1. INTRODUCTION

The ACM K-12 Education Task Force Report [14] draws attention to the need for appropriate CS teacher training programs and points out that "teachers must acquire both a mastery of the subject matter and the pedagogical skills that will allow them to present the material to students at appropriate levels." At the same time, claims are heard that many of the current teacher training programs do not sufficiently emphasize teaching skills that will allow the prospective teachers a smooth transition into their professional careers (cf. for example [3]). Gal-Ezer and Harel [4] referred to the "problematic of teaching programming" and the need to improve those skills in CS teachers training. Other authors similarly recognized that one of the major skills expected from CS teachers is to know how to cope with learners' difficulties in problem-solving situations [5, 10, 14].

In general, teacher preparation programs are based on three elements: the subject matter, education and pedagogy, and practicum in real classes. The practicum is usually based on observing lessons given by expert teachers and on teaching several lessons. As such, the practicum framework draws the prospective teachers' attention to CS content-knowledge, teaching activities and class management issues. However, it does not provide the prospective teachers with opportunities to guide problem-solving processes on the individual level, guiding pupils in the development process of an algorithm or a computer program for a given problem. Since problem solving is part of the CS core, in order to close this gap we propose a tutoring model for prospective CS teachers in which they tutor students' problem-solving processes in a continuous manner that allows them to follow the learner's understanding processes and the development of the learner's problem-solving skills as well as their own teaching.

The suggested tutoring model is integrated into a Methods of Teaching Computer Science course [6, 9] and is based on and supported by the course contents and activities. Each of the course participants, who tutor an undergraduate student taking an introductory CS course, performs the one-on-one tutoring. The tutoring framework gives the prospective teachers the opportunity to practice the new knowledge acquired in the Methods of Teaching CS course in a friendly, one-on-one environment, in which they can focus on problem-solving processes. In addition, the tutoring offers the prospective...
teachers opportunities to improve their own understanding of CS concepts.

In general, tutoring is defined as "interpersonal interaction where one intends to assist the other" [13], whereas in peer-tutoring in particular, which is the model employed in our research, the tutor must not be an expert, and the peer can be same-age or cross-age [7]. In our context, the tutors are new experts in CS but novice CS teachers.

Tutoring models have different purposes. Morgan, Whorton and Willets [11] investigated how peer mediation can develop pre-service teachers' instructional behavior, when the learned subject was teaching strategies (and not the teaching of a subject matter). Kloyer [8] investigated peer-tutoring in pre-service Math teacher preparation, whereby the tutors were at a more advanced stage of their studies than the tutees, and the focus was placed on lesson preparation. Tutoring and peer-tutoring is used also in CS academic studies to improve the tutees understanding of CS and to reduce dropout from academics programs [1, 2].

Common to these, as well as to other peer-tutoring models, is that they aim at promoting the tutees, even though most of the research reports also indicate improvement on the part of the tutors.

The innovation of the tutoring model presented in this paper is its focus on the student tutors – the prospective CS teachers – and its target is to improve their guiding skills of problem-solving processes.

2. THE TUTORING MODEL

2.1 Tutoring Goals
The main goal of the tutoring model is to enable prospective CS teachers to improve their teaching skills by practicing guiding CS learners through problem-solving processes.

The tutoring model aims at promoting the prospective teachers' skills with respect to three aspects:

1. **Disciplinary-pedagogical knowledge**: This aspect refers to the exposure of the prospective CS teachers to difficulties involved in CS learning. It is addressed theoretically in the Methods of Teaching CS course and is applied in the one-on-one tutoring model. The tutoring activity provides the prospective teachers opportunities to identify real learners' difficulties, to assist and promote learners while coping with problem-solving, to choose an appropriate teaching method that will promote their tutee's knowledge and understanding and to adopt a researcher's point of view.

2. **Pedagogical knowledge**: This aspect refers to the prospective teachers' general teaching skills, such as building personal relationships with learners, increase their confidence and becoming reflective practitioners [12].

3. **Disciplinary knowledge**: The tutoring process enables the prospective CS teachers to improve their own understanding of the subject matter, in our case, CS.

