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Increasing Motivation of Engineering Students: Combining "Real World" Examples in a Basic Electric Circuits Course*

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Literature indicates that electrical engineering students show little interest in the basic electric circuits course. Most of the students see it as a technical course, which does not provide an in-depth understanding of the discipline of electrical engineering. The Department of Electrical Engineering at the Technion—Israel Institute of Technology has decided to integrate into the course examples reflecting the diverse areas of study the Department offers and the various fields of practice in which electrical engineers are employed in the industry. The integration of the examples was designed to increase students' interest in the course in particular and in electrical engineering in general. Using quantitative and qualitative tools, the study described in the paper set out to examine the effectiveness of the proposed approach and check whether there was a difference in the motivation toward the study of electrical engineering between students who participated in the course in its new format (with examples) and that of students who participated in the course in its original format (without examples). One hundred and twenty three sophomore electrical engineering students took part in the study. The findings indicate a significant gap between the intrinsic motivation of students who attended the course in its new format and that of their peers.

Keywords: engineering education; motivation; basic course; electric circuit theory

1. Introduction

The basic electric circuits course is intended for sophomore electrical engineering students, after their completion of the basic courses in mathematics and physics. The course focuses on analyzing lumped circuits, frequency domain analysis, and time domain transients. It is important to note that in numerous universities, including in the Technion—Israel Institute of Technology, this is the first course on the curriculum dealing with electrical engineering in a manner based directly on mathematical and physical foundations, and is taught by the faculty members of the Department of Electrical Engineering.

Both the experience of the authors and the literature [1, 2] indicate the small amount of interest students find in the course, which they see as a technical course, providing nothing but skills to analyze electric circuits with minor relevance. As a response, the literature suggests teaching the course in non-traditional ways, such as project based learning [2], problem based learning [3], collaborative learning [4, 5], and enhanced guided notes [6]. In addition, it suggests integrating laboratories [7, 8] and web based tasks [1, 9] into the curriculum.

Recently, the Department of Electrical Engineering at the Technion has decided to try to increase students' interest in the course in particular and in electrical engineering in general by means of integrating examples reflecting the diverse areas of study the Department offers and the various fields of practice in which electrical engineers are employed in the industry (hereinafter: "real world" examples). It should be emphasized that the method of teaching employed in the course remains the traditional, lecture-based method, thus the proposed course is essentially different from the similar courses surveyed above.

The study described in the paper set out to examine the effectiveness of the proposed approach, namely to check if there was a difference in the motivation toward the study of electrical engineering between students who participated in the course in its new format (including examples from the "real world") and that of their peers who participated in the course in its original format (without examples).

The paper begins with a concise review of the self-determination theory—a leading motivational theory—which served as the theoretical framework for this study. Later on, the course "Electric Circuit Theory" is described and the research question and

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the methodology are presented. At the end of the paper, a discussion of the primary findings and the conclusions arising from them takes place.

2. Self-determination theory

Motivation theories try to investigate what drives a person's behavior. Skinner [10] claimed that the source of motivation is the reward a person gets for his/her behavior, therefore, providing a positive reward (a prize), will lead to increasing the incidence of the rewarded behavior, whereas a negative reward (a punishment) would result in a decrease of the incidence.

Herzberg et al. [11] observed a dichotomy between intrinsic motivational factors (e.g., interest and pleasure) and extrinsic motivational factors (e.g., material rewards). According to their claim, since the extrinsic factors prevent a lack of satisfaction whereas the intrinsic ones create satisfaction, only the latter could bring about the investment of resources on the part of the person and the improvement of his/her performance over time.

In the self-determination theory [12], Deci and Ryan described the sources of motivation as a continuum sprawling between the two poles identified by Herzberg et al., namely, extrinsic factors and intrinsic factors. Extrinsic motivation is located on one end of the continuum and it includes several types of regulation. The important ones are:

- External regulation stemming from the desire to receive an (immediate) reward for the behavior, or alternatively, the fear of being punished;
- Introjected regulation caused by the desire to fulfill the expectations of people who are important to the person, or by prestige considerations;
- Identified regulation emanating from identifying a value (other than interest or enjoyment) embodied in the behavior.

