Quantitative Study

The Use of Raspberry Pi in College STEM Courses and Students' STEM Majors

Steven Wong

New Jersey City University

Chapter 1: Introduction

Introduction

The Raspberry Pi Foundation is a non-profit organization based out of United Kingdom, and its mission is to spread the power of computing and digital making to eager learners throughout the world ("Raspberry Pi Foundation," 2018). According to the New York Hall of Science, digital making offers students the opportunity to test out different forms of technology, to inspire students to be creative and to encourage students to design innovative projects. The Raspberry Pi Foundation provides a wealth of resources available to Science, Technology, Engineering, and MATH (STEM) educators on how to integrate Raspberry Pi into their curricula. Will Raspberry PI initiative encourage college students to purpose a STEM major? Radu (2018) explains the severity of the STEM worker shortage based on a survey done by Emerson in 2018, a technology and engineering company out of Missouri; the study shows that 2 out of 5 Americans agreed that more needs to be done to encourage the next generation of the workforce to be interested in these roles. The working landscape is changing as more companies are spending to upgrade their infrastructures to be on the cutting edge. As the transition happens, companies need to recruit more workers in STEM-related positions to cover for available openings. More studies needed to be done to see whether the college student involvement with Raspberry Pi would encourage them to pursue a STEM major.

Statement of the Problem

Raspberry Pi has become a valuable learning tool in computer science course assisting students to engage in hands-on projects and to explore and apply learned concepts beyond the classroom (Williams & Kurkovsky, 2017). Steinhofer (2018) explains the offering of Raspberry Pi course by Centre College to motivate students to explore using Raspberry Pi. The course

develops an appreciation for the hardware and the software and to combine both aspects with come up with creative projects, and to help solve challenges and make something that could be helpful to them or to assist others as explained by Associate Professor of Computer Science David Toth. There are multiple studies conducted about the impactt of Raspberry Pi and STEM related course, including Raspberry Pi and Electrical Engineering Students (Wachira & Absaloms, 2017), Raspberry Pi and Computer Information Systems Course (Cooper, 2017), and Raspberry Pi and Computer Science (Williams and Kurkovsky, 2017). The study is not complete, therefore leaving an opportunity for the quantitative research on whether the use of Raspberry Pi in STEM-related courses would impact students to purpose a STEM major.

Purpose

The purpose of this quantitative research study is to check whether the use of Raspberry Pi in undergraduate college STEM courses encourage students to pursue STEM majors among the New Jersey City University undergraduate students. Mischie (2016) explains the different usages of Raspberry Pi in teaching an undergraduate university course and how the interaction provides a meaningful learning environment and lasting impression.

The following three research questions will guide this study:

Research Question 1: Is there a difference in students' major between students' using a Raspberry Pi or not in STEM undergraduate courses?

Research Question 2: How many undergraduate students think that the use of Raspberry Pi in STEM courses leads them to a major in STEM?

Research Question 3: Is there a relationship between the use of Raspberry Pi and STEM courses?

Chapter 2 Literature Review

Introduction

This overview will discuss the importance of Raspberry Pi (RP), and its influence on college students STEM course. The literature review will provide a perspective on social learning theory and how it impacts the use of RP in STEM courses. Parr (2012) explains the development of the RP by scientists at the University of Cambridge, who are concerned about the year over year decline in enrollment into computer science course at the institution. The aim for RP was to improve the level of learning and the quality of the course. However, the mission of RP fulfilled beyond its initial expectation. Educators at other universities saw the powerful impact of RP and wanted to introduce the RP units into the curricula. As word spreads, forums were established for students to exchange ideas with others and to encourage students to think out of the box and to challenge themselves to use RP to develop local and affordable solutions facing issues in their countries. However, a review of current literature did not provide relevant information on whether the use of RP in STEM courses encourage students to be major in STEM.

Theoretical framework

Bandura (1971) explains and goes in depth about the social learning theory and emphasizes learning acquired through direct experience. Students will gain hands-on experience through the use of Raspberry PI and will enhance the experience and learning in STEM courses. According to Kolb's experiential learning model, knowledge acquired from both personal and environmental experiences (Kolb, 1984). The understanding of how the course atmosphere setting plays a vital role for students to learn, whether the presence of Raspberry Pi unit will make a lasting learning impression on the college students.

