Importance of technical and soft skills: electronics students' and teachers' perspectives

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ABSTRACT: In light of the gap between the qualifications of engineering and technology programme graduates and those required in the industry, the importance assigned by students and teachers to the technical and soft skills required of two-year electronics programme graduates is examined. Forty-four electronics students and 13 electronics teachers from a two-year college in Israel took part in the study, in which quantitative and qualitative tools were utilised. It was found that both the students and their teachers assigned relatively high importance to technical and soft qualifications. However, the importance assigned by the students to these skills was significantly lower than that assigned by their teachers. It might be possible to explain the findings by the present curriculum not having sufficient emphasis on providing students with relevant technical and soft skills.

Keywords: Technical skills, soft skills, electronics students, electronics teachers, two-year colleges

INTRODUCTION

As a result of the gap between the skills of engineering and technology programme graduates and those required in industry [1][2], the Accreditation Board for Engineering and Technology (ABET) has determined the qualifications required of graduates of the programmes: engineering (Bachelor, Master) and engineering technology (Associate, Bachelor). It has been established that programme graduates should possess applicable knowledge, technical skills and soft skills, with specific knowledge and skills applying to each programme [3]. Of the technical skills is the ability to identify and solve engineering/technology problems, and among the soft skills - the ability to work in teams and communicate effectively.

Whereas the literature extensively covers the qualifications required of engineering graduates and the importance assigned to them by the students [4-6], research with regard to associate degree holders has been limited [7]. Therefore, this article is focused on the importance assigned by Israeli students and teachers to the technical and soft skills required of two-year electronics programme graduates.

A two-year technical college is a tertiary educational institution providing training that is mainly practical in various branches of technology. Most of the students of the college are from the socioeconomic periphery or attain relatively low academic achievements [8][9].

The length of training, the practical focus of the curriculum and the characteristics of the students at two-year colleges in Israel are similar to those of American colleges providing associate degrees [10][11]. The teachers at the college usually hold a Bachelor's degree in engineering or engineering education. They teach one or two courses per semester and are not required to engage in research.

The electronics curriculum, which is the focus of this study, has the purpose of providing students with knowledge and skills in three areas: analysis and design of analogue and digital electronic circuits, writing and developing software and designing embedded systems. The first year is dedicated to studying the basics of electronics, both in theory and in practice. In the second year, the students take advanced courses and complete a final project. The project is done in teams, and the students are required to present it both in writing and orally.

In addition to the contribution of this study to the limited body of knowledge on the skills required of technology programme graduates, its practical importance may be reflected in the implementation of the findings in the improvement of teaching and learning at two-year technical colleges in Israel and elsewhere. Such improvement may lead to the reduction of the existing gap between the skills of technology programme graduates and those required in industry.

The article begins with a concise review of technical and soft skills in engineering and technology education. It then presents the research goal and methodology. Finally, the main findings and conclusions are described.

TECHNICAL AND SOFT SKILLS IN ENGINEERING AND TECHNOLOGY EDUCATION

In general, *technical skills* (or *hard skills*) refer to capabilities that can be learned and are relatively easy to measure, such as the use of software. These qualifications are perceived to be connected to cognitive intelligence, and relate to the ability to perform a particular type of activity or task [12].

In the engineering/technology context, technical skills include the ability to apply the knowledge and skills of the discipline to engineering/technology activities, the ability to identify and solve engineering/technology problems, the ability to conduct experiments/standard tests and to analyse the results, and the ability to identify and use technical literature [3]. Traditionally, the focus in engineering and technology programmes has been on these types of qualification [13].

As a result of the technological development and accelerated globalisation, demand has increased for engineers and technologists with communication, teamwork and management skills [1]. Consequently, an understanding has developed among employers and researchers that it was no longer possible to settle for the set of technical skills listed above, but there is a need for an additional set of qualifications - qualifications that have been given the name, *soft skills* [13].

Soft skills are defined as a collection of interpersonal and social qualifications that permit the individual to function well in society and to achieve his/her objectives. It is customary to assign these skills to emotional intelligence and, contrary to technical qualifications, soft skills can be implemented in a broad context and are not limited to a particular type of activity [14]. In the engineering/technology context, soft skills include effective written and oral communication, efficient teamwork, engagement in self-directed learning, commitment to continuous improvement, and addressing professional and ethical responsibilities [3].

Recognising the necessity of soft skills, ABET has updated the accreditation criteria for engineering and technology programmes, so as to include soft skills alongside technical skills [3]. Consequently, educational institutions, such as Purdue University (US), University College London (UK) and Shantou University (China) have begun emphasising the importance of soft skills [14]. However, it should be noted that it is not simple to find the appropriate balance in the curriculum between technical skills and soft skills [15], and that there is still a gap between university training and industry requirements [16-18].

