students are primarily driven by intrinsic motivation and identified regulation. However, along with these factors, external regulation should be taken into account too.

A comparison of the findings to the distribution of the motivational factors in electrical engineering

Table 3. Motivational factors (practical engineering students)

Motivation	Regulation	Examples	Interpretation
Intrinsic		I clicked with it [electronics]. . . I enjoy myself when I'm studying. (Interview) The subject [electronics] is very interesting. (Questionnaire)	The student derives interest and pleasure from the study of electronics
Extrinsic	Identified	[I'm studying electronics because] it will benefit me significantly. (Questionnaire) [I'm studying electronics because] it's a sought-after profession. (Questionnaire)	The student identifies the value inherent to studying electronics
	Introjected	[I'm studying electronics because] I usually listen to the advice my mother gives me. (Interview) [I'm studying electronics because] my parents and teachers encouraged me to. (Questionnaire)	The student is studying electronics to fulfill expectations of people important to him/her
	External	[I'm studying electronics because] I had to choose between studying electronics and studying another option I really didn't want, so I chose electronics. (Questionnaire) I thought I liked the subject [electronics] and later on I realized that I didn't. . . but I kept on going since I've already been on this track for two semesters and quitting is an even worse option. (Questionnaire)	The student is studying electronics for the lack of another choice

Table 4. Partial satisfaction of needs (practical engineering students)

Need	Examples	Interpretation
Competence	It's not okay that there were questions on the test we weren't prepared for . . . an electronic circuit we'd never seen . . . so we didn't know how to cope with it. (Interview) When you are in class and you don't understand the material being taught, then it's bad, it's frustrating, it reduces the motivation to study. (Interview)	The need for competence is not fully met because the inability to cope with some of the study material
Relatedness	I feel less connected to some of the lecturers . . . a lecturer who comes unprepared . . . a lecturer who disrespects us and doesn't care about us. (Interview) It felt as if he [the lecturer] didn't want to help us . . . so we never approached him. (Interview)	The need for relatedness is not fully met because of the distant behavior of part of the teaching faculty

students [32] reveals that there is no significant difference between the two groups in terms of the grades for intrinsic motivation, identified regulation and introjected regulation. On the other hand, there is a significant gap in external regulation between the two groups, in favor of the first. In addition, it turns out that the more external the motivational factor is—thus the larger the effect characterizing the difference between the two groups. The effect sizes characterizing intrinsic motivation and identified regulation are negligible, the effect size for introjected regulation is small-medium and that of external regulation is medium-large.

It might be possible to explain the above difference by the findings that during the course of the studies the need for competence and the need for relatedness were only partially met in some students of practical engineering. According to the qualitative findings, the need for competence was not fully met due the inability of part of the students to cope with some of the study material, and the need for relatedness was not fully met due to some of the teaching faculty's distant behavior. Meeting these two needs, will lead, according to self-determination theory [18, 19], to an improvement in the intrinsic motivation at the expense of the external regulation.

Research has shown that intrinsic motivation for learning can be strengthened in engineering students in a number of ways: instilling students with the feeling of competence (e.g., by giving assignments which are challenging yet not too high), nurturing their feeling of relatedness to the faculty (e.g., by allowing direct access to the faculty members), and supporting students' sense of autonomy (e.g., by creating a menu of homework and laboratory assignments) [22, 24, 33, 34]. Improvement of intrinsic motivation is important since the study of

electronics requires the development of higher-order thinking and intrinsic motivation plays a central role at this level of studies [35].

The main limitation of the study is the relatively small number of participants. In order to overcome this limitation and with the objective of increasing the findings' trustworthiness, qualitative instruments were used alongside quantitative ones.