Raspberry Pi

The Raspberry Pi is a small sized unit similar to the dimension of a credit card that carries an enormous amount of computing capability for the size of the footprint ("Raspberry Pi Foundation," 2018). The unit designed and manufactured by the Raspberry Pi Foundation, an educational charity foundation based in the United Kingdom. The foundation's mission is to spread the teaching of basic computer science to all students throughout the world. The goal is to motivate and encourage every age group whether young or old to develop a basic understanding of computer science. Also, the unit was designed as a low-cost computer, where the cost is reachable for all individuals to purchase. Even though, the unit looks very simple but has many underlying features compare to a traditional desktop. Furthermore, the unit is capable of browsing the internet, playing games, and watching videos, etc.

Rethinking Computer Science Education

Limbo, Nhinda, & Sverdlik (2017) explain the need to reinvent the traditional university format of computer science, where introductory level programming classes based upon the use of the desktop platform and with the coursework focuses on input and output (I/0) and user interface design. Students mastered the course by demonstrating a proficiency in various programming skills including the sequential, conditional and iterative concepts. These assignments are perfect for practice, but do not provide a holistic perspective of what to expect in the real working environment. Students need to see beyond the print statements, demonstrating the program has written correctly and the output generated is what the program creator has expected (**L**imbo, Nhinda, & Sverdlik, 2017, p. 1).

The momentum has been built to call for a review on how students learn to program in introductory level computer science course after the soaring popularity introduction of RP in

2012. RP offers exceptional benefits to students who are new to programming. Also, RP is capable of doing more and beyond the traditional programming course. For instance, where an assignment involves writing a coding where the program repeats until the user enters a negative digit, now with RP, the coders can include an additional module component to RP, for RP to relay an output to LED light to flash when the user enters a negative digit (**L**imbo, Nhinda, & Sverdlik, 2017, p. 2).

Also, **L**imbo, Nhinda, & Sverdlik (2017) give another reason and benefit from integrating RP into computer science course compare to traditional computing. Students can solve a challenge that exists in front of them and to even be more passionate towards the challenge since they can connect or to relate to the problem (**L**imbo, Nhinda, & Sverdlik, 2017 p. 4). The RP environment allows the entire class to actively participate in the discussion on the best strategy to implement to solve the problem similar to a corporate setting when a presented challenge needs resolving.

Raspberry Pi to Trigger Creative Thinking in Electrical Engineering Students

Funding is limited and an issue when educators request administrators to request new resources for their students. It is a reason why RP has become a savior, welcoming, and critical success in its usage due to affordability, flexibility, and robustness design (Wachira & Absaloms, 2017). The cost of RP depends on the model, ranging from Raspberry Pi Zero around USD 5 to Raspberry Pi 2 for USD 35, a fraction of the actual cost of a traditional computer (Wachira & Absaloms, 2017, p. 688). What seems to be an insignificant amount to the developed countries; considered an opportunity for developing world, where the major obstacle to fully implement the technology is due to the cost.

Wachira & Absaloms (2017) explain the importance of using RP platform as a backdrop for developing countries like Africa to narrow the technology gap and to try to achieve global parity among the developed countries. The RP learning model gives students in developing countries the unique opportunity to help their countries solve pressing issues. For instance, third year engineering students at Nairobi University are tasked to work with RP to create local and affordable solutions to development challenges facing in Africa (Wachira & Absaloms, 2017, p. 688). The use of RP encouraged students to be more creative thinkers and to develop an entrepreneurial spirit as a part of the learning cycles.

Summary

The concept of social learning theory and experiential learning model are both presented through the use of RP in STEM college courses. Many studies have conducted on the powerful impact of RP on students' learning, but there is a void in research that needs covering on whether the use of RP in STEM courses motivate students to consider a STEM major. A comprehensive quantitative study needs to be done to examine where the use of RP in STEM courses encourage students to go for a STEM major. This study is important and valuable to corporations who are facing a shortage of applicants to take roles that are STEM-related. The hiring situation will get even worse as corporations continue to upgrade their infrastructures to be on the cutting edge.

