Robotics Education: Best learning practices that are implemented in schools and robotics institutions around the world

A dissertation submitted in partial fulfilment for the award of
Master of Science in Entrepreneurship

By

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Abstract

From smart phones to smart homes, we are living in a highly technological world. The pace of technological advancements is only growing, and we see technology around us. From instructing Alexa to play a song to using robot vacuum to clean our houses, we are surrounded by robots to make our lives easier. Children growing up in this era of technological disruption need to develop the capability to deal with changes, especially from the career perspective.

Robotics education is an evolving topic. There are not many research or papers written in the topic. This research provides a step forward to it. While exploring the available resources in the area, the study summarizes the important aspects that must be taken care to have the maximum impact on students learning robotics and get the maximum output out of it.

The study revealed that the conversation is mostly centered around robotic tools because that's a straightforward way to implement robotics education. But there are more important aspects that needs to be accompanied along to make the learning successful. As the innovation is happening is fast paced, there is a need for preparing the young ones in the best possible way. This paper provides the ways to surround kids with creative activities at home, at schools and outside as well.

The study discusses major aspects that teaching robotics education has and those should be implemented to get the best results. As the motive of this research is to provide the robotics educators with the best resources available as of now and help them keep updated with the new ones. The paper provides a step forward in the society of robotics education.

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CHAPTER ONE

1 INTRODUCTION

From smart phones to smart homes, we are living in a highly technological world. The pace of technological advancements is only growing, and we see technology around us. From instructing Alexa to play a song to using robot vacuum to clean our houses, we are surrounded by robots to make our lives easier.

Ability of robots to make our lives easier makes it more demanding. Also, its ability to automate tasks from smallest trivial ones in household to highly risky ones in healthcare sector widens the innovation possibilities and makes it an area of growth and opportunities. (Ahmed and La, 2019). After all, our houses are becoming more intelligent, and the number of gadgets connected to the Internet of Things (IoT) continues to expand. According to the Gartner consulting firm, 8.4 billion IoT devices were utilized globally in 2017-a, up 31% from the previous year. By 2022, it is expected that this usage will have risen to 21 billion gadgets.

Companies are already starting to catch up with the technological innovations to grow from every aspect. World economic Forum presented an article discussing how this will lead to change in company models resulting in major impact on the employment landscape in the coming years.

Children growing up in this era of technological disruption need to develop the capability to deal with changes, especially from the career perspective. STEM [Science Technology Engineering Mathematics] is a term coined to indicate the subjects that will provide the necessary technological and robotics development skills (Duane Bolin, 2021). Robotics development and STEM have common subjects, so they are used interchangeably in the educational context.

Robotics Education is one such stream that help students develop many skills including creativity, problem solving. Robotics can be merged with many different fields like Science, Arts, technology. So, the practices of robotics education often tend to coincide with the learning practices of STEAM (Science, Technology, Engineering, Arts, Mathematics). The practical aspect of robotics education makes it more

interactive and fun learning, that attracts students and binds their interest to the subject.

1.1 Aims and Objectives of Research

Research Question:

1. What are all the important aspects that needs to be covered to provide effective robotics education to children?
2. What are the best learning practices that robotics schools are implementing?
3. What are the resources available for robotics educators?
4. What are the online resources that a robotics educator can use to set up a robotics education institute?
5. How to build a playful robotics curriculum- learning environment around a kid.
6. What are best resources to refer for getting the latest updated projects for now and future.

Objectives:

To Explore: Important aspects of building robotics learning environment around a kid.

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Robotics Education

Robotics education is a “hot topic” these days. Although the word has lately gained popularity, robots and instructional robots have been around since ancient Greece. The first programmable humanoid robots are thought to have been developed in 1206 (Mataric,2004). In many regions of the world, the application has already begun. Robots are currently employed in schools and educational institutions to pique students' interest in cutting-edge technology such as artificial intelligence, coding, and robotics. It's also worth noting that robotics education is showing to be effective in increasing children's learning ability.

