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Coping With The Challenges Of The Integration Of Robotics In The Science, Technology, And Engineering Program And Influences To Students' Multiple Intelligences

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Abstract: *This qualitative study examines the experiences of Ten (10) Bodily-Kinesthetic Participants (PBK), Ten (10) Verbal-Linguistic Participants (PVL), Nine (9) Interpersonal Intelligent Participants (PII), Five (5) Logical-Mathematical Participants (PLM), and Three (3) Visual-Spatial Participants (PVS) on the integration of robotics in STE Program. The Meriam analysis revealed eight (8) primary themes: (1) Mode of delivery, (2) Programming abilities, (3) Low retention, (4) using online research platforms, (5) seeking social support, (6) engaging oneself cognitively (7) increases students' interest in science, technology, and engineering (8) fosters the acquisition of 21st-century skills. The first three (3) themes describe the students' challenges. Themes four (4), five (5), and six (6) are the coping mechanisms of the students. Seven (7) and Eight (8) are the robotics activities' influences on the students. These findings indicate that integrating robotics into the science curriculum poses challenges among students causing the development of healthy coping learning strategies.*

Keywords: *Coping Mechanisms, Multiple Intelligences, Robotics, Science Curriculum*

Introduction

The rapid industrial revolution in the dawn of the 21st century, where 21st-century skills have been in high demand, urged the education sector for global reform. Educational reform has been taking place worldwide (Jiang et al., 2021). There has been a shift in the focus of the educational curriculum from traditional to the technologically integrated curriculum (Kuang-Chao, 2021). New Zealand, for example, has integrated technology into the education curriculum as part of the reform (Buntting, 2021). England also proposed an integrative curriculum following the curriculum reform of Germany, the Netherlands, and Sweden (Mellander & Lind, 2021).

The big chunk of this reform is the implementation of K-12 curricula innovation (Gale et al., 2021), wherein countries around the globe have adopted and implemented STEM education (Suprato & C-H, 2019). As early as 2014, some schools and universities like Sydney University of Australia have been actively refining the STEM curriculum (Anderson,2018). Several schools in the United States of America have been adopting this integrated STEM curriculum (Balgopal,2020). Data revealed that the STEM integrative curriculum supported student problem solving (Kopcha et al., 2017). Under this new curriculum, students showed better performance and increased learning motivation (Chun-hung, 2021).

In the Philippines, few schools like the Camarin High School are making initiatives to improve STEM education through robotics integration (Galino & Tanaka, 2021). The Robotics curriculum is proven effective in stimulating students' interest in STEM (Chen & Chan, 2018). In general, robotics provides a rich and attractive learning environment for STEM education (Barak & Assal, 2016). Its use as a content organizer could positively influence the high school student's beliefs and interest in STEM concepts (Hilton, 2017; Whitehead, 2010). Another research showed that robotics activities could promote higher-self efficacy in STEM tasks (Hilton, 2017). They engage students in critical and computational thinking, problem-solving, and collaboration (Albert et al., 2017; Bernstein et al., 2022; Chiazzese et al., 2019). If done interracially, they would teach them friendship and tolerance in modern society and the world (Kerimbayeu et al., 2020).

The Acquisition of 21st-century skills facilitated by robotics is another significant reason to integrate robotics into the Philippine science curriculum (Montemayor, 2018). The Department of Education (DepEd) supported this integration by offering a robotics program in science high schools and some private schools throughout the country (Asia News Monitor,2018). It is under the Republic Act no. 2067, which emphasizes strengthening the country's educational system through technology integration (Manila, 1958). In 2012, Senator Manny Villar authored Senate Bill No. 1255, also known as " An Act Integrating Robotics Application in the Teaching of Secondary Science Education in the Philippines."

