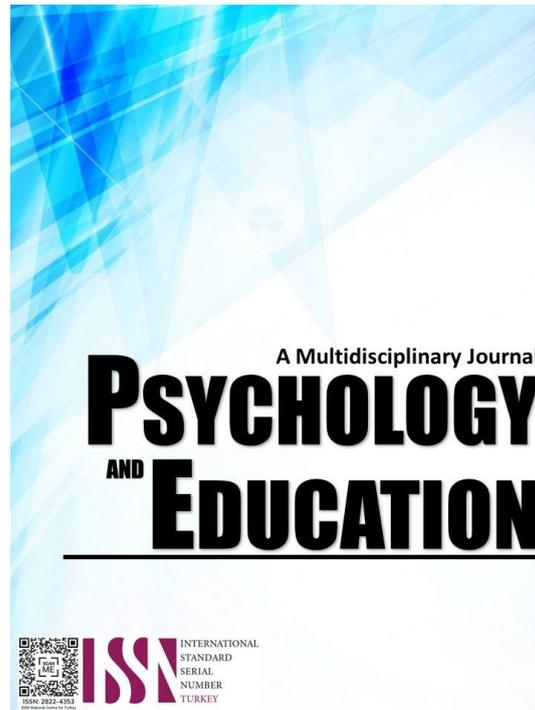


**UTILIZATION OF HANDS-ON ROBOTIC PROGRAM
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Utilization of Hands-On Robotic Program to Engage and Strengthen High School Students' Participation in STEM Education

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Abstract

The robotics program presents schools with a good chance to encourage the integration of reading and writing instruction with presenting skills, research, and creative thinking. To put it briefly, this program equips students for the workforce of the twenty-first century. This paper reports on a study that examined the use of a science and technology approach based on robotics to increase and strengthen the level of engagement in STEM courses. Demographic variables were measured to identify the factors that affect the learning process. The study examined and compared the pretest and posttest examination scores of the respondents before and after exposing to robotics program. The pre-test MPS of the examination on robotics was 35.46% and post-test examination with 82.99% MPS. The MPS examination increased with 47.53%. Fifty three respondents or (66.25%) were non-science courses and twenty seven respondents or (33.75%) were science courses during the pre-survey and 75% of science courses, 2.5% were non-science courses and 22.5% were undecided during the post survey as their preferred course in college. The program had a significant increase in MPS of the examination and strengthen the level of engagement into STEM courses.

Keywords: *STEM education, learning process, robotic program, hands-on, reading and writing instruction*

Introduction

As a result of the Philippines' lack of STEM graduates, the nation lacks enough scientists (Anito, Morales & Palisoc, 2019). Compared to the UNESCO standard of 380 per million, the Philippines has a very low number of scientists—only 189 per million (Anito et al., 2019). The low graduation rates in STEM-related fields have a significant impact on the nation's low number of scientists. In accordance with the average 5-year data up until 2016–2017, according to the Commission on Higher Education (CHED) report, just 21.10% of STEM degrees are completed. Specifically, the completion percentage for the sciences was 25.52%, followed by math (21.20%), computer technology (19.56%), engineering and technology (18.97%), and medical and associated areas with 14.38%. This situation is further supported by EduTECH (2016), which found that the Philippines has a STEM labor deficit.

Cloud computing, artificial intelligence, cyber security, and robotics topics have gained attention due to the trend of Industry 4.0, which is now the center of attention in all fields including production, medicine, entertainment, and the military, among others. As a result, investments and incentives in these fields have increased. Recent years have seen a rise in interest in the field of robotics due to the increased use of robots in industry and daily life. Particularly in the fields of science, mathematics, engineering, and technology,

robots are now often regarded as essential components of educational processes. As a result, robotic coding research are becoming more and more important and influential among the studies that are shaping the technology of the future today. Briefly said, all activities involved in the design, control, mechanical building, and programming of the robot are referred to by the notion of robotics, which expresses the operation and usage of robots (Kalelioglu & Keskinilic, 2017).

