Identifying and developing teachers' competencies for integrating a robotic environment in Science Education

Abstract

This study focused on technological, pedagogical, and scientific competencies required for the implementation of robotic activities in science education. The purpose of the study is to investigate the effects of the teachers' development program on the participating science teachers' competencies, self-efficacy, beliefs, and attitudes towards integrating robotic activities in science education. Middle school science teachers will participate in the program which was organized to promote their acquisition of the competencies necessary for the development and implementation of robotics activities suitable for science education. The study will carry out through qualitative and quantitative research methods. The data sources are questionnaires, observations, worksheets, teachers' reports, and interviews.

Keywords: Educational Robotics, Science Teachers Competencies, TPACK Model.

Introduction

In recent years studies have identified the benefits of integrating robotics as an educational tool in schools that promotes active learning and motivates students (Castro et al., 2018; Susilo et al., 2016). In addition, empirical evidence demonstrated the educational effectiveness of robotics as an educational tool in science lessons, helping learners understand abstract content tangibly (Chen et al., 2017; Kay et al., 2014; Kazakoff et al., 2013; Master et al., 2017; NGSS Lead States, 2013; Ziaeefard et al., 2017). Nevertheless, due to a lack of competencies and low self-efficacy, not many science teachers utilize a robotic environment in their teaching (Rahman et al., 2017; You et al., 2021).

This gap points to the importance of preparing science teachers to teach in a robotic environment (Atmatzidou et al., 2018; You et al., 2021; Ziaeefard et al., 2017). Teachers need to know not only how to operate robots but also how to integrate them effectively into their teaching. They need to be confident in using technology, know the content they want to teach, and effectively use the pedagogical strategies required to teach the content in general and with the technology in particular (Archambault & Crippen, 2009; Igel et al., 2012; You et al., 2021).

Thus, teachers' preparation program that develops competencies and raises the sense of self-efficacy may increase the feasibility of a broader application of robotics in science education.

Research Goals and Questions

This research aims to identify the competencies needed for teaching science in a robotic environment and design a teachers' development program for middle school teachers for developing these competencies. The program will be designed following the principles of constructivism, constructionism, and the TPACK model.

The research questions are:

1) What are the technological, pedagogical, and scientific competencies required for teaching science in a robotic environment?
2) How did teachers' competencies and self-efficacy for integrating robotic activities in science education developed as a result of their experience in the teachers' development program?
3) How did teachers' attitudes toward the integration of robotic activities in science education change as a result of their experience in the teachers' development program?
4) What are the relationships between teachers' competencies, self-efficacy, beliefs, and attitudes towards integrating robotic activities in science education?

Preliminary Results

In February 2020, thirty teachers from the Arabic sector participated in a pilot study. The study focused on middle school science teachers. A training workshop "Science studies in a robotic environment" was given at The Center for Professional Development for Teaching Staff in Science and Technology in Shlomi to teachers from all over the country. The teachers learned physical concepts such as velocity and acceleration through experimental activities in a robotic environment. The purpose of the workshop was to expose science teachers to robotics and to motivate them to integrate robotic activities in science education. The workshop consisted of one laboratory session and lasted 8 hours. It included a short lecture and hands-on experimentation. During a specially designed workshop, teachers tested kinematics of the robot's straight-line motion, tested kinematics of the robot's accelerated motion, constructed a shooting component, and tested ballistic movement. The workshop was conducted in computer laboratories equipped also with LEGO NXT robot kits.

At the end of the workshop, we administered attitude questionnaires. Positive results of the questionnaire analysis indicate the potential of the proposed approach. Preliminary results suggest that the workshop positively affected teachers' attitudes about robotics in science classes. Additionally, after the pilot study, the teachers’ attitudes and perceptions regarding robotics training have improved. It can be suggested that in-service teachers training programs should be developed for teachers to raise their awareness of the necessity of

robotics education, raise a sense of self-efficacy to teach science in a robotic environment, and enhance their competencies for integrating a robotic environment in science education. These positive results of the study indicate the desirability of its further exploration.