The students' experiences with robotics activities have helped them acquire and develop 21st-century skills (Albert et al.,2017; Bernstein et al., 2022; Chiazzese et al., 2019; Hilton, 2017; Loannou & Makridou, 2018). Studies show that robotics activities develop students' problem-solving, critical thinking, decision-making, teamwork, creativity, collaboration, self-direction, and communication skills (Khanlari, 2013 Kucuk & Sisman,2020). Moreover, Experiences with robotics activities proved to enhance students' interest, engagement, and academic achievement in various fields of STEM education (Anwar et al., 2019) and strengthen the learning skills of future engineers and scientists (Curto & Moreno, 2016). Robotics gives students exciting experiences and a fun vision of Science, Technology, Engineering, and Mathematics (Curto et al., 2016). At the same time, it provides a curriculum for playfully engaging students with computational thinking (Sullivan et al., 2017)

Generally, students have positive experiences with robotics activities. However, regarding its specific impact on gender, research shows that female students had significantly less desire and less confidence to learn robotics than male students (Kucuk & Sisman, 2020). Nonetheless, there is no gender effect on computational thinking and teamwork (Kucuk et al., 2020 ; Taylor et al., 2019). Students eventually reach the same level of CT skills development independent of gender (Atmatzidou & Demetriadis, 2016). Nevertheless, the same study also found that girls need more time to reach the same skill level than boys (Atmatzidou et al., 2016). It comes to age. It has no significant effect on the development of computational thinking. All students within the age range reached the same level of CT skills (Atmatzidou et al., 2016).

There are several studies about the comparison of male and female students' experiences in robotics. Some deal with the different impacts of robotics activities on each gender (Sullivan & Bers, 2016; Witherspoon et al., 2016). Currently, no existing study on the impact of robotics on each type of intelligence according to Gardner's Theory of Multiple Intelligences. This theory claims that at least eight existing intelligence humans could have (Garner, 1993). These are Visual-Spatial, Linguistic-Verbal, Logical-mathematical, Bodily-Kinesthetics, Musical, Interpersonal, Intrapersonal, and Naturalistic Intelligence. Every person has multiple intelligences, but he singles out one intelligence. Gardner called this a person's "strong intelligence," an area where he has considerable power to learn and perform. His "strong intelligence" differs from the others. His ability to win regularly at a game involving spatial thinking signals "strong spatial intelligence." While someone's ability to speak a foreign language well after just a few months of 'going native' signals "strong linguistic intelligence" (Gardner, 1983). Given this, teachers must understand their learners' multiple intelligences to carefully identify their goals and design activities to address individual intelligence (Sener & Lokcaliskan, 2018). The combination of computer-related instructions and attention to multiple intelligences will result in a more successful classroom learning environment and the fostering of creative thinking (Davis, 1991) which is one of the 4 Cs of 21st century skills.

The 21st century skills can be summed up into 4 Cs namely Critical thinking, Creative thinking, Communicating, and Collaborating (Magno et al., 2016). These skills resonate the core objective of the K to 12 Science Curriculum of the Department of Education, that is to produce citizens who are critical problem solvers, responsible stewards of nature, innovative and creative citizens, informed decision makers, and effective communicators (K to 12 Science Curriculum Guide, 2013). This goal is based on the conceptual framework of the K to 12 Science Curriculum which emphasizes science and technology literacy. The very heart of this framework is the acquisition and development of the five vital skills for the 21st century.

The present study includes the five categories of intelligence relevant to the acquisition of the 21st-century skills and mostly utilized in robotics activities. This study seeks to determine the impact of the integration of robotics in the STEP curriculum on Bodily-Kinesthetic, Interpersonal, Verbal-Linguistic, Visual-Spatial, and Logical-mathematical Intelligent Students. The demand for 21st-century skills caused a global educational reform changing the content-focused curriculum from traditional to technologically integrated (Kuang-Chao, 2021). The central part of this reform is the implementation of the K-12 curriculum (Gale et al., 2020). This curriculum implements STEM education (Suprato et al., 2019). STEM curriculum promotes the development of 21st-century skills (Kopcha et al., 2017) and increases students' academic performance and learning motivation (Chun-hung, 2021).