2.2 Tutoring Structure

2.2.1 The Methods of Teaching CS Course
The one-on-one tutoring requirements were integrated into the Methods of Teaching Computer Science course. The course includes five core issues:

1. **Difficulties** of CS learners with respect to the Israeli high school CS curriculum.
2. **Misconceptions** and alternative conceptions in learning CS concepts, and ways to recognize them.
3. **Teaching methods** to be used in class to enhance learners' understanding of the subject matter as well as their interest, curiosity, and joy.
4. **Research** in computer science education.
5. **Reflection** as a meta-cognitive tool.

2.2.2 Tutor’s Requirements
The tutoring model is based on a set of requirements that the tutor students must fulfill within two semesters. These requirements account for 25% of the course grade each semester. The requirements for each semester are as follows:

1. Find an undergraduate student tutee who is taking one of the Introduction to CS courses.
2. Meet the tutee five times during the semester; each session lasting approximately two hours.
3. After each tutoring session, complete and submit a Tutoring Session Feedback Worksheet (i.e., structured reflection).
4. Meet the course moderator for an interview twice: once after the first tutoring session and once after the last session.
5. Complete an Overall Evaluation Questionnaire.
6. Present one episode from the tutoring process as a case study in the framework of the Methods of Teaching CS course.

2.2.3 Tutor Support
Since the tutors are unfamiliar with the tutoring activity, an extensive support framework was established to assist the tutors. The support framework included a guidance talk in the first course lesson, a face-to-face meeting with the course moderator immediately after the first tutoring session with the tutee, written feedback on each of the submitted Tutoring Session Feedback Worksheets, an open-door (and open-email) policy on behalf of the course moderator and management of on-line forums.

2.3 Tutoring Guidelines
The following guidelines were formulated while designing the tutoring model:

- Tutor a single student in a continuous manner: This enables the tutor to examine the influence of the tutoring process on the tutee: What helps him/her? What does s/he still misunderstand? Which problem-solving tools did s/he adopt? This element also reduces the tutors' concerns because they become familiar with their tutee.
- Tutor a university student rather than a high school student: This enables the prospective CS teachers to tutor in their familiar surroundings and facilitates accessibility to the tutees.
- Conduct five two-hour long tutoring sessions: Five sessions enable continuity and development; a two-hour session enables to focus on problem-solving processes; a total of ten tutoring hours enables to achieve the model's targets and is not too demanding.
- Meet with the tutee in person: This guideline welcomes and fosters true problem-solving processes and avoids situations
3.1 Research Objectives and Questions

The research objectives were to investigate the pedagogical contribution of the tutoring model and to examine its practicability. The following research questions were derived from these objectives:

1. How do the prospective teachers acquire the following disciplinary-pedagogic skills:
   1.1. Identifying difficulties encountered by CS learners.
   1.2. Guiding CS learners through problem-solving process.

2. How do the prospective teachers acquire the following pedagogic skills:
   2.1. Becoming reflective practitioners.
   2.2. Applying a variety of teaching strategies.

3. Do the prospective teachers promote their disciplinary (CS) knowledge?

4. How do the prospective teachers evaluate the tutoring model?

5. Should the tutoring model be implemented within the Methods of Teaching Computer Science course?

3.2 Research Population

The research population consisted of ten students who participated in the Methods of Teaching Computer Science course at the Technion’s Department of Education in Technology and Science. The course consists of 56 hours of classes and training each semester, for two semesters, and is usually studied during the third year of study out of four. The population was diverse: six women and four men; six Israeli natives and four new immigrants; three spoke Hebrew as their mother language, three Arabic and four Russian.

3.3 Research Methodology and Tools

To answer the research questions, we employed both quantitative and qualitative tools. Though the quantitative data is not significant in small groups, it was used in this exploration to support the qualitative findings. To validate the findings, different research tools were used, as listed below:

1. “The future as a CS teacher” questionnaire filled by the tutors at the beginning of the tutoring and at its end. It was filled also by academic CS educators who were invited to speculate the prospective teachers’ perspectives.

2. Interviews with the tutors following their initial and final tutoring session with their respective tutees.

3. Tutoring Session Feedback Worksheets: Five forms completed by each tutor each semester.

4. An overall evaluation questionnaire completed by the tutors (with 36 standpoints questions and 16 open questions).

5. An overall evaluation questionnaire completed by the tutees (with 13 standpoints questions and 5 open questions).

6. A summarizing interview with some of the tutees.

7. Various homework assignments.

8. Researcher’s diary.

4. RESEARCH FINDINGS

Due to space limitations, in this paper we answer Research Questions (RQ) 1.1, 1.2, 2.1, and 4. The other research questions will be addressed in the conference.