Chapter 3 Methodology

Introduction

The use of Raspberry Pi as a learning tool in undergraduate STEM courses is increasing (Mischie, 2016). Students learned concept through the use of hands-on experience as explained by the Bandura's social learning theory and the learning atmosphere which is also vital as confirmed by the Kohl's experiential learning model. From the literature reviews, we find an impact on the use of Raspberry Pi on students' learning, but more studies needed to established the relationship between the use of Raspberry Pi in undergraduate STEM courses and students' pursuit of STEM major.

The purpose of the survey design is to provide a quantitative description between the use of Raspberry Pi in undergraduate college STEM at NJCU and students pursue of STEM major. Also, the research study intends to show if there is a relationship between the use of Raspberry Pi and STEM courses.

Research Design

A correlation study will be used to determine if there is a relationship between the variables. The quantitative research design will be used to determine the relationship between the use of Raspberry Pi in STEM courses and students' STEM majors. Based on current literature reviews, I hypothesize that there is a positive correlation between students who use Raspberry Pi in STEM courses and students pursue of STEM major.

Population & Sample

The population will include NJCU undergraduate students taking STEM courses. The sample may represent undergraduate students taking the following courses: Biology, Chemistry,

Computer Science, Geoscience, Mathematics, and Physics depending on the data collected. I will be performing a correlational study with a minimum sample size of 30 to the maximum amount I can collect data. The convenience sampling method will use since participants are willing and are available for the study (Creswell, 2015).

Instruments

National Survey of Student Engagement (Appendix Ai)

Emailed cpritems@indiana.edu to review the survey sample and to get permission to use the survey.

Procedures

1. Obtain permission from Internal Review Board (IRB) from NJCU.
2. Email letter is seeking permission to use the Survey Tools (Appendix Aii).
3. Create and test the Web-based surveys.
4. Once IRB approval, request site permission from NJCU to perform the study. (Appendix B)
5. Have the participants sign the permission forms before the survey participation (Appendix C).
6. Administer the Web-based survey
7. Compile the collected quantitative data.
8. Analysis of the data.
9. Report Findings.

References

Bandura, A. (1971). Social Learning Theory. NYC. General Learning Press.

Byrne, J. R., Fisher, L., & Tangney, B. (2015). Computer science teacher reactions towards raspberry pi continuing professional development workshops using the bridge 21 model. Proceedings of the International Conference on Computer Science & Education, Cambridge, UK, 10, 267-272. doi: 10.1109/ICCSE.2015.7250254

Cooper, G. (2017). Incorporating a raspberry pi into a computer information systems initial course. Proceedings of IEEE Frontiers in Education Conference, Indianapolis, IN, 1-5. doi: 10.1109/FIE.2017.8190737

Kolb, D. (1984). Experiential Learning: Experience as the Source of Learning and Development. New Jersey: Prentice –Hall Inc.

Limbo, A., Nhinda, G. T., & Sverdlik, W. (2017). Rethinking tertiary computer science education: let's have pi. Proceedings of IST Africa Week Conference, Windhoek, Namibia, 1-6. doi:10.23919/ISTAAFRICA.2017.8102331

Maheshwari, D. (2016). Raspberry pi technology. Splint International Journal of Professionals, 3(1), 34-37. Retrieved from https://draweb.njcu.edu

Mischie, S. (2016). On teaching raspberry pi for undergraduate university programmes. Proceedings of the IEEE International Symposium on Electronics and Telecommunications, Timisoara, Romania, 12, 149-153. doi:10.11109/ISECTC.2016.7781079

National Survey of Student Engagemnt. (n.d.) Retrieved from http://nsse.indiana.edu/html/survey_instruments.cfm

Parr, C. (2012). With raspberry pi, UK can have chips with everything. Times higher Education, 2081, 12. Retrieved from https://draweb.njcu.edu

Radu, S. (2018, Aug 23). STEM work shortage at a crisis, survey shows. U.S. News. Retrieved from https://www.usnews.com

Raspberry Pi Foundation. (2018). Retrieved from https://www.raspberrypi.org/

Steinhofer, K. (2018, Jan 10). CentreTerm: students explore using raspberry pi to build hardware and software systems. Retrieved from https://www.centre.edu/centreterm-students-explore-using-raspberry-pi-to-build-hardware-and-software-systems/

Wachira, K. & Absaloms, H. O. (2017). A raspberry-pi centred quasi-flipped learning model to trigger creative-thinking in electrical engineering students. Proceedings of IEEE AFRICON. Cape Town, South Africa, 688-693. doi:10.1109/AFRCON.2017.8095566.

