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Students' Motivation and Academic Achievement: The Case of an Engineering Preparatory Program*

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Engineering preparatory programs offer applicants who have not attained adequate achievements in their high school studies an opportunity to improve their chances to be accepted to undergraduate engineering programs. This study, which made use of quantitative and qualitative instruments, characterized the motivation for higher education in science and engineering in students attending an engineering preparatory program, and examined the relation between such motivation and the students' academic achievement. The study shows that at the end of the program, the degree of perceived control (coercion) in students who completed the program was significantly lower than that found in all the students at the beginning of the program. This difference was accompanied by a decline in the number of students attending the program. The gap could possibly be accounted for by the explanation that students with a relatively high initial degree of perceived control apparently withdrew from the program, whereas students characterized by a relatively low initial degree of perceived control and who completed the program probably experienced an increase in their degree of relative autonomy. The study shows that the degree of relative autonomy in students completing the program was significantly lower than that measured in outstanding 12th grade students majoring in science and engineering. The study indicates the importance of autonomous motivation in engineering preparatory programs by showing positive correlation between the Relative Autonomy Index and the students' academic achievement.

Keywords: engineering preparatory programs; motivation; academic achievement

1. Introduction

Understanding the factors affecting students' academic achievement is very important [1]. The literature offers a wide array of explanations for academic success or failure. Some explanations focus on the learning environment and particularly the quality of teaching [2], while others stress the socioeconomic status of the student's family [3]. There are explanations relating to the student's cognitive and metacognitive capabilities [4], and those viewing the student's personality traits [5] and motivation to learn [6] as central factors affecting his/her academic achievement.

The study described in this paper characterized the motivation for higher education in science and engineering in students attending an engineering preparatory program in Israel and examined a possible relation between such motivation and the students' academic achievement. By so doing, the current study continues a preliminary research which characterized the motivational factors of beginning students in this program [7]. The engineering preparatory program offers candidates who have not attained adequate achievements during their secondary education an opportunity to improve their chances to be accepted to undergraduate engineering programs. On the program, which typically lasts nine months, students intensively study mathematics, physics and English at a high school level. It should be noted that due to the students' weak academic background and the intensity of the preparatory program, motivation plays an important role in a program of this sort [7, 8]. The relevant literature, however, mainly deals with the academic motivation of high school students involved in engineering activities [9] and of undergraduate engineering students [10–12]. Therefore, in addition to the contribution of the current study to the meager body of knowledge on the subject, its findings may also contribute to reducing the lingering shortage of engineers in the Western world, including Israel [13].

The paper begins with a review of academic achievement and motivation. Later, the research goal and methodology are described. After presenting and discussing the main findings, the study conclusions are provided.

2. Theoretical background

2.1 Academic achievement

In light of the importance of academic achievement as part of the learning process, the research literature offers a variety of explanations for the factors that may contribute to successful learning [1]. Some explanations focus on the student's environment [2–4] while others are concerned with the student himself/herself [4–6].

An important approach dealing with the stu-

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dent's environment stresses the socioeconomic status of the student's family [3, 14]. According to this approach, there is positive correlation between parents' education and income and the student's academic achievement and belonging to an ethnic minority is usually detrimental to such achievement [15]. Additionally, parental involvement in their children's education, and particularly parental expectation for children's achievement, improves school outcomes [4, 16]. Other explanations are concerned with the classroom climate. According to them, high quality instruction that puts an emphasis on mastery, understanding and skill improvement, considerably contributes to promoting academic achievement [2, 17].

A main approach focusing on the student argues that the student's personality traits, such as conscientiousness and openness, favorably affect his/her achievement [5, 18]. Another explanation emphasizes the student's cognitive and meta-cognitive capabilities, including his/her ability to employ effective learning strategies [4]. Additional approaches attribute an important role to motivation in relation to academic achievement [6, 19]. This will be covered in the following sections.

2.2 Motivation and self-determination theory

The term motivation relates to an individual's wish to dedicate time and effort to a particular activity, even when this involves difficulties or failures.