Robotics is proven effective in stimulating students' interest in STEM (Chen et al., 2018). Its activities engage students in critical and computational thinking, problem-solving, and collaboration (Albert et al., 2017; Bernstein et al., 2022; Chiazzese et al., 2019). The Philippine science curriculum integrated robotics to widen the opportunity of developing 21st-century skills. Hence, fulfilling the mandate of Republic Act No. 2067, integrating technology into the educational curriculum.

Robotics experiential activities helped students acquire 21st-century skills (Albert et al., 2017; Bernstein et al., 2022). Studies show that robotics activities develop students' problem-solving, critical thinking, decision-making, teamwork, collaboration, and communication skills (Khanlari, 2013; Kucuk et al., 2020). Moreover, research findings claimed that robotics enhanced students' interest, engagement, and academic achievement in the fields related to science, technology, and engineering (Anwar et al., 2019).

Generally, students have positive learning experiences with integrating robotics into a curriculum. Its impacts on students have been the subject of previous studies. Research findings revealed the comparisons of robotics' impacts on students regarding age and gender (Kucuk et al., 2020; Taylor et al., 2019).

At present, there is yet to be a current study on the impact of robotics on each category of multiple intelligence. The M.I Theory claims that humans could have at least eight existing intelligence (Gardner, 2010). Every person has multiple intelligences, but he singles out one type of intelligence. Garner called it "Strong intelligence"-an area where a person has the most power to learn and perform. Given the difference in the preferred "strong intelligence," students are impacted by learning experiences differently.

The integration of robotics is the realization of the core objective embedded in the K-12 science curriculum of the Philippines' Department of Education. The curriculum aims to develop 21st-century skills among students. The inclusion of robotics in the Science, Technology, and Engineering Program is a step up to realizing its goal of science and technology literacy.

This study is limited to the five categories of intelligence which have much relevance to robotics. It includes Bodily-Kinesthetic, Interpersonal, Verbal-Linguistic, Visual-Spatial, and Logical-Mathematical Intelligence.

Method

Research Design

This study employed the Multiple case study. It is a qualitative research design that allows the researcher to analyze within and across settings (Baxter & Jack, 2008). Qualitative research is a systematic empirical inquiry (Shank, 2002) of understanding the human problem by building a holistic picture based on the participants' views (Creswell, 1994). It makes sense of the human experience in a specific context (Rahman, 2016) through an interpretative and naturalistic approach (Denzin & Lincoln, 2005). The term " interpretative and naturalistic" means that qualitative researchers do not manipulate the settings and behaviors of the participants. Researchers make sense of the phenomenon based on the meanings that the participants give to them (Ospina, 2004). In this study, the researcher used a qualitative research design, particularly the Case Study Approach of Merriam to explore the students' experiences in the integration of robotics in science curriculum. Merriam's multiple case study was utilized to view the experiences of students in multiple intelligence groups. This study focuses on five categories of intelligence that are relevant to the development of the 21st century skills through robotics activities. It consisted of five (5) cases. The case 1 includes the participants from the Bodily-kinesthetic intelligent students (PBK). They are those who learn best when using their hands and senses. The case 2 refers to the participants from Verbal-Linguistic Intelligent students (PVL). They respond and learn through the use of words and anything else related to language. The Interpersonal intelligent Participants (PI) are the third case. PI participants are good with people. They can understand and sympathize the emotions of others. The fourth case is the (PLM) or participants from Logical-Mathematical intelligent students. Belonging to this category are students who are good in numbers and reasoning. They can work better with abstracts concepts. The case 5 consists of the participants from the visual -spatial intelligence students (PVS). This group best learns visually. They are good in organizing things. Graphs, charts, maps, tables, illustrations, and puzzles are some of their favorites.

Baxter & Jack (2008) claimed that a multiple case study allows the researcher to examine several cases to understand the similarities and differences between cases. Considering it, the researcher can generate robust and reliable evidence (Baxter & Jack, 2008).