On the other end of the continuum is intrinsic motivation which stems from the interest and enjoyment entailed in the behavior. The more intrinsic the sources the motivation stems from—the more its quality is high.

The self-determination theory claims that it is possible to raise the quality of the person's motivation by means of meeting his/her three needs [13]:

- The need for autonomy—the need to feel that the person's behavior has not been forced on him/her;
- The need for competence—the need to feel that the person is capable of meeting challenging objectives;
- The need for relatedness—the need to be accepted and be part of a group.

For the sake of completeness, we mention that in addition to the self-determination theory, there are other modern theoretical approaches which attempt to trace the sources of motivation, such as the causal attribution theory [14] and the achievement goal theory [15]. However, since over recent years the self-determination theory has become the leading theory in the field of educational motivation [16], and has served as a theoretical framework for studies focusing on motivational factors of engineering students [17–21], we made use of it in this study.

3. Course description

The course "Electric Circuit Theory" is a mandatory course, intended for second-year students in the Department of Electrical Engineering. The course is aimed to provide the students with knowledge and skills in analyzing lumped circuits, small signal linearization, frequency domain analysis, coupled circuits, operational amplifier based circuits, and time domain transients. This knowledge and skills are designed to serve the students in consecutive courses in general and specifically in those focusing on electronic devices and analog and digital circuits. The course is based primarily on the textbook "Basic Circuit Theory" by Desoer and Kuh [22]. The course is thirteen weeks long, and each week has three hours of lecture, a tutorial hour and a workshop hour, in which additional exercises to those discussed during the tutorial are solved. The instructional approach in all the aforementioned meetings is teacher-centered. The score received in the course is determined by the final examination (80%) and the homework exercises submitted throughout the semester (20%).

As stated, with the goal of increasing students' interest in the course in particular and in electrical engineering in general, it was decided to incorporate into the course, for the first time, examples reflecting the diverse fields of both teaching and research taking place in the Department, and the variety of fields in which electrical engineers are employed in industry.

In the first week, the topics included in electrical engineering were reviewed as well as the areas of teaching and research in the Department. The various levels of practice were presented using abstraction layers, namely, an electronic device, a circuit, a chip and an entire electronic system. The emphasis was put on the fact that in order to successfully overcome the next technological hurdle, it is necessary to examine the possible assumptions allowing abstraction layers, and in order to redefine them, it is necessary at times to perform a basic electric analysis, with the help of the tools taught during the course. Later on, the term lumped circuit was defined and Kirchhoff's laws relevant to analyzing circuits under this approximation were discussed.

The second week was dedicated to the continued treatment of lumped circuit elements and to the discussion of resistive circuits, voltage and current sources, and circuit analysis using the nodal analysis technique. In light of past experience, which indicated that students usually found it hard to assimilate the generality of the associated current-voltage sign convention, as in understanding that a source could also serve as a load, the naive model of a cellular phone was presented as a combination of a load (resistor), voltage source (battery) and an additional source (a charger from the electrical grid). Discussing the familiar example of charging a cellular phone, made it possible to illustrate the load-source duality which might be valid even for an ideal source, and the need for a sign convention.

The third week dealt with completion of the nodal analysis technique and the presentation of network theorems: the superposition theorem, the substitution theorem and the Thévenin/Norton theorems.

The fourth week was dedicated to nonlinear circuits, in which the use of small signal linearization was discussed and demonstrated, as well as the use of large signal modeling. A resistor-diode AND gate was analyzed as an example for a circuit that operates in a large signal regime. It was emphasized that although the present course focused on analyzing linear problems, the field of digital circuits, which the students would study in consecutive courses, deals with very nonlinear circuits.