Self-determination theory [20], which formed the theoretical framework for this study, is one of the leading motivation theories today. According to this theory, the factors driving an individual can be placed along a continuum (Fig. 1). The continuum extends between the extremity of perceived autonomy which allows the individual to attain self-actualization, and the opposite extremity of perceived control (coercion) which does not allow the individual to attain self-actualization due to external or internal constraints [21].

The main motivational factors along this continuum will be described below, with perceived autonomy gradually decreasing (and perceived control gradually increasing). Intrinsic motivation stemming from interest and pleasure that are derived from the activity by the individual is the motivational factor characterized by the highest degree of perceived autonomy. A student learning by reason of interest in his/her studies is a perfect example of a student driven by intrinsic motivation. The next factor along this spectrum is identified regulation, which has as its source the identification of an activity's importance to the individual's goals or values. For example, a student assigning importance to higher education, as through it he/she is acquiring a profession which is in high demand, is a student driven by identified regulation. Introjected regulation is the next motivational factor, representing the wish to receive appreciation from others for performing the activity, or alternatively, the wish to avoid the feelings of guilt attached to a failure to perform it. For instance, a student attending college in order to appease his/her parents is a student driven by introjected regulation. The motivational factor characterized by the highest degree of perceived control and positioned on the opposite end of the spectrum is external regulation. This factor reflects the wish to attain material compensation for the activity, or alternatively, the fear of being penalized for failing to perform it. A student attending college for fear that if he/she fails to do so he/she will be enlisted to the military is a student driven by external regulation. The last three factors are extrinsic motivational factors, although identified regulation is perceived as relatively autonomous [22]. Research indicates that intrinsic motivation correlates positively with identified regulation and external regulation correlates positively with introjected regulation [23]. However, intrinsic motivation correlates negatively with external regulation [24]. In addition to intrinsic motivation and extrinsic motivation (which includes, as covered above, several types of regulation), self-determination theory also defines a condition of amotivation where the individual lacks any wish to act.

In order to determine the position of the factors driving the individual over the continuum described in Fig. 1, the Relative Autonomy Index (RAI) is customarily specified [25-26]. This index is defined as follows:

$$RAI = -3S_{External} - S_{Introjected} + S_{Identified} + 3S_{Intrinsic} \quad (1)$$

S_i is the score assigned to motivational factor i, as measured by an appropriate research tool. Defini-

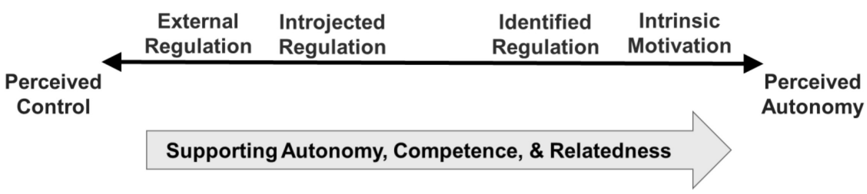

Fig. 1. Major motivational factors (self-determination theory).

tion (1) assigns a higher weight (as an absolute value) to a particular motivational factor as it gets closer to one of the continuum's ends. Additionally, motivational factors characterized by relatively high perceived autonomy are assigned positive weight, whereas those characterized by relatively high perceived control are assigned negative weight. Studies indicate positive correlation between the above index and desired results, such as academic achievement [26, 27].

Self-determination theory claims that an individual can be brought to a high degree of perceived autonomy (or high autonomous motivation) by satisfying his/her three innate needs [28]: the need for autonomy—the need to feel that the individual's behavior is not forced upon him/her; the need for competence—the need to feel that the individual is capable and can attain challenging goals; and the need for relatedness – the individual's need to communicate with others and be part of a group.

2.3 Motivation and academic achievement

As covered above, studies have attempted to understand the nature of the relation between motivation and academic achievement. Thus, for example, positive correlation was found between students' achievement in an introductory biology course and academic motivation as reflected in the learning objectives set by the students [29].

Other studies found positive correlation between a sense of competence and academic achievement of university students studying mathematics [6, 30]. Another study focusing on freshman and sophomore psychology students found positive correlation between intrinsic motivation for learning and achievement [31]. Finally, a comprehensive study covering hundreds of high school students found positive correlation between the Relative Autonomy Index and academic achievement [32].