Research Environment

The researcher conducted this study at Zamboanga del Sur National High School. It is part of District 4 of the Pagadian City Division. The researcher chose it as the research environment for two reasons: firstly, it is the only school implementing STEP with Robotics integration, and secondly, its accessibility and convenience, since he is currently a robotics teacher in this institution.

Research Participants

The participants of this study were thirty-seven (37) Grade 9 students of the Science, Technology, and Engineering Program of Zamboanga del Sur National High School. The researcher selected the participants from a population of eighty-four (84) STEP students. They have undergone a three-stage selection process using three Multiple Intelligence Tests. The researcher used three different types of Multiple Intelligence Tests to attain the maximum reliability of the result. To ensure that the participants would be objectively and correctly identified and grouped according to the five focal intelligence types, the eighty-four (84) grade 9 students were subjected to three stages of selection. First, they took the online Multiple Intelligence Test at IDRlabs.com. The IDRlabs or Individual Difference Research Laboratories are private companies that provide personality and multiple intelligence tests. Its tests are based on peer-reviewed scientific research of professionals and experts in the field (IDRlabs). Out of the population of 84 students, fifty-three (53) have come out to be part of the five focal intelligence groups. Twelve (12) students are interpersonal, twenty (20) students are Bodily-Kenisthetics, fifteen (15) students are linguistics-Verbal, and four (4) and two (2) students are Logical-Mathematical and Spatial-Visual Intelligent, respectively. The fifty-three (53) students were given the second Multiple Intelligence Test. It was a 70-item written Multiple Intelligence Test based on Howard Gardner's MI Model. Teachers, trainers, managers, academics, and researchers have used this test multiple times without questioning its reliability. Its use started in 2005. Businessball.com developed it. It is a learning and development resource for people and organizations. Forty-six (46) students have qualified to be in the five (5) focal intelligence groups. Seven (7) students were removed from the list of participants. The 46 students took the Multiple Intelligence (M.I.) Inventory to determine the participants. Walter McKenzie, a renowned international presenter on multiple intelligence and author, developed this test in 1999. The result showed that thirty-seven (37) students –Ten (10) for Bodily-Kinesthetics Participants (PBK), Nine (9) for Interpersonal Intelligent Participants (PII), Ten (10) for Verbal-Linguistic Participants (PVL),Three (3) for Visual-Spatial Participants (PVS), and Five (5) for Logical-Mathematical Participants (PLM) have qualified to be the final participants for this research.

Research Instrument

This study used interviews as the main sources in data gathering. The researcher himself was the primary tool to obtaining the needed data. The interview guide questions were constructed within the frame of the research questions to capture the necessary information that bears the participants' actual experiences. The researcher developed open-ended questions to allow the participants to express and describe their experiences in the integration of robotics into the science curriculum. The researcher also utilized in-depth interviews to extract the relevant data from the participants.

Data Gathering Procedure

The researcher followed the protocol in conducting research. A permission letter prepared by the researcher and noted by the Dean of the Graduate School of Saint Columban was sent to the office of the Schools and Division superintendent for approval to conduct the study. Other permission letters with the approved letter from the office of the SDS were sent to the district 4 Supervisor and the school principal's office, notifying them of the conduct of the study.

The researcher also prepared a separate letter for the Head Teacher of the science department seeking approval to conduct an orientation of the students. The orientation was set and conducted by the early part of September. The participants were made aware of the background of the study and the methods of selecting the final participants and gathering the data, respectively. The researcher administered the three multiple intelligence tests to identify and group the final participants in the third week of September. By October, the in- person depth interviews were conducted. The Ten (10) Bodily-Kinesthetic Participants (PBK) were interviewed first. The researcher jot down notes and also audio recorded the conversation. It took Five (5) to Ten (10) minutes for each participant to completely answered all the questions. The remaining four (4) groups of participants were interviewed for the successive days in the following sequence: (2) Interpersonal Intelligent Participants (PII), (3) Verbal-Linguistic Participants (PVL), (4) Visual-Spatial Participants (PVS), (5) Logical-Mathematical Participants (PLM). The researcher listened to the recorded audio to counter check the details of the written notes to accurately produce the transcript of the interview.

