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Supporting the Decision-Making Process of High-school Students in Choosing their University Track. A Raspberry Pi Case Study

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Abstract
Technical higher education, especially in the electrical field has become particularly appealing in recent years due to the incresed employment opportunities currently available on the Romanian labour market. This has contributed to an increased number of highschool students opting to pursue a university degree in electrical field. Yet, increasing drop-out figures in recent years show students find it difficult to finalise their studies in this field. One cause for this situation could be related to the structure of university studies which imply a time span of four years starting with a basis for the theoretical knowledge then followed by the practical skills development. First year students therefore often find themselves not understanding how exactly the theoretical knowledge will be put into practice. This then leads to them becoming dissengaged with the subjects proposed. The article aims to analyse whether the Raspberry Pi can be used as a means for explaining high-school students what it means to pursue a degree in the electrical field of a technical university. More clear explanations regarding the university studies structure and finality could support high-school students in their decision-making process for selecting an undergraduate track, as well as heping them develop realistic expectations in terms of what they will be able to do at the end of their studies. This would, in turn, support higher retention rates of students during the first years of studies. A simple device, the Rasberry Pi, was used to illustrate how the theoretical and the practical knowledge are combined throughout the four years of studies in order to equip graduates with the knowledge and skills required to perform as electrical specialists on the labour market. Using only basic programming skills, the device allows users to immediately see the applicability of their knowledge. Three projects which can be conducted using the Raspberry Pi were presented . The projects can be used to help high-school students understand how the theoretical and practical knowledge are combined, why the theoretical knowledge of the first two years is important, what is the difference between the various tracks in the electrical field, as well as give students an idea of the knwoledge and skills they will possess at the end of their studies. The paper is particularly relevant in the current context of increased drop-out rates among first year students in electrical higher education, while also being of interest to the admissions office as a means of effectively presenting higher education studies in the electrical field to high-school students and supporting their decision-making process when choosing their undergraduate specialty.

Keywords: higher education, Rasberry Pi, decision-making, high-school students.

JEL classification: M31.

1. Introduction

Engaging students in the learning process is one of the key struggles of the teaching staff. This is even more so in the context of technical higher education, where knowledge, skills and abilities are developed over a time span of four years. The curriculum generally first implies developing the theoretical knowledge required and then allows the practical experimentation

and development of projects. Current research indicates students in the technical field are taught a variety of algorythms and parameters they work with but often without the opportunity to experience the real impact of their programming (Sobota et al, 2013). Another issue currently depicting the technical higher education environment is related to the high attrition rates faced by universities. According to recent studies, attrition figures among European universities vary between 18% (UK) and 41% (Norway) (European Commission, 2015). For Romanian universities, the percentage of students deciding not to complete their tertiary education is around 30%, with the majority of those leaving university doing so after their first year (ANOSR, 2013). Among the causes of drop-out, Quinn (2013) indicates factors regarding learning strategies and a mismatch between students' interest and the subject which was chosen. It will often happen that first year students will find themselves not understanding how exactly the theoretical knowledge will be put into practice which then leads to them becoming dissengaged with the subjects proposed. Some of them will drop-out, while others will choose to rely soley on an immediate employment with on the job practical skills development. The latter will struggle to graduate, but will no longer be engaged in the subjects taught. This can be to the dissadvantage of students in the longterm as they may become extremely skilled in a very particular set of activities that are required by the employer while completely ignoring other aspects of their field of expertise.

The article aims to analyse whether the Raspberry Pi can be used as a means for explaining high-school students what it means to pursue a degree in the electrical field of a technical university. It is our view that more clear explanations regarding the university studies structure and finality could support high-school students in their decision-making process for selecting an undergraduate track, as well as heping them develop realistic expectations in terms of what they will be able to do at the end of their studies. This would, in turn, support higher retention rates of students during the first years of studies.