3. Research goal

The study characterized the motivation for higher education in science and engineering in students attending an engineering preparatory program and examined the relation between such motivation and the students' academic achievement.

The following research questions were formulated:

- What are the factors driving students in the program to study science and engineering?
- What is the correlation between students' motivation and academic achievement?

4. Research environment

This study focused on the engineering preparatory program offered by the Technion—Israel Institute of Technology (hereafter: the Technion) and intended mainly for students interested in studying engineering. Most of the program graduates continue on to engineering studies at the Technion or in other institutions of higher education. On this program, which lasts nine months, students intensively study mathematics, physics and English at a high school level.

The curriculum of the physics course (the research environment) deals with three topics: mechanics (16 weeks, with 14 teaching hours per week), electromagnetics (9 weeks) and light-matter interaction (6 weeks). When completing the course, students are expected to be able to solve problems in the above topics based on quantitative and qualitative considerations. The subject matter being taught is listed in Table 1. The teaching method employed in the course is teacher-centered instruction, and the assessment is based solely on three final exams (mechanics, electromagnetics and light-matter interaction).

5. Methodology

5.1 Participants

The participants in the study were students attending the physics course in the engineering preparatory program at the Technion, who had given their consent to participate in the study. Approximately one-fifth of the students were women. The students' age range was 21–26. All the students took three years off at the very least between the end of high school and beginning their studies in the program. During this period the students completed their two or three-year compulsory military service.

Table 2 shows that throughout the entire course, the number of students participating in the study (N_P) constitutes about 90% of the number of students attending the course (N_A). In addition, it appears that students withdrew from the course during its first half, and as of the 15th week, the number of students stabilized at approximately two-thirds of the initial number.

5.2 Procedure

The study utilized quantitative instruments as well as qualitative ones with the purpose of presenting various aspects of the phenomenon being studied and enhancing the findings' trustworthiness [33].

In order to answer the first research question focusing on the factors driving students to study science and engineering, the students completed an anonymous mixed questionnaire at the beginning (week 1), in the middle (week 19) and at the end of the course (week 33). Additionally, at the end of the course, the students filled out an anonymous open-

Table 1. Curriculum of the physics course (engineering preparatory program)

Topic	Week	Subject matter
Mechanics	1	Measurement, vectors and scalars
	2–3	Motion in one dimension
	4	Projectile motion
	5	Kinematics of circular motion
	6	Kinematics of simple harmonic motion
	7–10	Newton's laws of motion
	11	Dynamics of simple harmonic motion
	12	Gravitation
	13	Linear momentum
	14	Collisions
	15–16	Conservation laws
	17	Final mechanics exam
Electromagnetics	18	Coulomb's law, electric field, Gauss' law
	19	Electric potential
	20	Capacitance
	21	Electric current, Ohm's law
	22	Kirchhoff's laws
	23	Magnetic field
	24	Magnetic force
	25	Lorentz force
	26	Faraday's law of induction, Lenz's law
	27	Final electromagnetics exam
Light-matter interaction	28	Waves, Huygens' principle
	29	Geometrical optics
	30–31	Interference and diffraction
	32	Photoelectric effect, photons, De Broglie waves
	33	Bohr's model of the Hydrogen atom, emission spectrum
	34	Final light-matter interaction exam

Table 2. Number of participants (beginning, middle, and end of course)

Week	N_A	N_P	N_P/N_A
1	67	60	0.90
15	44	40	0.91
34	44	40	0.91

ended questionnaire, and nine semi-structured interviews were held with students. All interviews were audiotaped and transcribed. The quantitative data were statistically analyzed, and the Relative Autonomy Index was calculated. Through directed content analysis [34], based on self-determination theory, the qualitative data were coded by two independent reviewers and classified into categories. Only information coming up at least three times through the different research tools was included in this analysis.

In order to answer the second research question dealing with the correlation between motivation and academic achievement, the students were asked in the middle of the course (week 19) to note the grade they received in the final mechanics exam (which took place two weeks earlier) on the aforementioned mixed questionnaire. It should be noted that the final mechanics exam was preferred over the final electromagnetics or light-matter interaction exams to serve as the research tool, as the extent of material studied in mechanics is substantially greater than the other two topics (Table 1). Based on the collected data, Pearson correlation coefficients were calculated between the different motivational factors and the Relative Autonomy Index—and the students' scores on the final mechanics exam.