Students can now readily learn robotics code at all educational levels, from K–12 to higher education, despite it being one of the era's prerequisites and developing at an exceptional rate globally. The most well-liked educational trend in recent years is robotic coding instruction, which is effective at teaching 21st century abilities like algorithmic thinking, critical thinking, computational thinking, communication, analysis, and problem solving (Korkmaz, Altun, Usta & Zkaya, 2014; Silik, 2016). Robotic educational applications facilitate more lasting and meaningful learning and the development of innovative problem-solving techniques (Koc & Boyuk, 2013).

According to Barak and Assal (2018), Chaudhary, Agrawal, Sureka & Sureka (2016), Ching et al. (2019), Ucgul and Cagiltay (2014), and Yolcu (2018), educational robotics has three main goals: to introduce STEM skills; to develop broad learning skills like engineering design, questioning, product-oriented thinking, analytical thinking, creative thinking,



teamwork, and being more willing to investigate an issue.

Since students can immediately observe the impact of the robot on their actions, they can aid in the concretization of abstract concepts and provide an instantaneous output of the written program for educational robot sets (Kazakoff & Bers, 2012; Ucgul, 2017). Accordingly, the employment of robotic applications in the classroom can boost student engagement, improve their attitudes about the subject matter and programming, and help them become better at comprehending and resolving issues using STEM abilities (Kuzu & Turk, 2018).

STEM stands for a connection where science, math, technology, and engineering are entwined and assist one another. The goal of STEM education is to develop people who are prepared to investigate issues related to STEM, apply the scientific method in doing so, and recognize the cultural, contemporary, and financial environments created by each discipline in STEM. These individuals should be able to integrate all of these factors by understanding the characteristics of STEM disciplines (Roostika, Setiawan, Utami, Julie, & Panuluh, 2020). To this end, it is possible to state that STEM education has a strong potential to boost people's interests, accomplishments, and motivations while also promoting learning (Anikarnisia & Wilujeng, 2020).

STEM-based robotic applications enhance collaboration, problem-solving, and computational and creative thinking (Romero & Dupont, 2016). This education also helps students be more imaginative and creative because creativity often yields ideas and alternatives that can be useful in problem-solving and interacting with others (Tiryaki, Akrolu, & Yaman, 2019). Additionally, it is evident that it promotes students' active engagement in the course and helps them develop their programming logic, engineering, and design skills (Comek & Avci, 2016).

Future career decisions are believed to be influenced by a student's desire to actively participate, or attitude toward the course. Having a favorable attitude towards science might encourage students' interest in science courses and occupations related to science because attitudes have a big impact on what students think and do (Alam, 2017). Students are more likely to not take a science course seriously if they find it dull and do not comprehend its relevance to daily life. To improve students' attitudes about science, creative strategies should be used. In light of the literature and studies discussed above, it is essential to use a hands-on

robotics program to encourage and deepen high school students' involvement in STEM education.

Research Questions

The theoretical framework that guides this research is founded in the experiential learning model based on Kolb's (1984) theory of experiential learning. The main purpose of this study was to determine the effects of experiential science intervention based on robotics training. Specifically, the following research questions were addressed:

1. What is the profile of the respondents in terms of age, gender, and economic status?
2. What are the contents of the robotics training in line with the competency in computer science, mathematics, and physics?
3. What is the career path of the respondents during pre-survey and after robotics training?
4. What is the level of acceptability of the training as perceived by the respondents?

Literature Review

These days, there are a variety of physically programmable robotic training sets available, including the VEX IQ Platform Kits (Starter Kits), Makeblock Kits (mBot - STEM Educational Robot Kits), LEGO Education Mindstorms (NXT, Ev3), Lego Wedo, Robbo, Ozobots, Bee-Bot, Cubelets, and LEGO Education Mindstorms (NXT, Ev3). Both text-based and block-based programming environments and application tools are available for these robotic systems. Modkit, Enchanting, miniBlog, Robo Pro, Open Roberta, Arduino (S4A), Blockly, and mBlock are block-based programming environments, while C, Java, and Python are text-based programming environments (Costelha & Neves, 2018; Kalelioglu, Gulbahar, & Dogan, 2018).