Next, a teacher development program will be given at the "Pisaga" (פסג"ה) centers, a regional institution for the development of teaching staff in the education system in Israel, in the north of the country. To answer the research question, a multi-case participatory study will be performed. The study will utilize a mixed-methods approach combining quantitative and qualitative research methods. We will use questionnaires, observations, worksheets, teachers' reports, and interviews.

Contribution

On the theoretical side, this research has the potential to identify the technological, pedagogical, and scientific competencies required of teachers to implement robotic activities in science education. In addition, this study will also contribute to the literature on developing these competencies in science teachers' education. Furthermore, this study will add to the literature regarding the effectiveness and feasibility of integrating robotics for learning different fields of knowledge like science, technology, engineering, mathematics, and computer science. On the practical side, 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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REFERENCES

Archambault, L., & Crippen, K. (2009). Examining TPACK among K-12 online distance educators in the United States. *Contemporary Issues in Technology and Teacher Education*, *9*(1), 71–88.

Atmatzidou, S., Demetriadis, S., & Nika, P. (2018). How does the degree of guidance support students' metacognitive and problem solving skills in educational robotics? *Journal of Science Education and Technology*, *27*(1), 70–85.

Castro, E., Cecchi, F., Salvini, P., Valente, M., Buselli, E., Menichetti, L., Calvani, A., & Dario, P. (2018). Design and Impact of a Teacher Training Course, and Attitude Change Concerning Educational Robotics. *International Journal of Social Robotics*, *10*(5), 669–685. https://doi.org/10.1007/s12369-018-0475-6

Chen, G., Shen, J., Barth-Cohen, L., Jiang, S., Huang, X., & Eltoukhy, M. (2017). Assessing elementary students' computational thinking in everyday reasoning and robotics programming. *Computers & Education*, *109*, 162–175.

Igel, I., Poveda, R. L., Kapila, V., & Iskander, M. G. (2012). Examining the efficacy of a LEGO robotics training for volunteer mentors and K-12 teachers. *2012 ASEE Annual Conference & Exposition*, 25–598.

Kay, J. S., Moss, J. G., Engelman, S., & McKlin, T. (2014). Sneaking in through the back door: Introducing K-12 teachers to robot programming. *Proceedings of the 45th ACM Technical Symposium on Computer Science Education*, 499–504.

Kazakoff, E. R., Sullivan, A., & Bers, M. (2013). The effect of a classroom-based intensive robotics and programming workshop on sequencing ability in early childhood. *Early Childhood Education Journal*, *41*(4), 245–255.

Master, A., Cheryan, S., Moscatelli, A., & Meltzoff, A. N. (2017). Programming experience promotes higher STEM motivation among first-grade girls. *Journal of Experimental Child Psychology*, *160*, 92–106.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. https://doi.org/10.17226/18290

Rahman, S. M., Krishnan, V. J., & Kapila, V. (2017). Exploring the dynamic nature of TPACK framework in teaching STEM using robotics in middle school classrooms. *Proc. ASEE Annual Conference and Exposition*.

Susilo, E., Liu, J., Rayo, Y. A., Peck, A. M., Montenegro, J., Gonyea, M., & Valdastri, P. (2016). Stormlab for stem education: An affordable modular robotic kit for integrated science, technology, engineering, and math education. *IEEE Robotics & Automation Magazine*, *23*(2), 47–55.

You, H. S., Chacko, S. M., & Kapila, V. (2021). Examining the Effectiveness of a Professional Development Program: Integration of Educational Robotics into Science and Mathematics Curricula. *Journal of Science Education and Technology*. https://doi.org/10.1007/s10956-021-09903-6

Ziaeefard, S., Miller, M. H., Rastgaar, M., & Mahmoudian, N. (2017). Co-robotics hands-on activities: A gateway to engineering design and STEM learning. *Robotics and Autonomous Systems*, *97*, 40–50. https://doi.org/10.1016/j.robot.2017.07.013