5.3 Tools

The mixed questionnaire for evaluating the factors driving students to study science and engineering consisted of two parts. The first part was a five level Likert-like questionnaire ranging between "strongly agree" and "strongly disagree". This part was based on the Self-Regulation Questionnaire—Academic (SRQ-A) scale [25]. The questionnaire was comprised of twenty statements reflecting the four motivational factors mentioned in Section 2.2. Thus, for example, the statement, "I am interested in studying science and engineering because I think the studies will be interesting" represents intrinsic motivation; the statement, "I am interested in studying science and engineering because this will benefit me in the future" expresses identified regulation; the statement, "I am interested in studying science and engineering because my parents want me to study these subjects" reflects 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 range between 0.78 and 0.86 and indicate good internal consistency. A sample of the statements is provided in Appendix A. The second part of the questionnaire contained the following open-ended question: "Specify the two main reasons leading you to be interested in studying science and engineering".

A sample of the open-ended questionnaire questions and the interview questions is provided in Appendices B and C.

The final mechanics exam was validated by two experts in physics education and was graded using a rubric. The exam, which lasted for two hours and fifteen minutes, included five questions, out of which the examinees were asked to answer any three questions they chose. The students were allowed to use a non-graphic calculator and a formula sheet that was attached to the exam form. A sample of the exam questions is provided in Appendix D.

6. Findings

6.1 Motivation to study science and engineering

Since a substantial number of students withdrew from the course during its first half, and the number of participants only stabilized in the middle of the course (Table 2), the findings for the beginning of the course (week 1) and for the period with a constant number of participants (middle to end of course) will be presented separately.

Fig. 2 shows the mean score (ranging between 1 and 5) for each of the four motivational factors for studying science and engineering as obtained from the analysis of the mixed questionnaire (closed-ended part) completed by the students at the beginning of the course (week 1) [7]. The figure indicates that at the beginning of the course, the score for intrinsic motivation (M = 3.92, SD = 0.63) was the highest of the motivational factor scores, closely followed by the score for identified regulation (M = 3.66, SD = 0.47). The score for introjected regulation was in third place (M = 2.63, SD = 0.62) and the external regulation score (M = 2.19, SD = 0.84) was in the last place.

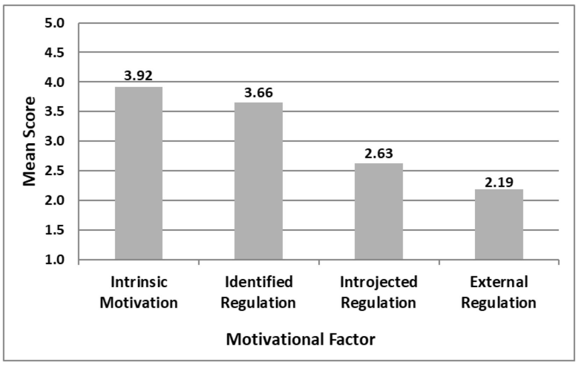

Fig. 2. Mean motivational factor scores (beginning of course).

A similar distribution of motivational factors was obtained from the analysis of the answers to the open-ended part of the questionnaire, in which the students were asked to state the two main reasons they were interested in studying science and engineering (Table 3). It is important to note that none of the statements expressed external regulation.

Fig. 3 shows the mean score for each of the four motivational factors for studying science and engineering, which was calculated based on the mixed questionnaire (closed-ended part) completed by the

Table 3. Frequency of motivational factors (beginning of course)

Motivation	Regulation	Frequency (%)	Examples	Interpretation
Intrinsic		45	I am interested in studying science and engineering because this field interests me more than the rest of the fields. I want to study science and engineering because I am interested in it.	Students are interested in studying science and engineering because they find it appealing.
Extrinsic	Identified	43	I want to study science and engineering because there is a lot of demand for people engaged in science or engineering. I am interested in studying science and engineering because it is a known fact that engineers earn well and I would like to support my family in dignity and provide them with a high standard of living.	Students are interested in studying science and engineering because they recognize the value of doing so.
	Introjected	12	I want to study science and engineering because I am expected [to do so] (my father studied engineering). I am interested in studying science and engineering because my father is a Technion graduate and my younger sister is currently a student at the Technion.	Students are interested in studying science and engineering in order to appease the people they care about.

