TECHNION Israel Institute of Technology | Mindful Learning Technologies Lab
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INNOVA
האדם הלומד בעידן הדיגיטלי
הכנס השנתי-עשר לחקר חדשנות וטכנולוגיות למידה ע"ש צ'ייס
יום שלישי, י' באדר א' תשפ"ב, ה-15 בפברואר 2022

Technological, pedagogical, and scientific competencies required for the implementation of robotics activities in science education

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Introduction

While the need for STEM workers is expected to continue to grow, there is a negative trend in the selection of these professions among students (NGSS Lead States, 2013). Robotics programs can be used to increase students' comfort levels with STEM applications, contribute to the development of engineering and computational thinking practices, 21st-century skills, and interest in STEM-related programs beyond high school (Saad & Verner, 2019; Ziaeefard et al., 2017). Nevertheless, due to a lack of competencies and low self-efficacy, many science teachers avoid incorporating technological accessories like robotics into their lessons and prefer to teach in traditional methods (Castro et al., 2018).

This study aims to identify the competencies needed for integrating robotics activities into science education and develop a teachers' development program for develop these competencies.

Research Questions

1. What are the teachers' competencies required for integrating robotics activities into science education?
2. What is the effect of a teachers' development program on teachers' competencies for integrating robotics activities into science education?

Research design

The study will utilize a mixed-methods approach combining quantitative and qualitative research methods. The research methodology for the study is an exploratory multi-case study.

To answer the first research question, we will collect data on the teachers' competencies by using literature review and interview experts in the education robotics field
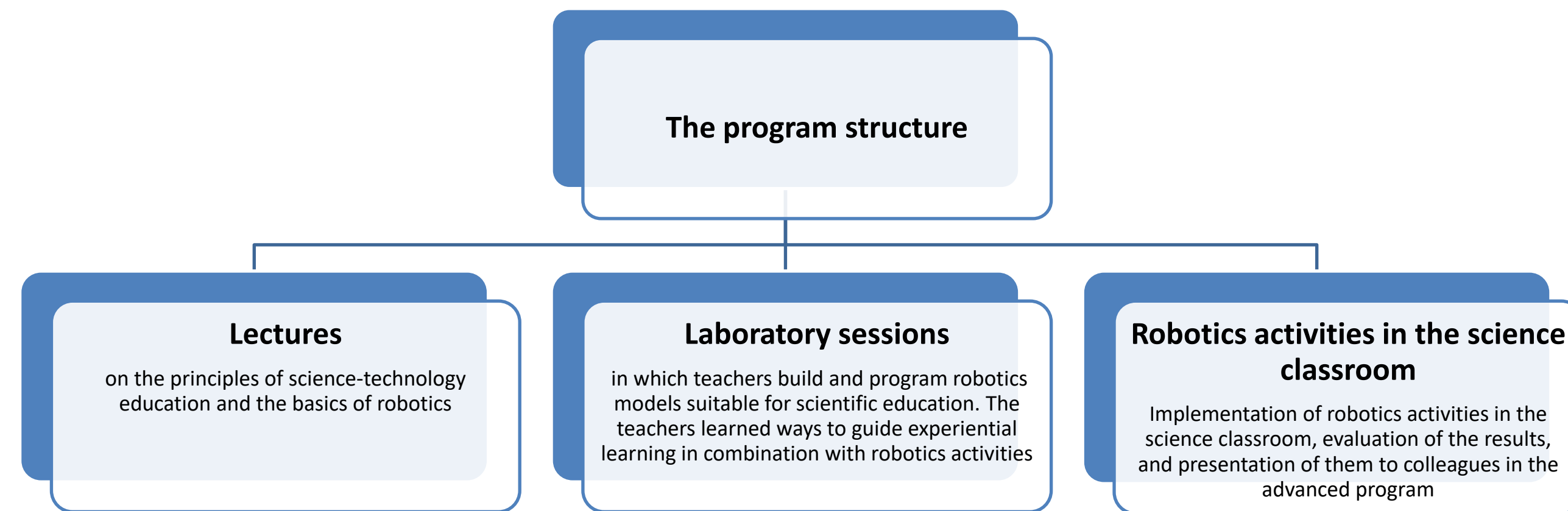
To answer the second research question, we will collect at each session data on teachers' observed competencies as well as self-rating questionnaire.
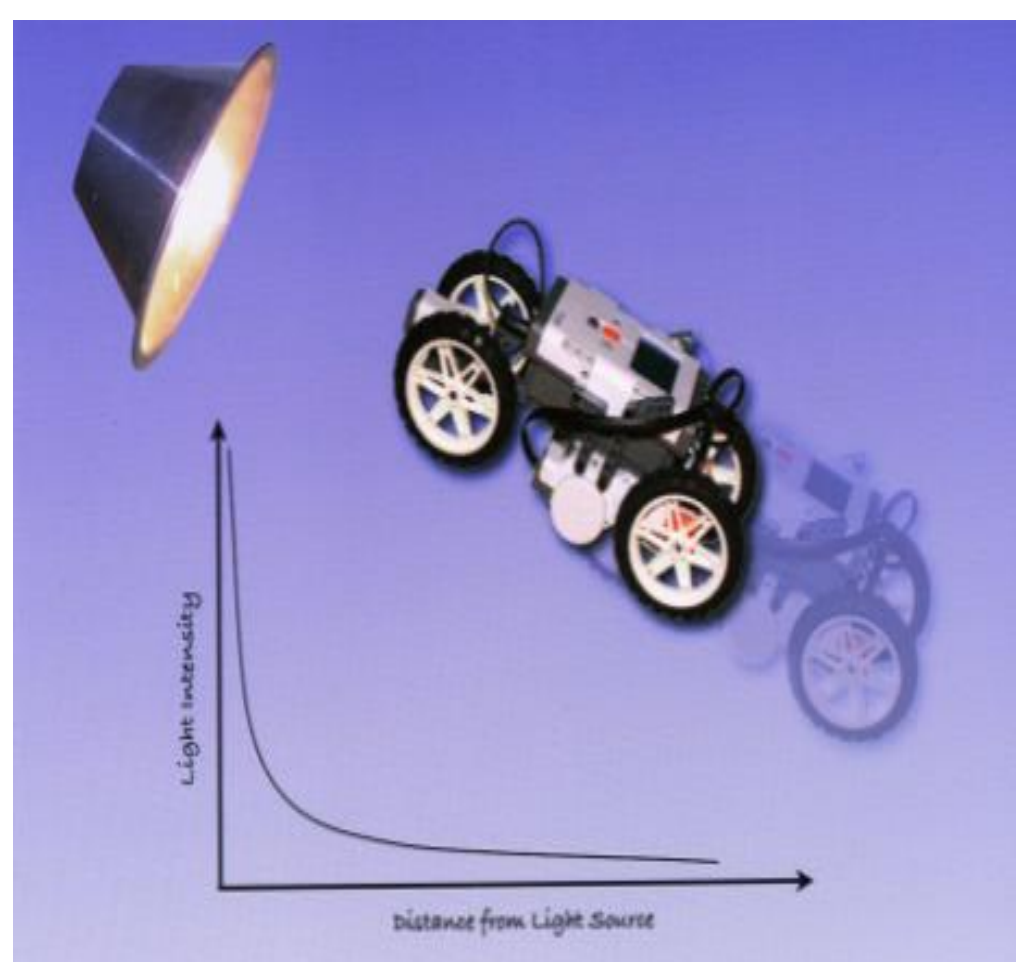
Method