RESEARCH GOAL AND METHODOLOGY

The study characterised the importance of technical and soft skills from the standpoint of electronics students and teachers at a two-year college. Forty-four second-year electronics students at a leading two-year college in Israel participated in the study. Their average age was 20 years. Additionally, 13 electronics teachers from that same college took part in the study. The teachers' average age was 50 years, and their average teaching experience was roughly 16 years. The participants were representative of the electronics students and teachers at the college.

Both quantitative and qualitative tools were utilised in this study. The students and their teachers completed an anonymous closed-ended questionnaire used for evaluating the importance they assigned to technical and soft skills. Additionally, five semi-structured interviews were held with students and five interviews with teachers to broaden the information gleaned from the questionnaire. The quantitative data were statistically analysed, and the qualitative data underwent conventional content analysis performed by two engineering education experts. Only information obtained from at least three different participants was included in the analysis.

The questionnaire for evaluating the importance assigned by students and teachers to the technical and soft skills required of two-year electronics programme graduates was a five-level Likert scale, ranging between *strongly agree* and *strongly disagree*. The questionnaire covered the four technical skills and the five soft skills established by ABET as the qualifications required of two-year technology college graduates [3]. These abilities were mentioned above. Thus, for example, the statement *…a two-year electronics programme graduate should be able to conduct standard tests and measurements, and to analyse and interpret the results* is related to a technical skill, whereas the statement *…a two-year electronics programme graduate should be able to function effectively as a member of a technical team* is related to a soft skill.

The questionnaire was validated by two engineering education experts and five students who did not take part in the study. Cronbach's alphas were 0.70 (technical skills) and 0.67 (soft skills), indicating acceptable internal consistency.

In the interviews, the participants were asked, *inter alia*, what the most important technical and soft skills for two-year electronics programme graduates were, and whether the present curriculum put sufficient emphasis on providing those skills.

FINDINGS

For each of the two skill groups, an importance index (hereinafter, technical/soft index) was defined as the average of the agreement ratings of the four/five qualifications belonging to that group. The indexes, ranging between 1 and 5, were calculated separately for the students and their teachers. The indexes are provided in Table 1.

Table 1: Importance index (students and teachers).

Importance index	Group	M	SD
Technical	Students	4.13	0.55
	Teachers	4.63	0.32
Soft	Students	4.08	0.49
	Teachers	4.43	0.35

For the students, it was found that the correlation between the technical index and the soft index was weak and not significant ($r = 0.24$, $p > 0.05$). The same was also true for the teachers ($r = 0.37$, $p > 0.05$). Therefore, MANOVA was not performed (with the technical index and soft index being dependent variables), but a separate statistical analysis was done for each index, as described in the following sections.

Technical Skills

To examine whether there was a significant difference between the students and their teachers as to the importance they assigned to technical skills, a *t*-test (unequal variances) was performed for the technical index. The findings indicate a significant gap in favour of the teachers ($t(35) = 4.16$, $p < 0.01$).

To identify the factors leading to the above gap, shown in Figure 1 is the mean importance score of each of the four technical skills (students and teachers), and displayed in Table 2 are the corresponding effect sizes (Cohen's *d*). The findings indicate a large effect size with regard to identifying and using technical literature and medium effect sizes with regard to the remaining qualifications.

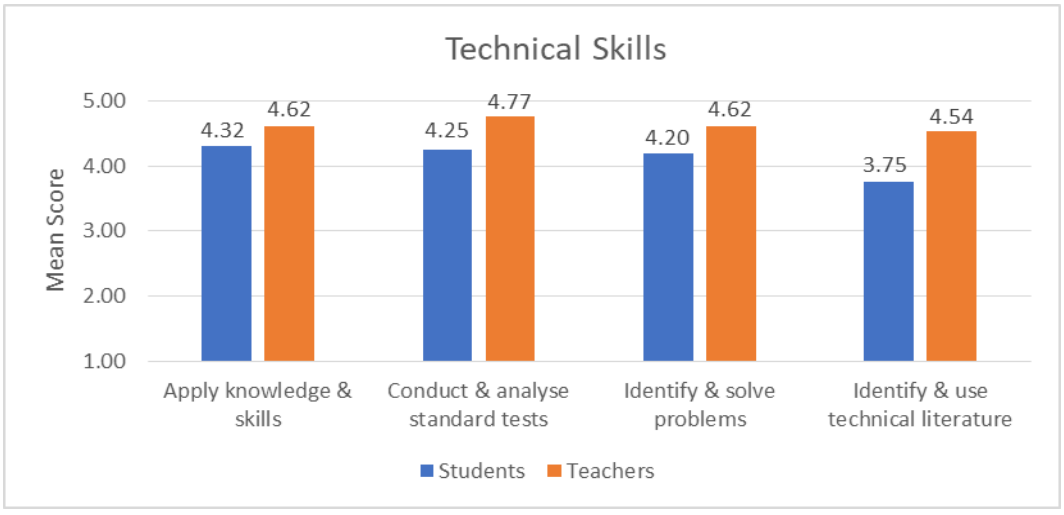

Figure 1: Technical skills: mean importance score (students and teachers).