The fifth week saw the beginning of the subject of sinusoidal steady state analysis. As an introduction, various modulation techniques in mobile communication (FDMA, TDMA, CDMA) were presented in a chronological order. The temporal and spectral bandwidth allocation in a CDMA modulation served as a means to convey to the students that in the industry an electrical engineer is required to have the ability to conceive time and frequency domains simultaneously. Later on, reactive elements were discussed, as well as phasor notation. The discussion was sealed with the mention of the Department's research and teaching activity in the field of communications.

The sixth week continued the treatment of sinusoidal steady state analysis and frequency filters were studied. In order to illustrate them, the students were presented with the example of measuring an ECG signal. The students were asked to compare a graph presenting a given ECG signal to two less successful measurements, and estimate which of the two was distorted due to excessive filtering of high frequencies and which was distorted by excessive filtering of low frequencies. Following the example, the Department's activity in the field of processing biological signals and physiological systems was mentioned.

In the seventh week, as a summary of the chapter dealing with sinusoidal steady state analysis, resonance, particularly in RLC circuits, was discussed. To add on the subject, the transfer function of the Fabry-Pérot optical resonator was analyzed qualitatively and quantitatively, and resonance was demonstrated on this photonic device. It was emphasized that the occurrence of resonance was relevant to numerous fields in electrical engineering beyond lumped circuits. That was followed by a presentation of the Department's activities in the fields of electro-optics and photonics.

The eighth week was dedicated to the subject of two-port networks, and after which, in the ninth week, capacitive and inductive coupling were studied. The lesson started with the description of the principles of operation of touchscreens familiar to the students from their smartphones and tablet computers, followed by an explanation of capacitive coupling. Later on, inductive coupling was studied, and as an example of coupled coils, a mobile phone wireless charger was presented.

The tenth week dealt with operational amplifier based circuits. The lesson started with a presentation of the operational amplifier as a response to the historical requirement for the realization of analog computation. A description of the need for a differential amplifier in order to process the currents from infra-red detectors in the four square structure, situated on heat-seeking missiles was given as an example of this computation. A short description of the Department's Microelectronics Research Center, initially focused on manufacturing such detectors, and currently used for advanced research of micro- and nano-electronic devices was given on that occasion. Later, the first contemporary application for operational amplifiers which was analyzed in the class was a comparator connected to a single-bit optic sensor, intended to serve as an analog to digital converter (for example, in the detection circuit of a compact disc reader). Afterward, the properties of operational amplifiers were analyzed, and analog applications were demonstrated, such as the amplification circuit connected to the microphone on the lecturer's lapel. In conclusion, simple structures of analog to digital and digital to analog converters were presented, emphasizing that in a world in which the processing and handling of information is primarily digital, the interface to the physical world is based to a large degree on operational amplifiers which started out in the world of analog computation.

The final three weeks of the course were dedicated to transient response of first order circuits (such as

Table 1. Course syllabus

Week	Subject	"Real World" Examples
1	Lumped circuits, Kirchhoff's laws	Areas included in electrical engineering, research and teaching activities carried out in the Department of Electrical Engineering
2	Lumped circuit elements, resistive circuits, voltage and current sources, nodal analysis technique	Charging a cellular phone
3	Nodal analysis technique (continued), network theorems	
4	Nonlinear circuits, small signal linearization	Realization and analysis of an AND gate
5	Reactive elements, phasor notation, sinusoidal steady state analysis	FDMA, TDMA, CDMA modulation formats, research and teaching activities in the field of communications
6	Sinusoidal steady state analysis (continued), frequency filters	Spectral analysis of an ECG signal, research and teaching activities in the field of processing biological signals and physiological systems
7	Resonance	Fabry-Pérot optical resonator, research and teaching activities in the fields of electro-optics and photonics
8	Two-port networks	
9	Capacitive and inductive coupling	Touchscreens, mobile phone wireless charger
10	Operational amplifiers, A/D D/A convertors	Infrared detectors in heat-seeking missiles, amplifying circuit connected to a microphone, research and teaching activities in the fields of micro- and nano-electronics
11–13	Transient response of first and second order circuits	Inverter maximum clock frequency, research and teaching activities in the field of fast digital electronics

