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Engineering students' attitudes towards teaching in secondary schools as part of the *Educational Clinic* programme

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ABSTRACT: As part of the effort to increase involvement in the community, the Technion - Israel Institute of Technology initiated a unique programme entitled the *Educational Clinic*, which trains students to be teaching assistants in secondary schools. After undergoing academic training, the students teach science and engineering to small groups of secondary school students for a period of ten weeks' duration. The study described in this article characterised, by means of qualitative tools, the attitudes of 46 engineering students towards teaching in secondary schools in the framework of the programme. It was found that the weight of the attitude component, which recognised the contribution of teaching in the programme was notably higher than the weight of the component indicating the difficulties that accompanied the teaching experience.

Keywords: Attitudes towards teaching, engineering education, outreach activities, secondary schools

INTRODUCTION

A unique programme, entitled the *Educational Clinic*, was recently developed by the Technion - Israel Institute of Technology (hereinafter: the Technion). The programme, extending over one academic year, was designed to train undergraduate students to be secondary school science and engineering teaching assistants. Like other similar academic programmes [1-3], this programme is part of the effort to increase involvement in the community and to encourage secondary students to pursue science and engineering studies. The programme is given added validity in view of the ongoing shortage of engineers and scientists in Israel and the Western world [4].

The first part of the programme is 13 weeks long (three hours per week) during which the theoretical and practical basis of teaching is taught. During the second part of the programme, which is 10 weeks long (also three hours per week), the students teach small groups of secondary school students science and engineering. The students participating in the programme receive three academic credit points.

A study examining the motivation to participate in the programme among 13 students who participated in the programme's first cohort (2013) has been published [5]. According to the findings, during the academic year, a considerable increase occurred in the weight of intrinsic motivational factors, which reflect the interest and pleasure the students derived from the programme. The current study examined the programme from a different perspective and characterised the attitudes of 46 engineering students who participated in the programme over the last two years, towards teaching in secondary schools as part of the programme.

The article opens with a description of the *Educational Clinic* programme. Later, the objective of the study and the chosen methodology are presented. After describing and discussing the primary findings, future research directions are proposed.

THE *EDUCATIONAL CLINIC* PROGRAMME

The first part of the *Educational Clinic* programme focuses on learning theories and teaching methods. The first three weeks are dedicated to the various aspects of learning. Thus, for example, theories of cognitive development [6] and the theory of multiple intelligences [7] are mentioned in regard to the cognitive domain. From the affective aspect,

motivation theories, such as the self-determination theory [8], are taught in their educational context. Finally, from the social perspective, phenomena relevant to learning, such as social facilitation, conformity and the Pygmalion effect are reviewed. Later on, leading learning theories, such as behavioural learning [9], cognitive-behavioural learning [10] and social learning [11] are presented. The following three weeks are dedicated to teaching, during which taxonomies of educational objectives [12] and various teaching and evaluation methods are presented.

In the seventh week, the course faculty give a model lesson on scientific or engineering subject matter at the secondary level, after which, during the eighth to thirteenth weeks, each student teaches his/her fellow students a 35-45 minute lesson on a subject of his/her choice from the secondary science or engineering curriculum. Among the subjects chosen by the students are *Newton's Second Law of Motion* (physics), *Acids and Bases* (chemistry), *Cell Components* (biology), and *Logic Gates* (electronics). The rest of the students participate actively in the lesson and, simultaneously, fill out an evaluation form. At the end of the lesson, a discussion with the participation of the student teaching the lesson, his/her peers and the course faculty takes place, at the end of which, the student is required to submit a reflection report on the lesson.

During the second part of the programme, the students teach science and engineering in secondary schools. The students teach small groups of 4-20 secondary students under the guidance of professional teachers. One should note that the students choose the field of study, lesson contents and the school according to their own free will. The result, therefore, is that some of the students help secondary students who are experiencing difficulties, whereas others facilitate enrichment activities for outstanding secondary students. The course faculty are continuously in touch with the students and the professional teachers, and hold guidance meetings with the students, in which points of difficulty are discussed.

RESEARCH GOAL AND METHODOLOGY

The study examined engineering students' attitudes towards teaching in secondary schools in the framework of the *Educational Clinic* programme.