This simple device represents a low-cost computer which can deepen students engagement with programming (Kölling, 2016) by having all its parts exposed and allowing students to both see inside and receive feedback for their programming (Simão et al, 2014). The device could be used to illustrate how the theoretical and the practical knowledge are combined throughout the four years of studies in order to equip graduates with the knowledge and skills required to perform as electrical specialists on the labour market. Three projects which can be conducted using the Raspberry Pi will be discussed in order to illustrate the specificities of the knowledge and skills acquired within the electrical field of university studies, namely: automation and computing science, electronics and tellecommunications and electrical engineering. The paper is particularly relevant in the current context of increased drop-out rates among first year students in electrical higher education. The three experiments could be used for presenting higher education studies in the electrical field to high-school students, either by admission officers or by career counsellors, to better support high-school students in their decision-making process when choosing their undergraduate specialty.

2. About the Raspberry Pi and its educational potential

The Raspberry Pi (Figure 1) is a small computer board developed by the Raspberry Pi Foundation (The Raspberry Pi, 2017) with the main purpose of promoting teaching activities in basic computer science among schools. However, its low cost and flexibility drove its popularity far more than anticipated, for uses in domains such as robotics or entertainment. The latest model, the Raspberry Pi 3 Model B, comes equipped with a 4-cores ARM microprocessor clocked at 1100 MHz and incorporated GPU inside a system on a chip (SOC), 1GB RAM, USB and HDMI connectors and Wi-Fi, offering sufficient computing power to host not only educational examples, but also complex real-world applications.

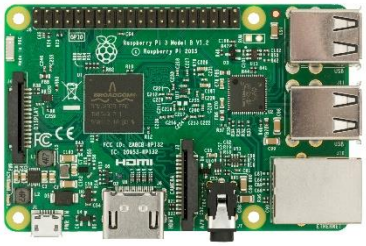

Figure 1- The Raspberry Pi

The Raspberry Pi and similar computing devices have an enormous educational potential in the context of how technology has evolved. Hardware and software have reached a level where students can interact with complex applications, offering compelling user interfaces and photorealistic graphics. Smartphones, tablets and similar devices are now accessible to everyone and are used on a daily basis. However, as technology evolves, devices become more complex, encapsulated and closed systems. We can no longer "see under the hood", tinker with settings or modify the code that makes these devices operate, leading to an increased risk of bringing up generations of students who have no idea of how computers and computing devices actually operate and what makes them tick. This is why devices such as the Raspberry Pi are so important in education, by reverting to the basics, stripping back all the non-essential shinny cases and well-polished user interfaces to offer the possibility to experiment, explore and understand how computers work, enlightening those for whom such a device is a "sealed box of magic tricks" (Rivers, 2014).

3. Raspberry Pi Case Studies

3.1. Building your personal web server and file storage cloud

Ever since the Internet has begun picking up momentum, so has the World Wide Web (WWW), the primary tool people use to interact online. The Web today is a growing universe of web pages and web applications full of photos, videos and interactive content and, since November 2016, is mostly accessed using mobile devices (StatCounter, 2016). With students focusing mostly on consuming web services on a daily basis, they fail to understand the interplay of web technologies and browsers that makes all this possible, taking all of it for granted.

The Raspberry Pi can be used to exemplify how a Web server works, how Web pages can be created and hosted on such a server and served to clients when requested. It can also be used to deploy a personal file storage cloud service similar to other well-known services such as Google Drive, iCloud, OneDrive or Dropbox. Furthermore, while learning to deploy such a server, students can become accustomed to installing and configuring software on Linux, discovering some innerworkings of an operating system other than Microsoft Windows. Linux is free and highly customizable and allows you to "peek under the hood" and to modify it in any way you see fit.

NGINX (NGINX Inc., 2017) is an opensource high-performance web server well known for its performance and low resource consumption. It uses a scalable asynchronous architecture that has small and predictable memory usage under load. This small footprint makes NGINX an ideal candidate for our educational example on the Raspberry Pi. The installation process is covered by the official Raspberry Pi documentation and there are also plenty of free tutorials available (Emmeshop, 2014), (Raspbian-France, 2017). The Web server case study is even more useful when augmented with information about HTTP security and SSL certificates (e.g. LetsEncrypt free certificates (LetsEncrypt, 2017)). Students can thus learn how all the web technologies come together to serve web pages securely across unsecured transmission media.