RC circuits) and second order circuits (such as RLC circuits). Throughout these weeks, examples for the use of the methods used for characterizing time constants in digital circuits were presented, for instance, computing an inverter maximum clock frequency, based on the model of an RC circuit. Later on, the Department's teaching laboratories, dealing with electrical limitations of fast digital electronics were described. It was clarified to the students that the ability to perform a simulation of signal propagation, based both on the lumped element model and distributed models, is an inherent part of modern digital design, such as the one carried out in the Fast Digital Systems Laboratory and in the Department's VLSI Systems Research Center.

A summary of the course contents and the "real world" examples used is presented in Table 1.

4. Research goal

The aim of the study was to examine the effectiveness of integrating into the course examples reflecting the various topics of electrical engineering. The study checked whether there was a difference in the motivation toward the study of electrical engineering between students who participated in the course in its new format (with examples) and that of students who participated in the course in its original format (without examples).

5. Methodology

5.1 Participants

One hundred and twenty three sophomore electrical engineering students who participated in the course "Electric Circuit Theory" took part in the study.

5.2 Method

The students were given the choice of studying the course in one of two different teaching groups, taught by different lecturers. The first group (hereinafter: the experimental group) was taught according to the new format, which includes the integration of "real world" examples as described in Section 3. The second group (hereinafter: the control group) was taught the same contents for the same number of hours, but without the integration of examples. It is important to note that both lecturers were experienced and no significant difference was found between their teaching scores (ranging from 1 to 5) before the course (Table 2), and that the tasks the students were required to fulfill as part of the course were identical in both groups. The

Table 2. Lecturers' teaching scores (experimental and control groups)

Teacher	N	Mean	SD	*p*-value
Experimental	10	4.00	0.28	n.s.
Control	8	3.93	0.25	

students, who were not aware of the difference between the two groups, chose the teaching group according to their own free will, so that there were 72 students in the experimental group and 51 in the control group.

At the beginning and the end of the course, the students in both groups were requested to fill out an anonymous, close-ended questionnaire, intended to estimate the motivational factors driving them to study electrical engineering. At the end of the course, the students from the experimental group were also asked to fill out an anonymous, open-ended questionnaire in which they were asked what they thought about the course. In addition, with the purpose of expanding the information gathered through the questionnaires, at the end of the course, nine semi-structured interviews took place with students from the experimental group.

The quantitative data were statistically analyzed and the corresponding effect sizes were calculated. The qualitative data were categorized by content analysis based on the self-determination theory. Only information which came up at least three times in the different research tools was included in this analysis.

5.3 Tools

A sample of the interview questions is given in Appendix A.

The questionnaire for assessing the motivational factors driving students to study electrical engineering was a five-level Likert-like questionnaire based on the SIMS (Situational Motivation Scale) [23] and the SRQ-A (Self-Regulation Questionnaire-Academic) [24] questionnaires. The questionnaire included 20 statements which reflected the four motivational factors, mentioned in Section 2. For example, the statement "I study electrical engineering because I think it is interesting" expresses intrinsic motivation; the statement "I study electrical engineering because I do it for my own good" reflects identified regulation; the statement "I study electrical engineering because my parents want me to study it" and the statement "I study electrical engineering because I want people to think I am smart" represent introjected regulation; and the statement "I study electrical engineering because I am supposed to do it" reflects 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 in Appendix B.

A sample of the open-ended questions, in which the students were asked to express their opinion about the course, is provided in Appendix C.

6. Findings

Figure 1 shows the mean score (between 1 and 5) the experimental group gave to each one of the motivational factors at the beginning of the course (pretest) and at the end of the course (posttest). It is apparent that both at the start and end of the course the intrinsic motivation score is the highest ranking among the motivational factors, the identified regulation's score is second, the score for introjected regulation is in the third place and the external regulation is the lowest. In addition, it has become clear that there has been an increase in intrinsic motivation and a decrease in the rest of the motivational factors.