The primary resources in the hands-on robotics program used in the current study were Arduino boards. It is an open-source development board for microcontrollers. A physical programmable circuit board and a computer running an integrated development environment (IDE) are both components of the device. The IDE allows users to create and upload computer code to the physical board. A smaller computer with a processing core, memory, and programmable input and output peripherals is what Arduino may alternatively be described as. The Arduino was used to read sensor data and operate motors and lights, among other things. It enabled the

upload of programs to this forum that communicate with real-world objects. The Arduino may function autonomously, much like a robot, by connecting to a computer, which gives it access to sensor data from the outside world and allows it to provide feedback. It can also be connected to other Arduinos, as well as other electronic devices and controller chips. A condensed version of the C++ programming language is used by Arduino.

Methodology

Participants and/or other Sources of Data and Information

To determine the effectiveness of the hands-on robotics program, a one-group pretest-posttest was designed. The pretest survey was administered to the group prior to the beginning of the program. The group participated in the robotics program every Saturday from June 4, 2022- August 6, 2022 for a total of 10 Saturday sessions. The program formulated relevant topics in robotics curriculum contents. It includes:

1. Basic Electronics and Prototyping
2. Electrical Circuit and Troubleshooting
3. Microcontroller Fundamentals
4. Advance Interfacing
5. Sensor Application
6. Mechatronics

The evaluation instrument was a paper-and-pencil based, 60-item assessment instrument with one right answer and three distracters per question created by the researchers. Each assessment question was derived from activities within the robotics curriculum content. The assessment instrument was administered during pre-test and post-test examination for the evaluation of the robotics program.

The test composition was inclusive of sixty (60) items, ten (10) items for each topic with corresponding one-way table of specification. This test was administered to thirty (30) learners of Grade 11 who had already taken the subject Robotics at Rizal National Science High School during the S.Y. 2021-2022 for item analysis. The pretest and posttest were limited to 10-item test per lesson with a total of sixty (60) items. All lessons or learning competencies in the Hands-on Robotics Program were interconnected to one another.

After the robotics program another evaluation survey was made to assess the objectives, content, materials, training experience, training time allotted, venue, and

facilities. After ten sessions, the posttest was administered to the group based on their preferred course in college. The participants for the study were all from Rizal National Science High School. The overall sample contained 54 (67.5%) students from Grade 9, with an age range of 13-15 years (median age was 14.00) and 26 (32.5%) students from Grade 10, with an age range of 15-17 years (median age was 16.00). Other variables measured in the study were gender and economic status of the respondents, respondent profiling was used. To determine the pretest and post-test exam result, MPS was used. To examine the level of acceptability of the training as perceived by the respondents, mean was used.

The questionnaire checklist was validated by fifteen (15) computer programming experts College of Engineering from University of Rizal System-Morong, University of Rizal System- Binangonan Campus, University of the Philippines- Diliman, University of Santo Tomas and Technological Institute of the Philippines- Quezon City. Other validation of the questionnaire checklists was set to fifteen (15) teachers who were inclined in Robotics from Philippine Science High School Main Campus, Philippine Science High School- Eastern Visayas Campus, Manila Science High School, Rizal High School, and Antipolo Science High School. Comments and suggestions were incorporated in the refinement of the questionnaire checklist of the study.

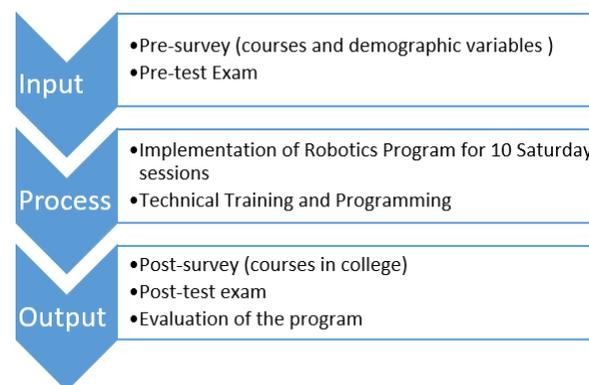


Figure 1. *Conceptual Model on the Implementation of Hands-On Robotics Program*

Data Gathering Methods

The study aimed to determine the effectiveness of the Hands-on Robotic Program to Engage and Strengthen High School Students' Participation in STEM Education utilizing descriptive and experimental

methods of research.