To complete the example with the deployment of a personal file storage cloud, we can use OwnCloud (OwnCloud Inc., 2017), an open-source suite of client-server software for file hosting and sharing services. The installation and configuration of OwnCloud on Raspberry Pi is covered by plenty of free tutorials (Burnett, 2016) (Project Pi, 2017). Once the server is deployed, files can be accessed using a web-based client or dedicated desktop or mobile applications.

3.2. Building your personal communication server

Communication devices have become ubiquitous and highly affordable ever since the mobile age began. Phone calls or conference calls are initiated and received at a press of a button, instantly ensuring connectivity among parties. However, from a technical point of view, the complexity of all systems involved in the communication process is hidden to the average user. To exemplify how communication is carried out, with immediate practical application and feedback, we propose this second case study, building a personal communication server using the Raspberry Pi and Asterisk and FreePBX.

Asterisk (Digium Inc., 2017) is an open-source framework for building communications applications and can turn any ordinary computer into a communications server. It can easily implement a software telephone private branch exchange (PBX), allowing calls between attached telephones and connections to other telephone services such as the public switched telephone network (PSTN) of voice over IP (VoIP) services. Asterisk is available worldwide and is implemented in over 1 million communications systems and has even attracted the attention of the Raspberry Pi community, which launched the RasPBX project (RasPBX, 2017), a Raspberry Pi based implementation of the popular Asterisk server.

The RasPBX project is easy to deploy and configure and can serve as an excellent test bed for exemplifying how communications work, how to create a session initiation protocol (SIP) trunk, how to access the server using a SIP capable phone or a software client and how to initiate phone calls between phones or clients. This makes it ideal as a case study for students who wish to pursue a career in communications, illustrating how different communications concepts and protocols work together to ensure voice connectivity, in a practical, real-world example.

3.3. Learning to code with lights and music

Computer programming (or coding) is essential to future IT specialists. It can be defined as the process of creating sets of instructions that tell a computer how to perform a task and involves computational thinking. Computer programming in Romanian schools is taught purely on a theoretical level and mostly involves learning and implementing specific algorithms, an approach that can lead to students becoming disengaged with the subjects proposed, mainly due to the lack of perspective on how coding relates to solving real-world problems. This third case study aims at engaging students in order to effectively teach them core fundamental programming using the Raspberry Pi and Sonic Pi.

Sonic Pi (Aaron, 2017) is an open-source programming environment that allows you to create sounds and music, developed by Dr. Sam Aaron, a researcher at the University of Cambridge Computer Lab. It was specifically designed for the Raspberry Pi platform and can be easily installed from the main software repository. Sonic Pi can be used to great success to teach basic programming concepts in an engaging sounds and music creation environment with immediate, motivating feedback. Most coding techniques can be represented by a feature of the Sonic Pi. It can even be used to teach more advanced coding topics such as concurrency or determinism by creating sound loops that play at the same time or by experimenting with random elements.

This educational example allows students to learn how to write code in order to produce music tracks using the Raspberry Pi. It facilitates learning basic computer coding concepts such as sequencing, iteration, conditionals, data structures, functions, algorithms, debugging and combining programming constructs to solve a problem. The immediate audio feedback can be complemented with visual feedback by connecting colored LEDs to the Raspberry Pi and using applications such as LightShow Pi (LightShow Pi, 2017) to synchronize the lights to music. The result is a programming environment that emphasizes a practical real-world application for coding, while teaching students basic programming concepts in an engaging, fast feedback, iterative way.

Conclusions and further research

This article presented an analysis of using the Raspberry Pi as a means for explaining technical university studies in the electrical field to high school students. This simple device was used to illustrate how the theoretical and the practical knowledge are combined throughout the four years of studies in order to equip graduates with the knowledge and skills required to perform as electrical specialists on the labor market. Three projects were chosen to illustrate the specificities of the knowledge and skills acquired within the electrical field of university studies, namely: automation and computing science, electronics and telecommunications and electrical engineering. All three projects represent applications used on daily basis by most students, that solve real-world problems, that, when implemented on the Raspberry Pi, result in an immediate application of the theoretical knowledge. This approach has the potential to help high-school students better understand what choosing an undergraduate track in the electrical field implies and support them in selecting their studies track. We believe a better understanding of higher education in the electrical field can contribute to decreasing the drop-out rates among first year students in electrical higher education.

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