Table 3 details the scores given by the members of both groups—the experimental and control groups—to the various motivational factors. The

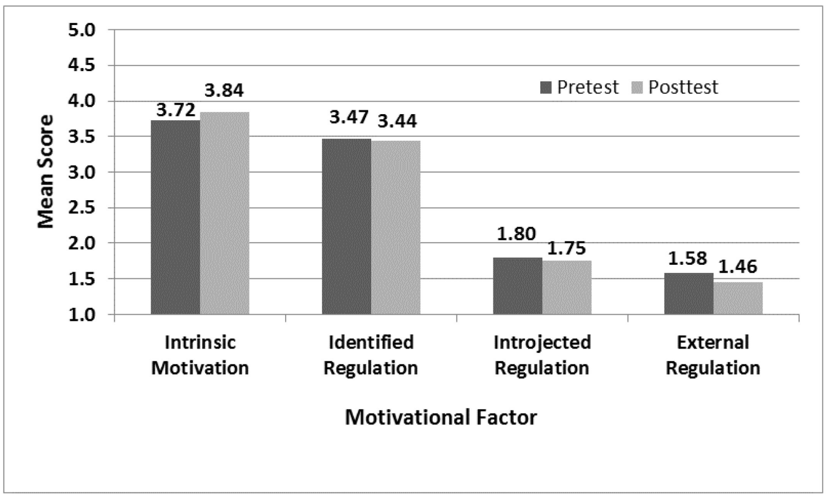

Fig. 1. Mean motivational factor score (experimental group).

Table 3. Motivational factor scores (experimental and control groups)

Motivation	Regulation	Test	Group	Mean	SD	*p*-value
Intrinsic		Pretest	Experimental	3.72	0.66	n.s.
			Control	3.59	0.75	
		Posttest	Experimental	3.84	0.60	<0.05
			Control	3.64	0.68	
Extrinsic	Identified	Pretest	Experimental	3.47	0.50	n.s.
			Control	3.63	0.59	
		Posttest	Experimental	3.44	0.56	n.s.
			Control	3.47	0.69	
	Introjected	Pretest	Experimental	1.80	0.61	n.s.
			Control	1.93	0.66	
		Posttest	Experimental	1.75	0.56	n.s.
			Control	1.99	0.74	
	External	Pretest	Experimental	1.58	0.58	n.s.
			Control	1.64	0.71	
		Posttest	Experimental	1.46	0.52	<0.05
			Control	1.71	0.66	

Table 4. Effect sizes

Motivation	Regulation	Cohen's *d*
Intrinsic		0.32
Extrinsic	Identified	–0.05
	Introjected	–0.38
	External	–0.43

t-tests revealed no significant difference between the pretest scores of the experimental group and those of the control group on the four motivational factors. Regarding intrinsic motivation and external regulation, there was a significant difference between the posttest scores of the experimental group and that of the control group. No significant difference was found for identified regulation and introjected regulation between the posttest scores of the experimental group and that of the control group.

Table 4 presents the effect sizes for the various motivational factors. The table indicates that the positive gap in the intrinsic motivation is characterized by a small-medium effect size, the negative gaps in the introjected regulation and the external regulation are accompanied by a small-medium effect size, and the gap in the identified regulation is negligible.

The analysis of the qualitative data (Table 5) allows identifying the methods by of which the course's lecturer was able to raise the interest in

Table 5. Methods for creating interest in electrical engineering studies (experimental group, end of course)