The researcher strictly followed the IATF mandates for health safety protocol against the virus for the entire period of the conduct of the study. The rights of the participants were always the priority. Their right to privacy has been observed.

Data Analysis

The study utilized the Merriam qualitative data analysis. It is a step-by-step process of analyzing data which starts with open coding (Mishra, 2021). Initial codes from the transcript would be determined. The researcher can include as many codes as he wants. From these initial codes, the construction of category as Merriam called it, would follow. Codes that keep repeating would be put together, they form a theme. This process is called "sorting categories". Sorting of categories would continue to reduce the number of categories into manageable level (Mishra, 2021). Fewer categories increase the effectivity of abstraction; hence clarity of findings would be attained.

Ethical Consideration in Doing Research

Research is a pursuit of trust (Kothari, 2006), an honest attempt to study a problem (Theodorson, 1969) for the establishment of new knowledge (Isidro & Malolos, 1979). In this study, the researcher strictly adhered to research ethics. He has been faithful to the principle of in-text citation, deception or misrepresentation, informed consent, privacy, confidentiality, and anonymity.This study utilized the Merriam multiple case study. It is a qualitative research design that allows the researcher to analyze within and across settings (Baxter & Jack, 2008). Additionally, the researcher can examine several cases to understand the similarities and differences between cases generating robust and reliable results (Baxter et al., 2008).

The researcher conducted this study in Zamboanga del Sur National High School-Pagadian City, Philippines, during the school year 2022-2023. The Thirty-Seven (37) participants were identified after the Eighty-Four (84) students had undergone the three-stage selection process using three multiple intelligence tests. In the first stage, students took the online intelligence test on IDRlabs.com. The fifty-three (53) students who qualified were given the second multiple intelligence test based on Gardner's (M.I) theory. The last selection process accommodated the forty-six (46) students who passed the second test. Thirty-Seven (37) students came out as the final participants of this study.

The researcher constructed interview guide questions. It consists of engaging, exploratory, and exits questions. The exploratory questions include (a) What are the common challenges the students encountered in the integration of robotics into the science curriculum? (b) How do the students cope with the challenges in the integration of robotics? (c) How does integrating robotics into the science curriculum influence the students to learn more about science, technology, and engineering? Strict adherence to research ethics was observed. Confidentiality and participants' anonymity are the basics of this exploration.

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Results

The eight (8) themes emerged during the data analysis: Three (3) themes described the challenges encountered by the students in integrating robotics into the science curriculum, three (3) themes constructed for the students' coping mechanisms, and two (2) significant themes for the influences of robotics to students.

Challenges:

Theme 1: Mode of Delivery. It refers to the format in which the lesson is delivered. It can be in-person, online, modular, and blended.

> *“Lisod siya sa grade 7 kay modular siya ug sa grade 8 kay online.” [I found robotics difficult in grade 7 because it was modular, and also the online class in grade 8.]-PBK1*

> *“Wala kaayo ko natun-an sa grade 7 and grade 8 kay modular.” [I did not learn much in grades 7 and 8 because it was modular.] – PBK9*

> *“It is easy for me to understand robotics because of the face-to-face classes. I learned more. I like it.”-PI4*

> *"In grade 7 and grade 8, I did not learn much since it was modular and online."-PVL3*

> *“Medyo may pagkalisod pud labi na sa Grades 7 and 8 kay modular. Kulang ako experience kay modular ra.” [It wasn't easy in grades 7 and 8, and I lacked experience because lessons were delivered through modules.] – PVL1*

Theme 2: Programming Abilities. Programming abilities pertain to the knowledge and understanding of various elements used in coding.

