Chapter 13
Developing Pre-Service Teachers' STEM Skills With Raspberry Pi Activities

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ABSTRACT

The aim of this study was to explore the development of pre-service primary school teachers' STEM skills with Raspberry Pi activities. Data were collected from 16 pre-service teachers through semi-constructed interviews, reports, and a questionnaire. The results of the qualitative analysis showed that the participants developed the STEM skills mentioned in the literature such as confidence, computing, problem-solving, creativity, technological skills, and enhanced the learning potential of robotics. Moreover, the ready-to-use Python codes on Raspberry Pi platform could be an effective strategy for pre-service teachers with lack of programming to provide solutions on real-world problems. In addition, the participants successfully connected the Raspberry Pi, sensor kits, and Python scripts with real-world problems. This equipment motivated them to transpose a real-world problem to school knowledge. According to the results the combination of Raspberry Pi, sensors, and Python helped the participants upskill in computing.

INTRODUCTION

Most countries have recently reformed or plan to revise their curricula in order to improve the quality of education and increase their students' uptake of Science, Technology, Engineering and Mathematics (STEM). The driving force of this change is the lack of STEM skills of students contrary to the 21st

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century demands (Kiss, 2016). Different approaches are reported in literature about the STEM skills definition. As Murphy at al. (2020) review, governmental reports often focus on relating STEM education outcomes to the industry demands, while other researchers refer to a more generalized STEM capability provided for all citizens. The common STEM skills lists in literature include creativity, critical thinking, designing, problem-solving and application of this knowledge for tackling complex real-world problems. Obtaining these skills will help future citizens to have a prosperous state as their parents did (European Commission [EC], 2017). There are two ways of importing STEM in education: either it can be realized through a totally new curriculum or just by integrating STEM activities in the current curriculum (Bergsten & Frejd, 2019).

In these educational reformations, the teacher's role is crucial. Particularly, teachers should act as facilitators, inspire the new generation to become enthusiastic, be more active and empathetic about Science and cultivate the necessary skills and competences of their students to meet the future's standards. To play such an important role, teachers should develop their own STEM skills. Gaps or mismatches of these teacher skills have been recorded, compared to the ones they gain from their tertiary studies (Jimenez-Liso et al., 2019; Rinke et al., 2016). Therefore, there is a need for upskilling and reskilling teachers (Commission Staff Working Document [CSWD], 2020).

The questions that arise are to what extent higher education prepares future teachers to support STEM education, which material is appropriate for such implementation and how easily STEM can be adopted. Additionally, one should consider that teaching as a profession experiences a serious shortage in western countries (CSWD, 2020; Sibieta, 2020). In particular, according to the CSWD report (2020), the in-service teachers are ageing, while on the other hand, the profession has become less attractive. This is a significant disadvantage that threatens the quality of education and any STEM integration.

STEM courses based in robotics are very popular in schools or after school programs. Educational Robotics (ER) can provide the framework in which students and teachers can both work on improving the learning outcomes and their skills (e.g., Chiazzese et al., 2019). Numerous projects and competitions based on Robotics have been applied to students and have significantly improved their perspective towards the STEM disciplines (Benitti, 2012; Kubilinskiene et al., 2017).

In a STEM context, the educational implementation of robotics is not limited in assembly activities. Robots can actively involve students to think how to solve real-world problems through experimentation, as well. The most feasible way to achieve it, is to upgrade robots with a platform for operating it and a sensor kit to measure physical quantities. This combination becomes a powerful educational tool as it can interact with the user and the real environment engaging students with real-world problems (Miller & Nourbakhsh, 2016) and introducing the learner to physical computing (Przybylla & Romeike, 2014). A great example of such interface platforms is the widely used microcontrollers with sensors in ER like the Raspberry Pi or Arduino. These applications have helped pre-service teachers develop their computing and also develop other STEM skills like problem-solving and creativity (Kim et al., 2015). The term of computing refers to coding, scripting, programming or computational thinking (Rich et al., 2019). Computing is not only a digital tool for problem-solving, but also a way to meet the algorithmic thinking and the mathematical conceptual knowledge of which lay both in the STEM core (Gravemeijer et al., 2017).

This chapter studies the skills that the concept of ER provides pre-service teachers through the use of Raspberry Pi and "Sense Hat" sensor suite. Its aim is to examine whether pre-service teachers can develop STEM skills through training activities designed on the Raspberry Pi platform and the extent of this development. Programming in Python of this single board computer becomes an ideal tool not only