Table 2: Technical skills: effect sizes.

Technical skill	*d*
Apply the knowledge and skills of electronics to technology activities	0.51
Conduct standard tests and analyse the results	0.64
Identify and solve problems in electronics	0.57
Identify and use technical literature	1.01

The key themes derived from the qualitative analysis are presented in Table 3. According to the findings, both students and teachers believe that the present curriculum does not sufficiently stress providing students with relevant technical qualifications.

Table 3: Technical skills: key themes (students and teachers).

Group	Category	Examples	Interpretation
Students	Insufficient reflection	*[Providing] technical skills constitutes maybe 10% [of the curriculum]… In the curriculum it is not given importance.* *The ability to apply [the] knowledge and skills [of electronics to technology activities] is not taught [on the programme]… [As to] technical literature - there is a course in technical English, but the course does not teach how to read and understand technical literature, but focuses on reading comprehension.*	The current curriculum does not sufficiently stress providing the students with relevant technical qualifications
Teachers	Importance of technical literature	*One of the most important technical skills for a two-year electronics programme graduate is using technical literature.* *They [the students] should read data sheets, understand what each component does and how it works.*	Using technical literature is a key skill
	Insufficient reflection	*Due to time constraints, technical skills are not reflected in the curriculum.* *Technical skills are provided only in electronics laboratories, which is very little… More things are necessary.*	The current curriculum does not sufficiently stress providing the students with relevant technical qualifications
	Connection to real-world scenarios	*I try to give them [the students] real-life problems and integrate them into the lectures and exercises… But, it is not part of the syllabus.* *They [the students] should be provided with the connection to the actual things… They should build a circuit and measure.*	The connection to real-world scenarios should be emphasised

Soft Skills

To examine whether there was a significant difference between the students and their teachers as to the importance they assigned to soft skills, a *t*-test (equal variances) was performed for the soft index. The findings indicate a significant gap in favour of the teachers ($t(55) = 2.36$, $p < 0.05$).

To identify the factors leading to the above gap, shown in Figure 2 is the mean importance score of each of the five soft skills (students and teachers), and presented in Table 4 are the corresponding effect sizes. The findings indicate a zero-effect size with regard to communication skills, and medium effect sizes with regard to the remaining qualifications.

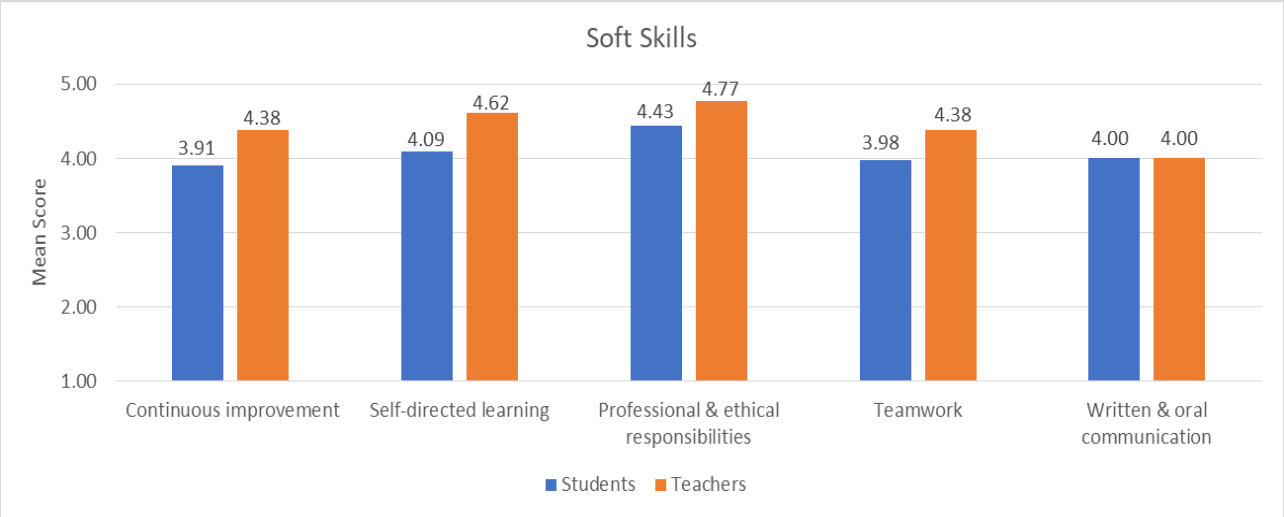

Figure 2: Soft skills: mean importance score (students and teachers).