We illustrate our findings with representative qualitative and quantitative data of two kinds: Evidence that relates to the Methods of Teaching CS course and evidence that relates to the tutoring model from both the tutors’ and the tutees’ perspective.

The quantitative findings are based on the Overall Evaluation Questionnaire completed by the tutors and the tutees using a 1-7 scale (1- low, 7- high). For each such entry we display the average and the standard deviation in parentheses. The qualitative findings are based on short quotes taken from the different research tools. When presenting a quote, the tutor is indicated by a number in squared brackets (e.g., [St. 4]).

4.1 Identifying Learners’ Difficulties (RQ 1.1)

The research findings indicate that the tutors improved their skills in identifying learners’ difficulties and attributed this improvement to the activities in the Methods of Teaching CS course that addressed learners’ difficulties and to the tutoring model. Table 1 presents the tutors’ positive evaluations of these activities.

Table 1. Contribution of different course activities to the skill of identifying learners’ difficulties - Tutors (N=10)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Average (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure to research in CS education</td>
<td>6.50 (0.70)</td>
</tr>
<tr>
<td>In-depth study of one research article in CS education</td>
<td>6.30 (0.67)</td>
</tr>
<tr>
<td>Reviewing the article: “What (Else) Should CS Educators Know?” [4]</td>
<td>6.10 (0.73)</td>
</tr>
<tr>
<td>The activity: “The teacher as a researcher”</td>
<td>6.10 (0.99)</td>
</tr>
</tbody>
</table>

Here are several quotes explaining the contribution of the course and the tutoring model to improving the tutors’ skills of identifying pupils’ difficulties:

The course: The “The teacher as a researcher” activity gave me an overview of how pupils think, what learners’ mistakes are in specific subjects, how their knowledge can be improved, where they have misconceptions, and how to fix them. I will know now where the misconception may be and how to fix it a-priori. [St. 7]

The tutoring: I learned how to identify a misconception and how to fix it and not to do things that can cause misconceptions. [St. 4]

The tutors’ standpoint is reinforced by the tutees’ responses as shown in Table 2.
Table 2. Contribution of the tutoring activity to acquiring skills of identifying learners’ difficulties - Tutees (N=10)

<table>
<thead>
<tr>
<th>Assertion</th>
<th>Average (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I felt that my tutor identified the source of my difficulties</td>
<td>6.44 (1.01)</td>
</tr>
</tbody>
</table>

4.2 Guidance of the Problem-Solving Process (RQ 1.2)

The research findings indicate that the tutors increased their awareness with respect to their responsibility of guiding the tutees through their problem-solving processes and that the tutoring activity provided them with the opportunity to investigate how learners function in problem-solving processes. Following are several illustrative excerpts in which the tutors reflect on their ability to direct CS learners in problem-solving processes during the tutoring activity:

You should make sure that he understands. He should understand – that's it. You are responsible for his understanding. It is not you who should transfer the material – and this is the point – this is the essence. [St. 5]

I succeeded in simplifying that [the solution]. I succeeded in going down to the way she thinks and did not give her the solution. I was thinking together with her. I told her: “What shall we do with this? What shall we do with that?” It helped me and it seems to me that it helped her that I did not solve the exercises for her, but rather guided her thinking process. I didn't help her solve the exercise. [St. 7]

The tutees’ feedback further emphasizes the tutors’ skills in guiding them through problem-solving processes. The tutees felt that they acquired problem-solving tools and that the tutors tailored their explanations to the tutees’ personal needs. This perspective is reflected in their Standpoint Evaluation Questioner as shown in Table 3 and in the following quote:

[She] focused my attention on the correct solving method, giving me a lot of experience in solving exercises, opening my eyes to points I did not notice before and to problematic points that I might fail in. [she] taught me approaches. [St.6]

Table 3. Contribution of the tutoring activity to skills related to guiding the problem-solving process - Tutees (N=10)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Average (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I gained tools that help me in solving problems</td>
<td>6.11 (1.05)</td>
</tr>
<tr>
<td>The tutor adapted his/her explanations to my needs</td>
<td>6.44 (0.72)</td>
</tr>
<tr>
<td>I felt that the tutor guided me in the process of developing a suitable solution for a given problem</td>
<td>6.55 (0.53)</td>
</tr>
</tbody>
</table>