Method	Examples	Interpretation
Initial exposure to electrical engineering	Interesting course; the first to show us a bit of what an "electrical engineer" is and let us taste the field. (Questionnaire) An interesting course, opening the doorway to real electrical engineering and not just complicated math and abstract physics [which we have been studying up till now]. (Questionnaire)	The interest was created by the initial exposure to an electrical engineer's field of practice
Exposure to the areas of study in electrical engineering	The course is interesting, gives a feeling of what we are to be learning in the program [electrical engineering]. (Questionnaire) It [the course] helps to understand what we will be learning about in the Department [of Electrical Engineering]. (Questionnaire)	The interest was created by the initial exposure to the areas of study in the Department of Electrical Engineering
Relevance of the study material to the work of electrical engineers	They [course faculty] always made sure to show us in what way the [studied] topic was important to the work of an electrical engineer, and that is quite interesting. (Questionnaire) An interesting course. The lecturer makes sure to emphasis what an electrical engineer does in the industry. (Questionnaire)	The interest was created by tying the contents being studied to the electrical engineer's work in the industry
Connection to everyday life	In one of the lessons an example of how circuits are used in the operation of touchscreens was presented. The connection to everyday life was interesting. (Questionnaire) The lesson that interested me personally was about operational amplifiers. It gave us an intuition about "real" things, such as the amplification of a microphone. (Questionnaire)	The interest was created by tying in the studied material to electronic systems familiar to the students from their everyday life

Table 6. Meeting needs (experimental group, end of course)

Need	Examples	Interpretation
Relatedness	[Following the course] I felt more connected to the Department [of Electrical Engineering] . . . I also know more people in the Department – lecturers and tutors – and their fields of practice as well. (Interview) Up until now I felt as if I didn't belong and now I understand how it [what I'm studying] is related to the program [electrical engineering] and why I've been studying it, now everything makes sense. (Interview)	The need for relatedness was provided by an introduction to the areas of study in electrical engineering, exposure to the electrical engineer's fields of practice, and a personal acquaintance with the faculty members
Competence	The course is challenging . . . I feel as if I can cope with it [the course], but I have to make an effort. (Interview) It was not easy for me, but it wasn't extremely difficult either. (Interview)	The need for competence was met by a challenging—yet not too high—level of teaching

electrical engineering studies among the experimental group members.

On a deeper level, the interest the course managed to raise among the students could be attributed to the satisfaction of two of their basic needs, as specified in Table 6.

7. Discussion

According to the quantitative findings, two distinct groups of motivational factors relating to the study of electrical engineering can be identified among the members of the experimental group. Both at the start and the end of the course, the score of the intrinsic motivation and the identified regulation is similar (with an advantage to the intrinsic motivation), and is substantially higher than the score of the introjected regulation and the external regulation. This finding could be attributed to the background of the students: sophomore electrical engineering students, whom, had they not found an interest in the demanding curriculum—would have not reached this stage in their studies. In addition, the students are aware of the high wage conditions of electrical engineers in the industry, and this is expressed in the considerable amount of weight they attribute to the identified regulation. A similar distribution of the motivational factors among electrical engineering students is described in [25, 26].

At the end of the course, significant gaps between the experimental group and the control group were revealed in relation to intrinsic motivation (a positive gap) and external regulation (a negative gap)—gaps characterized by small-medium effect sizes. This can be explained by means of the qualitative findings, according to which, the students found the course in its new format interesting thanks to the examples from the "real world" that were integrated into it. The interest stemmed from a number of sources: initial exposure to an electrical engineer's field of practice and to the work he/she does in the industry, an acquaintance with the areas of study in the Department of Electrical Engineering, and ultimately, tying in the studied material to electronic systems familiar to the students from their everyday life, such as touchscreens and microphones. This interest caused the higher intrinsic motivation (and lower external regulation) among the members of the experimental group in comparison to the members of the control group. The effectiveness of real-life examples was also demonstrated in chemical engineering education [27] and software engineering education [28].

On a deeper level, the aforementioned significant gaps may be attributed to two out of three of the students' basic needs being met during the improved course—which according to the self-determination theory [12, 13], resulted in higher motivational levels. The need for relatedness was probably met by the students' initial acquaintance with the areas of study in the Department of Electrical Engineering, their exposure to the electrical engineer's fields of practice, and a personal acquaintance with the faculty members. The need for competence was apparently met by a challenging—but not too high—level of teaching.