The study population included 46 undergraduate students at the Technion (34 men; 12 women) who participated in the programme over the last two years. The students, who were in the 3rd-8th semester of their studies, belonged to the following departments: Civil and Environmental Engineering, Mechanical Engineering, Electrical Engineering, Chemical Engineering, Industrial Engineering and Management, Materials Engineering and Biomedical Engineering. The participants served as teaching assistants in Northern Israel in the following subjects: mathematics, physics, chemistry, biology, computer sciences and electronics. It is important to note that the students had no previous teaching experience in schools. In addition, one should note that the format of the programme (including contents and assignments) and the course faculty remained the same over the last two years.

Since the study focused on characterising students' attitudes, the qualitative methodology [13] was chosen. Each student was asked to fill out an open-ended questionnaire at the end of the programme. The questionnaire is provided in Appendix A. In addition, after the end of the programme, seven semi-structured interviews were conducted with students. A sample of the interview questions is presented in Appendix B. The data were subjected to content analysis and were classified into categories. The tri-component attitude model [14] served as the theoretical framework for the qualitative analysis.

FINDINGS

The analysis of the findings indicates the presence of an affective component and a cognitive component in students' attitudes. From the affective aspect, approximately 40% of the students answering the questionnaire stated that teaching was pleasurable: …*Teaching is pleasurable because you can see the enthusiasm in the* [secondary] *students' eyes* (questionnaire). Approximately one-fifth (21.7%) noted the satisfaction entailed in teaching: …*During the activity* [teaching physics], *I experienced satisfaction when I saw the* [secondary] *students making progress, and especially at the end* [of the activity], *once they got their test scores and said thank you and that it had helped them* (questionnaire). Approximately one-tenth (10.9%) of the students thought the teaching experience contributed to reinforcing their sense of self-confidence: …*The experience contributes to reinforcing self-confidence in facing an audience* (questionnaire).

From the cognitive aspect, approximately one third (34.8%) of those answering the questionnaire pointed out that the educational activity contributed to the improvement of their teaching skills: …*The activity contributes to the improvement of teaching skills… especially in regard to writing in a clear and organised manner on the board and a correct distribution of time* (questionnaire). Approximately one-quarter (26.1%) of the students noted the contribution of the activity to promoting secondary students' learning: …*I taught the students mathematics… I think the* [secondary] *students get a lot out of it* [the activity]*… it helps them overcome their weak points in mathematics* (questionnaire). Approximately 15% of the students stated that the teaching experience contributed to the recognition of the complexity of the teacher's role. The following quote, taken from an interview with a student who taught chemistry, demonstrates the point: …*I noticed a lot of aspects of the teacher's work that I had not considered before, like verbal and nonverbal communication… providing positive reinforcement for the students' answers… my most important conclusion* [from teaching] *is that teaching is not a simple task* (interview).

Some students were of the opinion that there were a number of difficulties involved in teaching in secondary schools as part of the programme. Approximately one tenth (13.0%) of those responding to the questionnaire thought the activity was too short to forge a significant relationship with the students: …*It is a pity it* [the educational activity] *was so short… in such a short period of time it is difficult to forge a deep enough relationship with the* [secondary] *students* (questionnaire).

Others (8.7%), noted the difficulty in adapting the level of teaching the students were used to at the Technion to a secondary level. Support for this finding can be found in the following quote taken from an interview with a student who taught electronics: …*It is not easy to adapt the level of teaching I am used to* [from my studies at the Technion] *to the level of secondary school students… it is hard not to use terms like holes and mobility, which for me come naturally, but secondary school students are not supposed to know them at all* (interview).

Table 1 summarises the students' attitudes towards teaching as part of the *Educational Clinic* programme. The frequency stated in the Table refers solely to the frequency of the findings arising in the questionnaire. In addition, the examples in the Table have been taken from the students' answers to the questionnaire.

Table 1: Teaching in the *Educational Clinic* programme - engineering students' attitudes.