The theoretical contribution of the study is in characterizing, for the first time to the best of our knowledge, the motivational factors toward the study of electronics among students at a two-year college. Beyond this theoretical contribution to the limited body of knowledge on the subject [1], the practical contribution is likely to be expressed in identifying problems inherent to this course of study and in finding ways to increase its attractiveness. The importance of this research is amplified in view of the severe lack of practical engineers and in light of their significant contribution to Israeli industry [5]. In addition, the study's results may be relevant in the many countries that have a tertiary technological education system.

In the next study, we intend to expand the study's population to include students from other colleges and in other tracks of study.

8. Conclusions

The study characterized the factors motivating students to study electronics at a leading two-year college in Israel. According to the findings, the students are primarily motivated by an interest in the studies (intrinsic motivation) and by the recognition of the value inherent to the studies (identified regulation). However, an additional factor that should be taken into account is external regulation, according to which, some of the students study electronics for lack of any other option. A comparison of the findings to the distribution of the motivational factors in electrical engineering students reveals a significant difference between the two groups in relation to the external regulation. This gap, in favor of the first, is characterized by a medium-large effect size. The relatively high weight of the external regulation could be explained by the findings, according to which, during the studies the need for competence and the need for relatedness are only partially met among some of the practical engineering students.

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Appendix A: Curriculum for the degree of "Practical Electronics Engineer"

Listed below are the subjects of study for the degree of "Practical Electronics Engineer", according to the Practical Engineering Yearbook [29]. This curriculum is discussed in Section 3.

- Technical English
- Mathematics
- Microcomputers (3 sub-courses)
- Computer Communications (2 sub-courses)
- Introduction to Electrical Engineering
- Analog Electronics (3 sub-courses)
- Digital Electronics (3 sub-courses)
- C Programming Language (2 sub-courses)
- Hardware Description Language (2 sub-courses)
- Communications Systems (3 sub-courses)
- Digital Signal Processing (2 sub-courses)
- Measurements and Equipment
- Control Systems (2 sub-courses)
- Electronics Laboratory (3 sub-courses)
- Microcomputer Laboratory (3 sub-courses)
- CAD Laboratory
- Communication Laboratory (2 sub-courses)
- Specialization Laboratory (2 sub-courses)
- Project Laboratory

Appendix B: Questionnaire for evaluating motivational factors

The close-ended questionnaire for assessing the motivational factors driving students to study electronics, mentioned in Section 5.3, is a five-level Likert-like questionnaire based on the SIMS (Situational Motivation Scale) questionnaire [30] and the SRQ-A (Self-Regulation Questionnaire—Academic) questionnaire [31]. The questionnaire included twenty statements. Below is a sample of statements. Statements 1 and 7 reflect intrinsic motivation, statements 3 and 8 reflect identified regulation, statements 2, 4, 5 reflect introjected regulation and statement 6 reflects external regulation.

1. I am studying electronics because I find the studies pleasurable.
2. I am studying electronics because my parents want me to study electronics.
3. I am studying electronics because this will benefit me in the future.
4. I am studying electronics because I want people to think I am smart.
5. I am studying electronics because my friends are studying electronics.
6. I am studying electronics because I do not have a choice.

7. I am studying electronics because I think the studies are interesting.
8. I am studying electronics because I think working in electronics would be a good job for me.

Appendix C: Interview questions

Below is a sample of questions from the interview mentioned in Section 5.3:

1. Why are you studying electronics at a two-year college?
2. What do you think about the curriculum? Explain.
3. What is the best thing about the course of study?
4. What is the worst thing about the course of study?

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. Dr. Gero is a faculty member in the Department of Education in Technology and Science at the Technion. His research focuses on electrical engineering education and interdisciplinary education that combines physics with electronics, such as electro-optics and microelectronics education. Dr. Gero is on Sabbatical leave from the Technion and is currently with the School of Engineering Education, Purdue University, Indiana.

Shai Mano-Israeli holds a BSc and an MSc in Technology and Science Education from the Technion—Israel Institute of Technology. He is now a PhD student in the Department of Education in Technology and Science at the Technion.