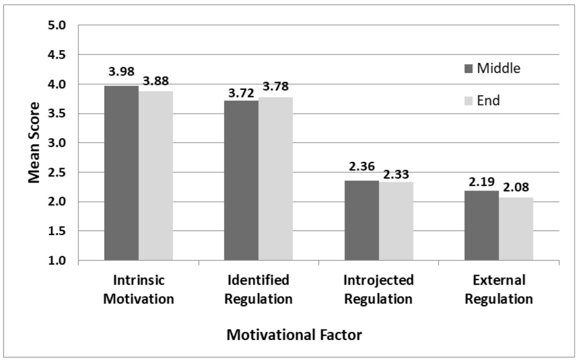

Fig. 3. Mean motivational factor scores (middle and end of course).

Table 4. Motivational factor scores (middle and end of course)

Motivation	Regulation	Point in Time	*M*	*SD*
Intrinsic		Middle	3.98	0.65
		End	3.88	0.71
Extrinsic	Identified	Middle	3.72	0.57
		End	3.78	0.64
	Introjected	Middle	2.36	0.66
		End	2.33	0.72
	External	Middle	2.19	0.93
		End	2.08	0.88

students in the middle and at the end of the course. It has become clear that both in the middle and at the end of the course the intrinsic motivation score was the highest among the motivational factor scores, closely followed by the identified regulation score in second place. The score for introjected regulation was in third place, closely followed by the external regulation score, in the last place. Table 4 shows the scores of the four different motivational factors.

A distribution of motivational factors similar to the one described in Fig. 3 was obtained from the analysis of the answers to the open-ended part of the questionnaire (Table 5). For each motivational factor, the top example in the table was obtained from the questionnaire completed in the middle of the course and the lower example from the questionnaire filled out at the end of the course. The impression one gets is that intrinsic motivation and identified regulation are the most common motivational factors among the students, both in the middle and at the end of the course, and that introjected regulation is far behind in third place. Similarly to the beginning of the course, no statements expressing external regulation were found on the two additional dates the questionnaires were completed.

Table 6 presents the findings obtained through content analysis of the data collected at the end of the course from the open-ended questionnaires and interviews. According to the findings, the course seemed to be successful in satisfying the basic needs of most students completing it.

Due to the anonymity of the questionnaires and the withdrawal of students during the course, it was impossible to perform a statistical analysis based on

Table 5. Frequency of motivational factors (middle and end of course)

Motivation	Regulation	Frequency (%) Middle	Frequency (%) End	Examples	Interpretation
Intrinsic		48	43	I want to study science and engineering because I've dreamed of becoming an engineer from the age of thirteen, and I've always been interested in science. I want to study science and engineering because this area interests me and appeals to me.	Students are interested in studying science and engineering because they find it appealing.
Extrinsic	Identified	47	53	I am interested in studying science and engineering because of the relatively high salary, which allows a better and more comfortable life. I am interested in studying science and engineering because I would like to earn a respectable income [when I graduate].	Students are interested in studying science and engineering because they recognize the value of doing so.
	Introjected	5	4	I want to study science and engineering because my father is an engineer and has a degree in physics and he says that [studying] mechanical engineering suits me. I am interested in studying science and engineering because my parents are pushing me to do so.	Students are interested in studying science and engineering in order to appease the people they care about.

Table 6: Satisfying needs (end of course)

Need	Examples	Interpretation
Autonomy	We are constantly being told we should study independently. . . If you can't solve an exercise—read a little, use the Internet. (interview) The teacher [in class] gives us an exercise, he gives us about 15 minutes to crack our brains and cope with the exercise on our own. . . If we do it—good. . . If not—he solves the exercise on the board. (interview)	The course faculty cultivate independent learning among the students.
Competence	The engineering preparatory program really helped me and improved my math and physics, so I feel better prepared for studying at the Technion. (questionnaire) The engineering preparatory program improved my academic level, and my ability to study is better [now]. (questionnaire)	As a result of participating in the program, improvement occurred in students' sense of competence to cope with studying science and engineering at university.
Relatedness	Now [at the end of the program], it is really fun [in class]. . . I also have friends. . . There is always someone who can help. . . Very good atmosphere. (interview) At the beginning [of the program], there wasn't a learning atmosphere. Now [at the end of the program], only the serious students attend, and there is a positive learning atmosphere in class. (questionnaire)	During the program, the atmosphere in class improved, so at the end of the program students feel at ease with their peers and see them as friends.