The study used an experimental method of research utilizing a Pre-Test-Post-Test design. Pre-Test-Post-Test design was used in the study to measure the effect of the Hands-on Robotic Program through the result of the compared pretest and post-test.

The researcher-made test was used as the main instrument to determine the level of performance of the two groups of learners in the Hands-on Robotic Program. In determining the scope of the test to be constructed, the researcher considered the topics in Robotics with the corresponding table of specifications. The test was a multiple-choice test with four options in every item.

The Hands-on Robotic Program evaluation materials were evaluated by computer programming experts and teachers inclined in Robotics based on the 5-point Likert Scale.

Results and Discussion

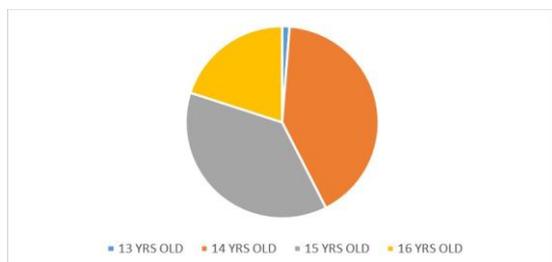


Figure 2. Profile of the Respondents in Terms of Age

The figure showed the profile of the respondents in terms of age. Only one (1) student belongs to 13 yrs. old (1.25%), thirty three (33) respondents belongs to 14 years old (41.25%), thirty (30) respondents with 15 years of age (37.5%) and sixteen (16) respondents (20%) with 16 years of age.

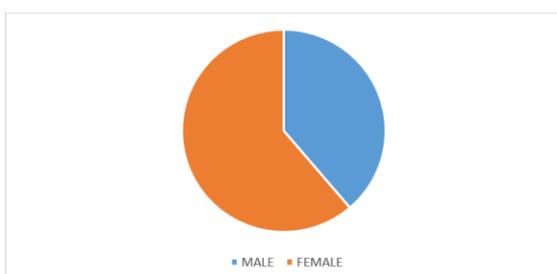


Figure 3. Profile of the Respondents in Terms of Gender

Figure 3 showed a total 31 or 38.75% male and 49 or 61.25% female as the respondents of the study.

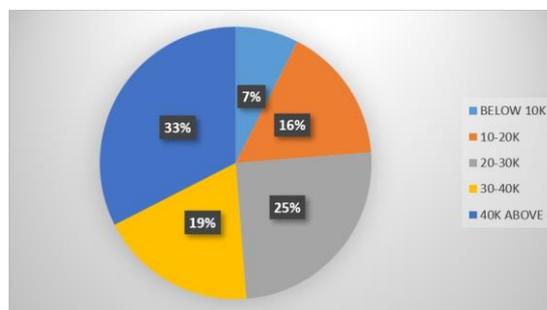


Figure 4. Profile of the Respondents in Terms of Economic Status

In terms of economic status, the figure showed 26 (32.5%) belongs to above 40 thousand monthly family income (MFI), fifteen (15) or 18.75% for 30-40 thousand MFI bracket, twenty (20) or 25% for 20-30 thousand MFI, thirteen (13) or 16.25% for 10-20 thousand MFI and six (6) or 7.5% below 10 thousand MFI.

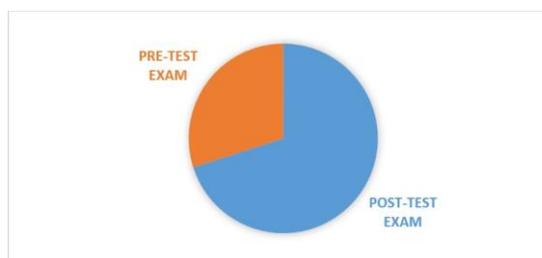


Figure 4. Mean Percentage Score on Pre-Test versus Post-Test Exam Results in Robotics Program

The figure showed the MPS of the pre-test examination on robotics with 35.46% and post-test examination with 82.99% MPS. It revealed that after the robotics program the MPS in the examination increased with 47.53%. It simply reflected from the results that robotics program with technical training increases the student's knowledge.