Table 4: Soft skills: effect sizes.

Soft skill	*d*
Commitment to continuous improvement	0.55
Engage in self-directed learning	0.56
Address professional and ethical responsibilities	0.57
Function effectively as a member of a technical team	0.48
Apply written and oral communication	0

Table 5: Soft skills: key themes (students and teachers).

Group	Category	Examples	Interpretation
Students	Importance of effective communication	*In the industry, upon graduation, one should be able to communicate effectively, both orally and in writing.* *Expressive abilities are very important... In the industry you should be able to clearly explain yourself.*	Effective communication is a key skill
	Insufficient reflection	*Self-directed learning - we were not taught that… I see students sit and wait to receive explanations… [As to] continuous improvement - no one talks to us about it.* *It can be said that [in the programme] there is no focus on teamwork… There is no [focus on] independent learning, and no focus on expressive abilities either.*	The current curriculum does not reflect the need to provide the students with relevant soft skills, almost at all
Teachers	Importance of effective communication	*One of the most important [soft] skills is knowing how to communicate effectively.*	Effective communication is a key skill
	Insufficient reflection	*This [reflecting soft skills in the curriculum] is almost non-existent.* *This [providing soft skills] is not built into the curriculum.*	The current curriculum does not reflect the need to provide the students with relevant soft skills, almost at all
	Dependence on teachers	*When the teacher does not have it [providing soft skills] in writing [in the curriculum] that it needs to be done, then it will not happen.* *It [providing students with soft skills] depends on each teacher and his or her method.*	Providing students with soft skills depends on the individual teacher's teaching method

The qualitative analysis (Table 5) reveals the high importance assigned by both students and teachers to effective communication, and indicates that the present curriculum does not reflect the need to provide the students with relevant soft skills, almost at all.

DISCUSSION AND CONCLUSIONS

According to the findings, the mean scores of the technical index and soft index were over 4, both for the electronics students and teachers. These results indicate that the students and their teachers assign relatively high importance to technical and soft skills. These findings correspond in part to the results of earlier studies that have shown that students of computer engineering [4], civil engineering, electrical engineering and mechanical engineering understood the relevance of soft qualifications [1]. A study performed among students of a two-year technical college has also indicate a positive perception of soft skills as an indicator for success at work [7].

Beyond that, the present study indicates a significant gap in the importance assigned to technical skills between the students and their teachers. This gap, in favour of the teachers, was characterised by a medium-large effect size. According to the findings, the biggest difference between the two groups was in the importance assigned to identifying and using technical literature. Regarding soft skills, it was found that the importance assigned by the students to these

qualifications was significantly lower (medium effect size) than that assigned by their teachers. However, both students and teachers agreed concerning the importance of effective written and oral communication.

Most of the findings above possibly could be explained by the present curriculum not having sufficient emphasis on providing technical qualifications (particularly the use of technical literature), and not reflecting adequately the need to provide soft skills. This fact did not permit the teachers to dedicate the necessary time, throughout the entire programme, to these subjects that they viewed as very important, and this possibly could have affected the importance assigned to these qualifications by their students. However, it should be noted that the above imbalance in the curriculum is characteristic of many educational institutions [15], and is one of the causes for the gap between the training provided by them and industry requirements [16-18].

Thus, the authors recommend to revise, where needed, the curriculum of two-year electronics programmes, so as to dedicate sufficient time to providing the students with both technical and soft skills. Based on the findings, one of the means proposed for developing these qualifications (including the use of technical literature) is integrating *real-life* problems into the curriculum. It should be noted that this tool promotes learning in both the cognitive [19] and affective domains [20][21].

The main limitation of the study is the relatively small number of participants. Therefore, to increase the findings' trustworthiness, both quantitative and qualitative instruments were used.

Beyond the theoretical contribution of the study to the limited body of knowledge concerning the technical and soft skills of students at two-year technical colleges, its practical importance may be reflected in the implementation of the study findings for the purpose of improving the quality of teaching and learning at two-year colleges in Israel and in other countries. Such improvement may lead to the reduction of the existing gap between the skills of technology programme graduates and those required in the industry [2].

In a future study, the authors will examine the importance assigned by employers to the technical and soft skills required of two-year electronics programme graduates. In addition, it is intended to investigate other technology programmes, such as mechatronics and biotechnology.

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BIOGRAPHIES

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