Williams, C. & Kurkovsky, S. (2017). Raspberry pi creativity: a student-driven approach to teaching software design patterns. Proceedings of IEEE Frontiers in Education Conference, Indianapolis, IN 1-9. doi:10.1109/FIE.2017.8190735

Yamanoor, N. S. & Yamanoor, S. (2017). High quality, low cost education with the raspberry pi. Proceedings of IEEE Global Humanitarian Technology Conference, San Jose, CA, 1-5. doi: 10.1109/GHTC.2017.8239274

Appendix Ai: National Survey of Student Engagement - Sample screenshot

Topical Module: Learning with Technology

Developed in partnership with EDUCAUSE, these questions examine the role of technology in student learning, focusing on usage, contribution to learning, and perceptions of institutional support. This module complements questions on the core survey about learning with peers, quality of interactions with others, and institutional emphasis on academic support. (Similar FSSE set available.)

We want to know how technology relates to your learning. By "technology," we mean any or all of the following:

- Hardware (desktop computer, laptop, tablet, smartphone, etc.)
- Software (word processing, spreadsheet, presentation, graphics, statistical, etc.)
- Online tools (communications, social networking, etc.)
- Websites (for courses, library resources, etc.)

1. During the current school year, how much has your use of technology contributed to the following:

	Very much	*Quite a bit*	*Some*	*Very little*
a. Your understanding of course materials and ideas	O	O	O	O
b. Demonstrating your understanding of course content	O	O	O	O
c. Learning, studying, or completing coursework **on your own**	O	O	O	O
d. Learning, studying, or completing coursework **with other students**	O	O	O	O
e. Distracting you from completing your coursework	O	O	O	O

2. During the current school year, how much have your courses improved your understanding and use of technology?

Very much	*Quite a bit*	*Some*	*Very little*
O	O	O	O

ED MATERIAL

Appendix Aii: Letter of Permission to Use Tool: National Survey of Student Engagement

National Survey of Student Engagement
Center for Postsecondary Research
Indiana University School of Education
1900 East Tenth Street, Suite 419
Bloomington, IN 47406-7512
Phone: 812.856.5824
Fax: 812.856.5150
Email: **nsse@indiana.edu**

Dear Sir/Madam:

I am a doctoral student from New Jersey City University, located in Jersey City, NJ. I am conducting dissertation research to examine the relationship between the use of Raspberry Pi in undergraduate STEM courses and students' STEM major.

I want your permission to use the National Survey of Student Engagement.

If these are acceptable terms, please email me back at swong@njcu.edu.

Sincerely,

Steven Wong
Doctoral Student

Appendix B: Letter of Permission to Dean to Conduct Survey in University

March 16, 2019

Deborah Woo, Ed.D.
Interim Dean
New Jersey City University
2039 Kennedy Boulevard
Jersey City, NJ 07930

Dear Ms. Woo:

I am a doctoral student from New Jersey City University, located in Jersey City, NJ. I am conducting dissertation research to examine the relationship between the use of Raspberry Pi in undergraduate STEM courses and students' STEM major.

I want your permission to research at New Jersey City University, Jersey City, NJ. I will follow all policies set by the university and will share the findings from the research with the university. If this is an acceptable proposal, please reply to my email at swong@njcu.edu. I am looking forward to hearing from you. Thank you.

Sincerely,

Steven Wong

Doctoral Student

Appendix C: Letter of Permission from Participant to Participate in the Survey

March 16, 2019

Dear Participant:

I am a doctoral student from New Jersey City University (NJCU), located in Jersey City, NJ. I am conducting my dissertation research at NJCU. The focus of my research is to examine the relationship between the use of Raspberry Pi in undergraduate STEM courses and students' STEM major.

I am seeking your permission to participate in the survey. While performing the research study, all university policies followed and the information collected would be kept confidential. You have the right to discontinue the participation at any time of the research project. If you have any additional questions before the study, please ask for clarification. Thank you for your assistance.

Steven Wong
Doctorate Student

I grant permission to participate in the research study. Please sign below.

_____

Participant's Signature