> *“Naglisod ko sa programming, complicated kaayo man gud.” [I have difficulty in programming. It is complex.]–PBK2*

> *“Sa coding maglisod ko kay taas siya malimot ko sa mga isulat.” [I found Coding difficult; there are many things to write I forgot what to write.] – PBK6*

> *"I have difficulty in coding. I need to memorize many things.”-PII3*

> *"I have a problem with the coding. I cannot properly memorize. It is complicated."-PVL3*

> *“Problema ko sa coding kay if naay gamay sipyat dili mowork ang robot. Magstruggle ko kay mafrustrate na dayon ko tungod ani.” [I have a problem with Coding because I need to be very careful once there is a slight error the robot won't work. This would frustrate me.] – PVL7*

> *“I have a hard time understanding programming. I was easily discouraged if I encountered problems.”–PVS1*

> *“Nagstruggle ko sa programming. Lisod siya.” [I struggled with the programming part. It was not easy.] -PLM2*

Theme 3: Low Retention. Learning retention refers to the ability of the student to store new information in long-term memory so that he/she can access it anytime he/she needs it (Colman, 2022). Low retention means the inadequacy of the student to store new information in his/her long-term memory, which results in forgetting.

> *“I have struggled with memorizing the components of the robot because there were plenty of them. They must be memorized.”– PBK3*

"I struggled in identifying parts of certain thing that needs to be identified." [I have difficulty identifying parts of the robot's components that have to be identified.] – PI2

"I struggled to connect the wires correctly because I had difficulty remembering how it was done."–PI1

"Ang problema nako mostly magremember sa symbol sa code." [remembering the symbols and functions in Coding was my problem in robotics.] – PVL9

"Remembering the symbols and functions in coding was my problem in robotics."– PVL4

"My struggle is remembering the lesson. I have memory loss."–PSV3

"Difficulty in connecting wires. Memorizing the parts." [I had difficulty connecting the wires because I could not remember the robot parts correctly.]- PSV2

"I have difficulty memorizing the specific parts of the robot's components. It hinders me from learning robotics."–PLM1

Coping Mechanisms:

Theme 4: Using Online Research Platforms. It is a coping strategy in which the students use various online platforms for researching and studying. The participants used two common online platforms- YouTube and google.

"I researched on google and watched video tutorials on YouTube."–PBK8

"Motan-aw ko ug Youtube tutorials para makasabot ko." [I watched video tutorials on Youtube to understand the lessons.] – PBK1

"I searched on google."–PII5

"Research ko sa google and Youtube." [I did some research on google and Youtube.] -PVL4

"I searched on YouTube and watched short videos."–PVL2

"I watched YouTube tutorial and searched in google."–PVS1

"Maminaw jud sa discussion tapos magsearch sa Youtube ug google." [I listened attentively, then I did further research on youtube and google.] -PVS2

"Maresearch sa google sir." [I did research in google, sir.]–PLM2

Theme 5: Seeking Social Support. It refers to students' coping with the lesson's difficulty by asking for help from classmates, teachers, and family members.

"I asked help from my classmates if I encountered difficulty."–PBK6

"I borrow materials from my classmates." [If I lack materials used in the lesson, I borrow from my classmates.] -PBK10

"I asked questions from my groupmates if I did not understand something."–PII3

"I asked my classmates and my parents."–PVL4

"I usually reach out with my friends. Makipagcommunicate ko sa ilaha. Mangayo ug sample." [I did reach out to some friends and communicate with them. I asked for some examples.] - PVL2

Theme 6: Engaging Oneself Cognitively. Cognitive engagement refers to the degree of willingness of the students to receive and perform the given task. It includes the amount of effort the students are willing to invest in doing the task and how long they persevere.