Table 7. Relative Autonomy Index (engineering preparatory program students and outstanding high school students)

Group	*M*	*SD*	*p*-value
EP	6.84	3.45	<0.05
HS	8.53	3.49	

repeated measures to examine whether there were significant differences between the beginning, middle and end of the course for each motivational factor. Therefore, according to literature [35], the observations were assumed to be independent, and a one-way ANOVA, which has a lower power, was performed. No significant differences were observed between the beginning, middle and end of the course in regard to intrinsic motivation, identified regulation and external regulation. However, the results indicate a significant difference in regard to introjected regulation ($F(2, 137) = 3.21$, $p < 0.05$), accompanied by a small-medium effect size ($\eta^2 = 0.04$). The post-hoc LSD tests reveal that the significant differences were between the beginning and the middle of the course ($p < 0.05$) and between the beginning and the end of the course ($p < 0.05$). No significant difference was found between the middle and end of the course.

In order to evaluate the students' autonomous motivation at the end of the program, Table 7 presents the Relative Autonomy Index (mean *M* ranging between −16 and +16, and standard deviation *SD*) calculated for students completing the physics course (EP). For the purpose of comparison, the table also contains the value of this index for top 12th grade students majoring in science and engineering (HS). These students filled out the same questionnaire (with the necessary adaptations) that was completed by the study participants [9]. It can be concluded that the high school students' index is above the third quartile, whereas the index for the students completing the engineering preparatory program is below it. According to a *t*-test, the difference between the two groups is significant ($t(70) = 2.05$, $p < 0.05$) and is characterized by a medium effect size ($d = 0.49$).

Table 8. Pearson correlation coefficients (engineering preparatory program)

Motivation/Index	Regulation	*r*	*p*-value
Intrinsic		–0.05	n.s.
Extrinsic	Identified	–0.21	n.s.
	Introjected	–0.04	n.s.
	External	–0.41	<0.01
RAI		0.24	<0.1

6.2 *Correlation between academic motivation and academic achievement*

Table 8 shows the Pearson correlation coefficients between the different motivational factors and the Relative Autonomy Index—and the students' scores on the final mechanics exam.

The correlation between external regulation and academic achievement is significantly negative ($p < 0.01$) and the correlation between the Relative Autonomy Index and academic achievement is positive ($p < 0.1$).

7. Discussion

According to the findings, a substantial number of students withdrew from the program during its first half, and the number of participants only stabilized in the middle of the program. The study found that at the beginning of the program (week 1), the students were driven primarily by an interest in 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 fulfill the expectations of those who are important to them (such as parents), also bears notable weight. The results obtained for the second half of the program indicate a non-significant change between the middle and the end of the program in regard to the distribution of the motivational factors. It was found that during this period, the students were primarily motivated by intrinsic motivation and identified regulation.

The study shows that at the end of the program, introjected regulation in students completing the program was significantly lower than that measured at the beginning of the program in all the students (small-medium effect). It was also found that the differences between the beginning and the end of the program in the rest of the motivational factors were non-significant. In other words, at the end of the program, the degree of perceived control in students who completed the program was significantly lower than that found in all the students at the beginning of the program. As aforementioned, this gap was accompanied by a notable decline in the number of students attending the program, which occurred during its first half. Fig. 4 depicts this in a schematic manner.

The above-mentioned gap may stem from the following reasons: (1) during the first half of the program, students characterized by a relatively high initial degree of perceived control withdrew from the program and/or (2) during the first half of the program, the degree of perceived control in the students completing the program decreased. This explanation assumes that due to the program's intensive nature and the central role of autonomous motivation in such a program [8], the students who dropped out in the first half of the program were probably with a relatively high initial degree of perceived control. This did not provide them with sufficient autonomous motivation to persist with their studies. Those who completed the program were probably characterized by a relatively low initial degree of perceived control, permitting them to complete their studies. It should be noted that a considerable student drop-out rate from academic preparatory programs is a known phenomenon which is sometimes attributed to students' motivation [1].