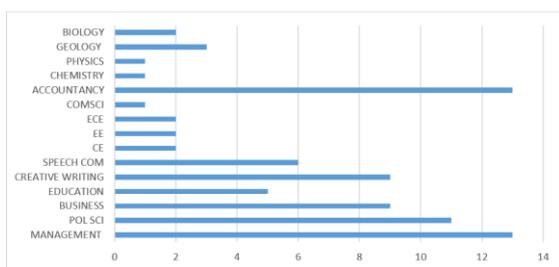


Figure 5. Pre-Test Result of the Respondents' Preferred Course in College

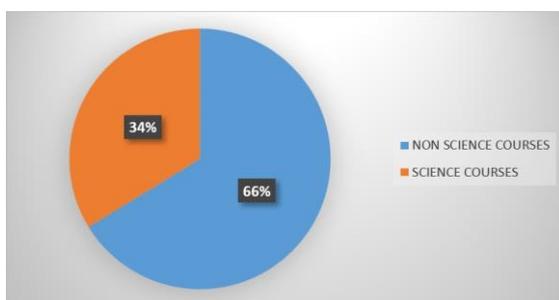


Figure 6. Percentage on Pre-Test Result of the Respondents' Preferred Course in College

Figure 5 and 6 revealed that during the pre-survey of 80 respondents, fifteen (15) courses reflected as their top priority courses in college. Fifty three respondents or (66.25%) were non-science courses and twenty seven respondents or (33.75%) were science courses. The higher percentage output composed of courses in Management (16.25%), Political Science (13.75%), Business (11.25%), Education (6.25%), Creative Writing (11.25%) and Speech Communication (7.5%) and lower percentage output or (33.75%) composed of Accountancy (16.25%); Civil Engineering, Electrical Engineering, Electronics and Communication Engineering and Biology (2.5% each courses); Geology (3%); Computer Science, Chemistry and Physics with 1% each courses.

Peer influence was included in the study as another important factor. Students' decisions about the courses to take can be influenced by friends or peers because this is how they try to fit in with the group (Ouano, Torre, Japitan, & Moneva, 2019; Robnett, & Leaper, 2013). Not every student can enroll in their favorite course since colleges have enrollment caps for various programs or quota courses. Lack of resources, family support, and cultural capital were additional obstacles

that students had to overcome. Although the institution has put in place a number of financial assistance to help quota students, they lack formal academic aids like bridging programs, additional training, and tutoring (Childs, 2015). Today, we need to think about how students might actively participate in their education because simply increasing student interest in science may not be enough to persuade more students to pursue a career in the field. In doing so, we can assist children in developing their own sense of self (Holmegaard, 2015).

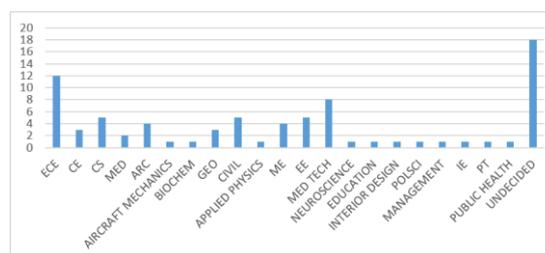


Figure 7. Post-Test Result of the Respondents' Preferred Course in College

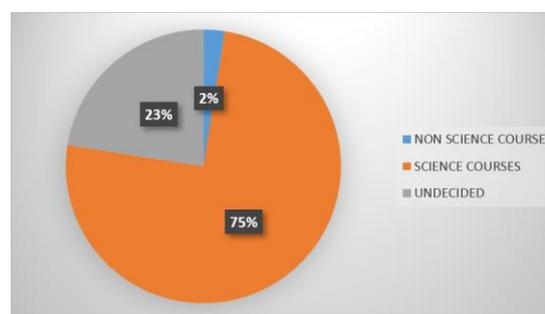


Figure 8. Percentage on Post-Test Result of the Respondents' Preferred Course in College