These findings are consistent with the findings of Koh et al. [17], which demonstrated that simulation-based learning of mechanical engineering students met the students' three basic needs and thus improved their intrinsic motivation. In addition, the findings are in keeping with Gero and Danino's findings [29], which indicated an increase in intrinsic motivation among high school students who participated in an introductory course on engineering design in which the aforementioned needs were met.

The study has one primary limitation: the assignment of the students into the experimental group and the control group was not random. With the purpose of dealing with this limitation, which is characteristic of studies taking place in educational institutions, a preliminary test was held in order to rule out a significant difference between the two groups. In addition, in order to increase the findings' trustworthiness and with the purpose of presenting different aspects of the phenomenon under study, qualitative tools were used along with quantitative ones.

The theoretical contribution of the study is in the characterization—to the best of our knowledge for the first time—of the motivational factors toward the study of electrical engineering among students attending a basic course on electric circuits. The practical contribution is likely to be manifested in taking into account the findings while developing new basic courses on electrical engineering and improving the existing ones. This contribution is reinforced in light of the benefit attained from the course in its new format in relation to the low cost of the change made to it. As aforementioned, the course retained its original lecture-based format and the only change was the integration of relevant examples in the curriculum. Thus, the vast amount of resources necessary for adopting a non-traditional way of teaching in the course, such as project based learning [2] and collaborative learning [4, 5] was saved. Hence, we recommend combining "real world" examples in basic university courses covering electric circuits.

In a continued study, we intend to monitor the participants to examine whether the differences in the motivational factors between the experimental group and the control group will also manifest later on, in the duration of their studies.

8. Conclusions

Examples reflecting the Department of Electrical Engineering's diverse areas of study and the fields of practice in which electrical engineers are employed in the industry were integrated into a basic electric circuits course at the Technion—Israel Institute of Technology. The study described in the paper set out to examine the effectiveness of this approach and to check if a difference existed in the motivation toward the study of electrical engineering between students who participated in the course in its new format (with examples) and that of students who participated in the course in its original format (without examples). The findings of the study, which made use of quantitative and qualitative tools, indicate a significant gap between the intrinsic motivation of the students who participated in the course in its new format and that of their counterparts—a gap characterized by a small-medium effect size. The aforementioned results may be attributed to meeting two of the students' basic needs: relatedness and competence. The need for relatedness was apparently met by the examples which allowed, for the first time in the course of their studies, an acquaintance with the Department's areas of study and an exposure to the electrical engineer's fields of practice in the industry. The need for competence was probably met by a challenging—yet not too high—level of teaching.

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Appendix A: Interview questions

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

1. What do you think about the course? Explain.
2. What do you thing about the integration of examples into the course? Explain.
3. Describe the most interesting lesson in the course. What was interesting about it? What did you learn in it?
4. What do you think about the course's level of study? Were you able to cope with it?

Appendix B: Questionnaire for the evaluation of motivational factors

The questionnaire for the evaluation of motivational factors driving the students to study electrical engineering, mentioned in Section 5.3, was a five level Likert-like questionnaire based on the SIMS (Situational Motivation Scale) [23] and the SRQ-A (Self-Regulation Questionnaire-Academic) [24] questionnaires. The questionnaire included 20 statements. Following are some of the statements. Statements 1 and 7 reflect intrinsic motivation, statement 3 expresses identified regulation, statements 2, 4, and 5 reflect introjected regulation, and statement 6 expresses external regulation.

1. I study electrical engineering because I think the studies are enjoyable.
2. I study electrical engineering because my parents want me to study it.
3. I study electrical engineering because I do it for my own good.
4. I study electrical engineering because I want people to think I am smart.
5. I study electrical engineering because my friends study electrical engineering.
6. I study electrical engineering because I am supposed to do it.
7. I study electrical engineering because I think it is interesting.

Appendix C: Open-ended questionnaire

Following is a sample of questions from the open-ended questionnaire, mentioned in Section 5.3.

1. What do you think about the course?
2. What was the most interesting lesson in the course?
3. What, do you think, is the best thing about the course?

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