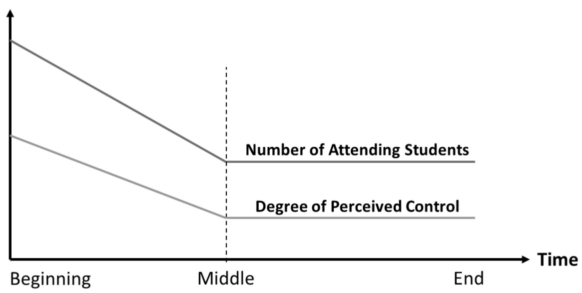

Fig. 4. Degree of perceived control and number of attending students.

The study findings support a combination of both of the reasons mentioned above. According to the findings, as a result of the students who were "not serious" (and were apparently characterized by a relatively high initial degree of perceived control) dropping out, the classroom climate improved, so that at the end of the program, the students remaining felt at ease with their peers. In this way, their need for relatedness was probably fulfilled. Additionally, the students testify that in the course of the program, the course faculty cultivated independent learning (need for autonomy), and that as a result of their participation in the program their sense of competence to cope with studying science and engineering at university improved. It seems, therefore, that in the course of the program the basic needs of most of the students (who completed their studies) were satisfied, which is reflected, in light of self-determination theory [20, 21], in increasing the degree of relative autonomy.

These findings match those obtained through studies conducted among undergraduate engineering students [23, 36, 37], students at two-year technical colleges [38], and high school students involved in science and engineering activities [9, 39]. According to the latter, satisfying the three basic needs or part of them through an educational activity has led to improvement in the students' autonomous motivation.

In spite of the improvement in the students' degree of relative autonomy, at the end of the engineering preparatory program it was still significantly lower than the degree of relative autonomy in outstanding 12th grade students majoring in science and engineering (medium effect). In view of this finding and considering the importance of high autonomous motivation in programs developing higher-order thinking skills [40], like the current program, it is recommended to take action in order to further increase this motivation. Among other ways to achieve this, the existing literature offers the following: permitting students to select a task out of a given collection of tasks [37] (autonomy), working on problems that are challenging but not too challenging [36] (competence), and incorporating "real world" examples into the curriculum [41] (relatedness).

Additionally, the current study indicates significant negative correlation between external regulation and academic achievement and positive correlation between the Relative Autonomy Index and academic achievement. These results, which match those of earlier studies conducted in high schools [32], support the existing evidence of the important role of autonomous motivation in the learning process [8].

The major limitation of the study is the relatively small number of participants. Additionally, since the questionnaires used were anonymous, it was impossible to characterize the motivational factors of the students who withdrew from the program and compare them to those of students who completed the program. However, it is important to mention that the research goal was to characterize the *participating* students' motivational factors at different points over the course of the program.

The study's theoretical contribution is the characterization of motivational factors for higher education in science and engineering in students attending an engineering preparatory program and the examination of the relation between these factors and academic achievement. To the best of the authors' knowledge, such characterization was performed here for the first time. The study's practical contribution may be reflected in the implementation of its findings to increase the autonomous motivation of students attending a program of this sort. Such contributions have even greater value when one considers the limited body of knowledge on this subject and the acute shortage of engineers in the Western world [13].