Figure 7 and 8 showed the percentage on post-test result of the respondents' preparable course in college. A total of twenty one (21) courses reflected as chosen careers in college. It includes Electronics and Communication Engineering (15%); Civil Engineering and Geology (3.75% each courses); Computer Science, Chemical Engineering and Electrical Engineering (6.25% each courses); Medicine (2.5%), Architecture (5%); Aircraft Mechanics, Neuroscience, Interior Design, Biochemistry, Industrial Engineering, Physical Therapy, and Public Health (1.25% each courses) for a total of 75% of science courses. Only

two (2.5%) were non-science courses which include Education and Political Science (1.25% each courses) and Eighteen respondents (22.5%) were undecided.

Regarding the knowledge and experiences of the students, Franco and Patel (2017) identify five linked categories: students' conceptions of engagement, obstacles to engagement, teachers' facilitation of engagement, course assignments and engagement, and facilitation of content usefulness. Future career choice in a STEM profession is predicted by a strong, positive STEM identity (Martin-Hasen, 2018).

A person's understanding of STEM careers may influence their decision to pursue one in college (Compeau, 2016; Nugent et al., 2015; Zhang & Barnett, 2015). The impact of a student's professional interests and preferred future career activities on their decision to pursue a STEM career (Blotnicky, Franz-Odenaal, French, & Joy, 2018). Additionally, students enroll in STEM because they are interested in these fields. Because of the expansion of this idea in the field of science educational societies during the last two decades of the 20th century, interest is a significant component in the study of science (Akram et al., 2017). Additionally, science education is a key driver of sustainable development and economic advancement and self-sufficiency (Rogayan, & Macanas, 2020). This suggests that the respondents' level of participation in STEM (science, technology, engineering, and mathematics) courses has increased as a result of the robotics program.



Figure 9. Level of Acceptability of the Training as Perceived by the Respondents

Figure 9 showed the evaluation of the training program. “Trainers were well prepared” rank no.1 with an average mean of 4.5375 with a verbal interpretation of “strongly agree” and “This training experience will be useful in my work” rank last with an average mean of 3.75 with a verbal interpretation of “neutral”. The level of acceptability of the training got an average mean of 4.10 with a verbal interpretation of “agree”.

Conclusion

Overall, the findings of this study support the use of robotics program to engage and strengthen the student’s participation in Science and Technology Engineering and Mathematics (STEM) careers in college. The evaluation instrument developed to test the research study is reliable and valid. More research is needed to determine the effectiveness of the hands-on robotics program with different populations.

Moreover, research is needed to examine whether the program helps fosters positive attitudes towards STEM in school and as a career. Researchers have provided explanations for why family income affects the career path of the students. First, poverty associated with increased levels of parental stress, depression, and poor health conditions that might adversely affect parent’s ability to nurture their children. The hands-on engaging robotic design activities are the tools to really help high school students gain perspective on STEM education and become interested in it. The hands-on design project helps the student to see the big pictures. It help student to make connections among the various STEM courses they take and gave them a new perspective.

This paper suggests that senior high schools plan a variety of events during Career Week. Students' career motivation, job aptitude, and potential career paths in STEM-related courses are some of these activities. In order to help students choose the right path and prevent problems with course quotas, schools may also hold career counselling seminars. Different programs for student career preparation may be implemented with cooperation from the Department of Education (DepEd). The students' awareness of potential career paths and ability to resist peer and outside pressure will both improve as a result of this training.

The management of the school may also hold an orientation on STEM, its requirements for various industries, and how STEM workers may contribute to the expanding economy of the nation. To help STEM teachers better understand how to prepare their students for careers, DepEd may offer seminars. In this way, educators will receive career coaching training to help students choose careers that match their interests and abilities.

Personal development programs and family mentorship sessions are suggested to help students make better career decisions because personal aspiration and family are the two factors that have the biggest impact on their decision to pursue a STEM job.

In order to better meet the demands of the Industrial Revolution 4.0, a collaborative, authentic, and goal-oriented learning environment must be strengthened.

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