“I used my free time to study very well. I have read the lesson repeatedly until I understood it.”–PBK2

"I bought materials for advanced hands-on study at home.”–PI5

“I must be patient and calm. I analyzed the problem slowly.”-PVL7

"I confronted the problem. I would always find a way to solve it. I used trial and error most often. I also spent enough time studying.”–PVS1

“I improved my study habit. I studied and familiarized the lesson.”–PLM1

Influences on Students:

Theme 7: Increases Students’ Interest in Science, Technology, and Engineering

“My interest in technology has improved. I am more interested in how manufacturers put things inside of them.”–PBK1

"Robotics improved my knowledge of technology. I am now interested to discover new things about technology and science.”–PII1

"I am familiar, or the various materials used in science because of robotics activities. I am now interested in science.”–PVL3

"I became interested in the manufacturing of cellphones, robots, and other appliances.”-PSV3

“Robotics is interesting. It helps me to learn science and math.”–PLM1

Theme 8: Fosters the Acquisition of 21st-Century Skills

“I was aloft before, but now I learned to be in a group because robotics activities require teamwork.”–PBK7

" I become more critical of details.”-PVL1

“It helps my brain to think.” – PSV2

“My problem-solving ability improved when I experienced building robots.”-PII2

“…face the problem and find a way to solve it.”–PSV1

“Robotics improves my creativity and productiveness, especially in dealing with math.”-PLM3

“I do usually reach out to others like my friends. I communicate with them.”–PVL2

“I like it because activities are done through groupings. We can help each other by sharing ideas.”–PII4

Discussion

The participants unveiled that learning robotics is challenging when taught through modular and online classes. The absence of face-to-face interactions and hands-on experience makes the subject unattractive, less enjoyable, and hard to learn for the (PBK), (PVL) and (PII). The Bodily-kinesthetics, Visual-Linguistics, and Interpersonal Intelligence need interaction to learn effectively. The (PVS) and (PLM) did not express difficulty in learning through modular or online classes. Spatial-Visual intelligent students would learn effectively even in online classes if the materials were related to colors, images, and shapes. Logical-Mathematical Intelligence is object-related intelligence (Campbell et al., 1996). It does not rely on physical interaction with the teachers or fellow students to learn. Learning would still be at best if teaching materials were related to logic, patterns, and relationships.

Robotics involves designing, constructing, and programming robots. Each of these tasks requires skills and abilities. Most of the participants have difficulties in programming. This difficulty has been experienced by participants from the five types of intelligence. Though linguistics and Logical-Mathematical intelligent students have the natural disposition to learn this type of task (Yogatama et al.,2019), the learning modality used to teach it was unsuitable for the student's level. They were frustrated knowing that the task was far beyond their learning capacity.

Robotics tasks, especially programming, require remembering. Students must memorize acronyms, symbols, and functions to create a sketch successfully. Participants manifest difficulty in remembering. In robotics, everything is connected. If they need help recalling previous topics, it is easier for them to understand the new lesson. Things needing to be understood would pile up, eventually frustrating them. Given the variety of "strong intelligence" of students and the versatility of robotics activities in providing experiential and effective learning to all types of learners, it is surprising that low retention has become common among students from the five focal intelligence types. According to Gardner, the five intelligence types will learn best if there are words, graphs, numbers, games, hands-on activities, and group activities. These are embodied in robotics activities, yet their effect is incongruent with their purpose. One possible explanation is the unmastered competencies in Grades 7 and 8, as reflected in their responses regarding the mode of delivery.

Students have developed strategies to cope with their problems in integrating robotics into the science curriculum. One of the most common copings is doing online research. Students used online research platforms to research and study further unmastered lessons. The two frequently used online research platforms are YouTube and Google. The participants from the five focal intelligence types are known to use YouTube and Google as the two common research engines. The elaborate video tutorials with demonstrations, graphs, clear descriptions, illustrations, and content that show collaborative activities attract the five (5) focal intelligence groups (Gardner, 2010) to search for and study unmastered topics.

Participants showed using social support to overcome the challenges they encountered in robotics. The problems in robotics urged the students to be resourceful. One way of doing it was to tap others. They asked for help from fellow students, teachers, and family members. This coping has engaged them more socially, therefore, developing social skills.