4.3 Becoming Reflective Practitioners (RQ 2.1)

The research findings indicate that the tutors understand the importance of reflective thinking and assimilated this kind of thinking in their practice, as is reflected in Table 4 and in the following quote:

Therefore, had I asked him to execute his program on a specific input, I would have achieved two things:

understanding the tutee’s ways of thinking in the problem-solving [process] and improving the tutee’s understanding by identifying problems in the solution he proposed. [St. 4]

Table 4. Contribution of reflection processes - Tutors (N=10)

<table>
<thead>
<tr>
<th>Assertion</th>
<th>Average (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflective thinking contributed to my learning</td>
<td>6.00 (1.15)</td>
</tr>
<tr>
<td>Reflective thinking will contribute to my work in the future</td>
<td>6.50 (0.52)</td>
</tr>
<tr>
<td>It is important to complete a reflective report after each tutoring session</td>
<td>6.20 (1.13)</td>
</tr>
</tbody>
</table>

Further, as it turns out, the tutors pointed out that they used reflection in their tutoring sessions and guided their tutees to do so as well:

I asked her to find what was wrong with what she wrote and that gave her [an opportunity] to think about thinking; that is, to find her mistake and, in this way, she will improve her thinking and arrive at the solution. [St. 7]

I guided the tutee in reflecting on why he didn’t succeed in solving the problem and learning from his mistakes. [St. 8]

4.4 Evaluation of the Tutoring Model (RQ 4)

The questions in both the tutors’ and the tutees’ Overall Evaluation Questionnaires were divided into four categories: Overall contribution of the tutoring, acquisition of problem-solving skills, teaching framework and atmosphere, and teaching skills. Figure 1 presents the average grade given by each population (tutors and tutees) to each category. Figure 1 also indicates that there is a relationship between the way the tutors and tutees perceive and evaluate the tutoring activity and the high ranking of the first two categories – overall contribution of the tutoring and acquisition of problem-solving skills – which were among the main targets of the tutoring model.
Table 5. Evaluation of the tutoring model – Tutors (N=10)

<table>
<thead>
<tr>
<th>Assertion</th>
<th>Average (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The tutoring model is important for prospective teachers</td>
<td>6.00 (0.94)</td>
</tr>
<tr>
<td>A similar model can be applied in other domains as well</td>
<td>6.30 (0.67)</td>
</tr>
</tbody>
</table>

These evaluations are further supported by the following quotes, which address the model in general and the importance of the one-on-one component of the model in particular:

I learned to think about possible problematic points that might be encountered by the pupils and to focus my teaching around these problems. [St. 4]

I see that he [the tutee] started to progress in the material. He has already acquired specific problem-solving skills and he uses them successfully. He no longer waiting for me to start guiding him, he begins problem solving right away. In addition, he is not satisfied only with what is written, but also checks it. [St. 10]

5. CONCLUSION

The relative and intensive supervision, including the reading of the tutors’ feedbacks and talking to them on almost weekly basis, revealed the tutors' significant advancement with respect to teaching processes. The tutors’ increased their awareness, and at the same time enriched their available tools regarding teaching problem-solving processes and understanding learners' difficulties. Further, the tutors became reflective practitioners and increased their confidence with respect to teaching processes.

The tutors, prospective CS teachers, appreciated the contribution of the tutoring model to their future fieldwork. Since they had not been previously exposed to this kind of experience in the course of their training, they readily seized its potential. They believed that experiencing a tutoring process is an important element that can train them to identify pupils' difficulties and find tools to support the tutee's learning processes, especially with respect to problem solving. In addition, the tutors suggested that a similar tutoring model can be implemented in methods of teaching courses that relate to other scientific disciplines.

It is also interesting to note that all tutors expressed their concern in promoting their tutees' learning, irrespective of the time they had to invest to achieve this goal. Furthermore, they even wished that their tutees enjoy the learning process and gain a positive perspective towards CS.

Additional findings, which were not presented in this paper, raised several topics and suggestions for improving the model which require further exploration. Among these topics we mention here the load that the tutoring model adds to the course requirements, one-on-one vs. group tutoring model and the tutee's influence on the tutoring process. These issues, as well as additional observations and questions, will be shared and discussed with the audience in the conference.

6. ACKNOWLEDGMENTS

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7. REFERENCES