Component	Category	Subcategory	Frequency (%)	Example	Interpretation
Affective	Causing pleasure		39.15	We spent three hours studying trigonometric functions together… we had a fruitful discussion… it was very pleasurable.	Teaching causes pleasure
	Creating satisfaction		21.70	I felt that I was contributing to the [secondary] students… it is what made me feel great and gave me a sense of satisfaction.	Teaching causes a feeling of satisfaction
	Reinforcing the sense of self-confidence		10.90	The teaching experience helps reinforce your self-confidence, because you get used to talking in front of an audience.	Teaching contributes to reinforcing the sense of self-confidence while facing an audience
Cognitive	Strengths	Improving teaching skills	34.80	It [the educational activity] contributes to improving teaching skills.	The educational activity contributes to the improvement of teaching skills
		Promoting secondary school students	26.10	It [the activity] allows the secondary school students to get academic help and support.	The educational activity contributes to the promotion of secondary students' learning
		Recognising the complexity of the teacher's role	15.20	I realised it is not easy to be a teacher… it is a challenging and complex task.	Teaching contributes to recognising the complexity of the teacher's role
	Difficulties	Difficulty in creating a significant relationship with the secondary students	13.00	The activity is too short… it is just about impossible to create a significant relationship with the [secondary] students in the time allotted to it [the activity].	There is a difficulty in creating a significant relationship with the secondary students due to the activity's relatively short duration
		Difficulty in adapting the teaching level	8.70	It is difficult to get used to using [in the classroom] secondary student terminology and not that of students at the Technion.	There is a difficulty in adapting the university level of teaching the students are used to, to a secondary level

DISCUSSION AND CONCLUSIONS

The study findings indicate the existence of an affective component in students' attitudes, according to which, teaching in the *Educational Clinic* programme is pleasurable, satisfying and even contributes to reinforcing the sense of self-confidence, and a cognitive component, which refers both to strengths and difficulties accompanying teaching in this

unique programme. The primary strength identified refers to the improvement of the students' teaching skills and the main difficulty revealed is the difficulty in creating a significant relationship with the secondary school students due to the relatively short duration of the activity. According to the results, the weight of the component that recognises the contribution made by teaching is substantially higher than the weight of the component indicating the difficulties involved in it.

It is interesting to compare the findings of the current study to those of the study investigating students' motivation to participate in the programme's first cohort [5]. According to its findings, during the academic year, a considerable increase occurred in the weight of intrinsic motivational factors, which reflect students' interest and pleasure in the programme. These results are in line with the ones received in the current study, according to which, at the end of the teaching segment (which is the last stage of the programme) the students reported the notable amount of pleasure they derived from the programme.

A study tracking the attitudes of engineering students who demonstrated laboratory experiments to secondary school students in Brazil reported the interest and pleasure the students found in the activity, along with the improvement of their teaching skills and an increased understanding of the fields they taught [3].

A comparison to the findings of the current study reveals that causing pleasure and improvement of teaching skills are the most frequent components in students' attitudes in this study; however, the aspect referring to improving students' understanding was not found. Additionally, the rest of the aspects in the students' attitudes that are less frequent and which were found in the current study were not mentioned in the other study.

The theoretical contribution of the study is reflected in the characterisation of the attitudes of engineering students towards teaching in secondary schools in the framework of the unique programme described in this article. This is the first time this has been done, to the best of the author's knowledge. The practical contribution is likely to be manifested in taking into account the findings, while improving the current programme or planning new programmes, which promote the involvement of students in the community and encourage secondary school students to pursue science and engineering studies. The importance of these contributions is given added validity in view of the grave shortage of engineers and scientists in many countries [4]. In a future study, the author intends to examine the secondary students' attitudes towards the programme.

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BIOGRAPHY

Aharon Gero holds a BA in Physics, a BSc in Electrical Engineering, an MSc in Electrical Engineering, and a PhD in Theoretical Physics, all from the Technion - Israel Institute of Technology. In addition, he has an MBA from the University of Haifa, Israel. He is a faculty member at the Department of Education in Technology and Science of the Technion. His research focuses on electrical engineering education and interdisciplinary education that combines physics with electronics, such as electro-optics and microelectronics education.

APPENDIX A: OPEN-ENDED QUESTIONNAIRE

Following is the open-ended questionnaire:

- What do you think about teaching in the programme? Explain.
- Describe what you were feeling while teaching.
- What are the advantages and disadvantages inherent to teaching in the programme?
- What did you learn from teaching in the programme?

APPENDIX B: INTERVIEW QUESTIONS

Following is a sample of questions from the interview:

- What do think about teaching in the programme? Explain.
- Describe what you were feeling while teaching.
- Describe the event most important to you, which took place while teaching. Explain why you chose that event.
- What are the advantages and disadvantages inherent to teaching in the programme?
- What was the best thing that happened while teaching? Explain.
- What was the worst thing that happened while teaching? Explain.
- What did you learn from teaching in the programme?