Three intelligence types, namely the Bodily-kinesthetic, Linguistic, and Interpersonal, employed this coping. The (PVS) and (PLM) used different copings aligned with their "strong intelligence." As previously discussed, these two groups preferred to engage intellectually alone. They are productive when working and solving problems by themselves. Logical-Mathematical and Visual-Spatial intelligence are more inclined toward scientific inquiry, which is more on experimentation rather than asking opinions of others (Blakeley, 2022; Kelly, 2019). While Bodily-kinesthetic, Verbal-Linguistic, and Interpersonal intelligence operate best when there is social interaction. Their "strong intelligence" worked best when the activities involved other people. They express themselves and relate to people based on words, facial expressions, body gestures, and emotions (Schuttle et al.,2022).

The participants revealed that to overcome their struggles in programming, connecting wires, and Coding, they have to add effort in engaging themselves intellectually in the activities. They must focus on the given tasks. They put additional time into studying and understanding the lessons. The students from (PBK), (PVL), (PII), (PVS), and (PLM) have developed this coping to counteract the difficulties they experienced in the integration of robotics in STEP. The problems that each robotics activity presents have engaged the "strong intelligence" of each group, causing them to tap their intellectual potency. They stretched their intellectual engagement beyond what had been practiced. They have done it under their "strong intelligence." The (PBK) has done it by using manipulatives, the (PVL) by focusing on words and descriptions, the (PII) by engaging in discussions with others, the (PVS) by illustrating complex concepts, and (PLM) by building connections (Gardner, 2010).

Integrating robotics in the STEP affects how students feel and think about science, technology, and engineering. Robotics activities enhance students' interest in Science, Technology, and Engineering (Anwar et al., 2019). Their experiences with robotics activities create a personal interest in technologies like cell phones and other gadgets. They become interested in how these gadgets are manufactured. They have become interested in learning new things in science, technology, and engineering, like building a robot with a new design and purpose.

Responses from the five intelligence groups suggest that integrating robotics in the STEP has improved their interest in science, technology, and engineering. The contents, activity types, and teaching strategies inherent to robotics have engaged the students, igniting their interest in robotics-related things. Robotics activities give experiential learning to the students. Students are engaged in intellectual, emotional, social, and physical aspects. The strength of each type of intelligence is anchored to one of these aspects. For example, Logical-mathematical and Visual-Spatial intelligence are based on intellect rather than emotion. Therefore, it is fitting to infer that robotics activities aflame students' interest in the five focal intelligence types to science, technology, and engineering-related materials. As qualified to provide experiential learning, robotics activities address the learning needs of learners with different intelligences.

The integration of robotics into the science curriculum develops students' 21st-century skills. As it offers programming, computing, diagramming, and actual assembling of the robot (Cano, 2022), students improve their critical and creative thinking skills in communicating and collaborating. The participants from the five intelligence types have shown improvements in critical thinking skills. They engaged in robotics activities intellectually. They asked questions, investigated, experimented, and were curious and creative. By doing it, they develop critical thinking (Albert et al., 2022).

Additionally, integrating robotics into the science curriculum increases students' creativity (Cano, 2022). Students participating in robotics activities become creative in solving problems (Bernstein et al., 2022). Robotics is a group-activity-based subject. It is taught with hands-on activities through groupings wherein students must talk and communicate with each other. Robotics activities developed students' communication skills (Chiazzese et al., 2019) because of their engagement in group work. Moreover, the participation of students in the robotics activities helped them learn to collaborate with others (Ioannou & Makridou, 2018). They become confident and skillful in sharing and accepting ideas from others.

Conclusions

Integrating robotics in the STEP increases students' interest in learning science, technology, and engineering. Through embodying experiential learning, it develops the students' 21st-century skills. Its varied activities present problems causing the development of students' effective learning mechanisms that are useful in real-life settings.

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