Participants. One hundred and twenty science teachers in middle schools from the Druze sector will participate in the teacher development program that will be given at the "Pisga" centers in the North of Israel. Also, five experts in the education robotics field and five experienced robotics teachers will be interviewed on robotics in education and the competencies required to teach science with robotics.

The teacher development program. A 30-hour teachers' development program was designed to promote the science teachers' acquisition of the competencies necessary to develop and implement activities suitable for robotics education.

The program structure

Lectures
on the principles of science-technology education and the basics of robotics

Laboratory sessions
in which teachers build and program robotics models suitable for scientific education. The teachers learned ways to guide experiential learning in combination with robotics activities

Robotics activities in the science classroom
Implementation of robotics activities in the science classroom, evaluation of the results, and presentation of them to colleagues in the advanced program

Preliminary Results

Teacher competencies required for using robotics in science education

We identified science teacher's competencies required for using robotics in science education, focused on different aspects of the TPACK model (Koehler & Mishra, 2008):

Table 1: Examples of competencies required for using robotics in science education

Competency type	Competencies
Technological knowledge	Basic skills of robot building and programming.
	Base robot troubleshooting skills.
Pedagogical knowledge	Ability to analyze the activity sheets and to provide meaningful feedback, and ability to identify misconceptions
Content knowledge	Content knowledge, practices, and strategies of scientists (as listed for example in NGSS)
Pedagogical and Content knowledge	Selecting effective teaching approaches to guide students' thinking and learning in science in robotics focused lessons.
Technological and Content knowledge	Knowledge about using robotics for understanding and doing science.
	Use the science inquiry process to debug programs.
Technological and Pedagogical knowledge	An understanding of where and when to use robotics in the classroom.
	Know how to use robotics to enhance students' problem-solving and collaboration skills.
Technological Pedagogical, and Content Knowledge	The ability to design appropriate robotics activities for science education.
	Know how to select effective robotics teaching approaches to guide student thinking and learning in science in robotics focused lessons.
	Connect robotics to real-world situations.

Figure 1: Teachers' experience with robots

Contribution of the Study

This research has the potential to identify the competencies required of teachers to implement robotics activities in science education. This study will also contribute to the literature on developing these competencies in science teachers' education. Another theoretical contribution is to the TPACK model in the context of a combination of two educational disciplines science and robotics. The study will explain teachers' choice for integrating robotics activities in science through correlations among teachers' attitudes toward robotics usage in education, their self-efficacy, and their development of the competencies required for integrating robotics activities into science education.

The study may offer a model for teachers' development programs that prepares science teachers to integrate robotics activities in their classrooms. It will be possible to adjust the syllabus for other disciplines within and outside science education.

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