8. Conclusions

Using quantitative and qualitative tools, the study characterized the motivation for higher education in science and engineering in students participating in an engineering preparatory program and examined the relation between such motivation and the students' academic achievement. According to the findings, a notable number of students withdrew from the program during its first half, and the number of participants only stabilized in the middle of the program. The study found that at the beginning of the program (week 1), the students were driven primarily by an interest in science and engineering (intrinsic motivation) and by recognition of the value inherent to these studies (identified regulation). However, alongside these factors, introjected regulation, according to which some of the students have undertaken these studies in order to fulfill the expectations of those who are important to them, also bears considerable weight. The results obtained for the second half of the program indicate a non-significant change between the middle and the end of the program in regard to the distribution of motivational factors. During this period, the students were primarily motivated by intrinsic motivation and identified regulation. The study shows that at the end of the program, the degree of perceived control in students who completed the program was significantly lower than that found in all the students at the beginning of the program. This gap could possibly be accounted for by the explanation that students with a relatively high initial degree of perceived control apparently withdrew from the program, whereas students characterized by a relatively low initial degree of perceived control and who completed the program, probably experienced an increase in their degree of relative autonomy. This improvement apparently occurred following a certain satisfaction of the basic needs during the program. However, at the end of the program, the degree of relative autonomy in students completing the program was still significantly lower than that measured in outstanding 12th grade students majoring in science and engineering. The study indicates the importance of autonomous motivation in engineering preparatory programs, in that it presents a positive correlation between the Relative Autonomy Index and academic achievement.

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Appendix A: Mixed questionnaire (closed-ended part)

The closed-ended tool for evaluating the motivational factors driving students to study science and engineering, mentioned in Section 5.3, was a five level Likert-like questionnaire based on the Self-Regulation Questionnaire—Academic (SRQ-A) scale [25]. The questionnaire was comprised of twenty statements. Below is a sample of statements. Statements 1 and 8 express intrinsic motivation, statements 3 and 7 reflect identified regulation, statements 2, 5, 6 express introjected regulation, and statement 4 represents external regulation.

1. I am interested in studying science and engineering because I think the studies will be pleasurable.
2. I am interested in studying science and engineering because my parents want me to study these subjects.

3. I am interested in studying science and engineering because this will benefit me in the future.
4. I am interested in studying science and engineering because I have no choice.
5. I am interested in studying science and engineering because I want people to think I am smart.
6. I am interested in studying science and engineering because my friends are studying these subjects.
7. I am interested in studying science and engineering because I think working in science and engineering would be a good job for me.
8. I am interested in studying science and engineering because I think the studies will be interesting.

Appendix B: Open-ended questionnaire

Following is a sample of the questions comprising the open-ended questionnaire mentioned in Section 5.3:

1. Why are you interested in studying science and engineering?
2. Describe the learning atmosphere in class.
3. What is your opinion of the level of physics studies on the program? Explain.
4. What is the best thing about the physics classes? Explain.

Appendix C: Interview

Following is a sample of the questions comprising the interview mentioned in Section 5.3:

1. Why are you interested in studying science and engineering?
2. Describe the most interesting lesson you have attended so far. Explain your selection of that specific lesson.
3. Do you feel you can express your capabilities during your physics studies? Explain.
4. What would you like to improve in the physics lessons?

Appendix D: Final mechanics exam

Following is a sample of the questions comprising the final mechanics exam mentioned in section 5.3:

1. A plane inclined at an angle α to the horizontal consists of two surfaces made of different materials and connected to each other at point A (Fig. D1). At $t = 0$, a small block is released from rest from a point located on the top surface at a distance d from point A. The static and kinetic friction coefficient between the block and the top surface is μ_1 and the static and kinetic friction coefficient between the block and the bottom surface is $\mu_2 > \mu_1$. The block passes, without interference, from the top surface to the bottom one and stops after a while on the bottom surface.
   A. What is the block's maximum speed?
   B. When does the block pass over point A?
   C. At what distance from point A does the block stop?
   D. If the experiment is performed on the moon, where the gravitational acceleration is smaller than on Earth, will your answer to the last question change? Explain.

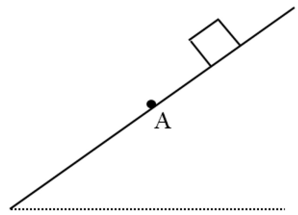

Fig. D1. Question no. 1.

2. Two small identical masses $m_1 = m_2 = m$ rotate at an angular speed ω around a common center on a smooth horizontal table. The inner mass is connected to the rotation axis with a string of length L and to the outer mass with a spring of constant k and relaxed length L.
   A. Is the spring stretched or compressed? Explain.
   B. By how much is the spring stretched (or compressed) from its relaxed length?
   C. Calculate the tension in the string.

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