Children learn best when they play with tangible objects, according to numerous studies (Hall,2007). Children's attention is drawn to them because they are more engaging. Children must be prepared for technological advancements because they are the world's future. They must possess the appropriate talents for the twenty-first century to do so. As more effective techniques of learning, robotics, or DIY (Do It Yourself) toys are one way to improve a child's cognitive skills (Alexandros merkouris, 2017). There is a plethora of new toys on the market right now. However, they are still unable to reach a beneficial outcome.

“Not enough attention has been paid to essential variables like guidance and collaborative scripts,” says Theodosios Sapounidis in his research. He talks about how to get more people to work in the industry and how to promote it.

Because the traditional learning system is not built to match today's skill requirements, other skill development platforms are urgently needed. “Traditional education is insufficient for individuals to acquire these abilities, and they have difficulty adapting to their age.” (Eguchi, 2013). Robots are proving to be useful instruments for improving children's learning capacities. Many case studies and research have demonstrated

this, and it is important to continue to encourage it. He made a strong point in his paper that

"*Students have become familiar with the use of information technology (e.g., desktop computer, smartphone and tablet, video-game console, etc.), but do not have skills in computer programming*"

His research adds to a greater understanding of how children might be trained to learn and adapt to technological environments. He describes how children learn, claiming that including them in the voluntary production of tangible objects improves their learning and encourages them to engage in similar activities (Teaching Programming). Because it increases learning capacity, playful teaching is in high demand. Robots, such as Legos and DIY toys, have been shown to be effective tools for developing early childhood technology. While playing, you're learning as well, unknowingly, which removes the burden (Nagai, 2001).

As a result of their ability to ignite children's interest, Do It Yourself and Robotics are in high demand these days. Robots are extremely helpful aids in the development of children's skills. The paper by Abdel Rahim El Mouhamad contains useful information concerning robots as instructional tools. There has been much discussion on how robots are used as toys and how they affect children's skill development. Toys like Lego Mindstorms and Bricks, as well as other robotics toys, play a vital role in improving children's learning abilities (Eguchi, 2013).

The findings will aid other teachers and institutions in collaborating, cooperating, and growing together to make robotics education a success. This will provide key resources for those working in this field.

Robotics Education is one such field which provides students with 21st century skills. It develops creativity, problem solving and innovative skills that is required to deal with the upcoming technological advancements and yet to be developed professional roles.

2.1.1 Effective way of learning using Tangible objects.

Children learn more with tangible objects. The research suggests that there is a strong link between physical activity and cognitive abilities in human brain. The research shows physical materials supports learning. Robotics is one such field where students can code and see the outcome then and there itself. This helps them understand the consequences of their action and encourages them to keep trying until the work is done. (Paul Marshall,2007)

Sung Eun Jung's study is a comprehensive and thematic review of the available literature on robotics education for young children who use robotics kits which does not include social robots. The following topics were explored in this study: (1) the definition of robotics education; (2) thematic patterns of important findings; and (3) theoretical and methodological characteristics. According to this study, past research findings are mostly about results and outcomes. Also, most of the past research has employed constructivist and constructionist frameworks not just to design and implement robotics curricula, but also to investigate young children's involvement in robotics education. A study suggests analyzing young children's robotics participation utilizing social and cultural theoretical frameworks as well as critical analytical lenses, taking into consideration their historical, cultural, social, and institutional contexts. (Jung and Won,2018)

The world is full of tremendous opportunities as well as risks. There are so many challenges such as business, political, scientific, technological, health and environmental challenges that society is facing in today’s world. All of which needs to be acknowledged and solved. The coming generation needs to be prepared with the skills to face the challenges and tackle them. As these challenges are in diverse environment and communities, that hinge on social networking and collaborative working. (Esposito,2017) Esposito describes the state of robotics education as positively transforming especially in postsecondary education.

Learning and Innovation Skills:

- Creativity and innovation skills
- Critical thinking and problem solving
- Communication and collaboration skills

Information, Media and Technology Skills:

- Information literacy
- Media literacy
- ICT

Life and Career Skills:

- Flexibility and adaptability
- Initiative and self-direction
- Social and cross-cultural skills
- Productivity and accountability
- Leadership and responsibility

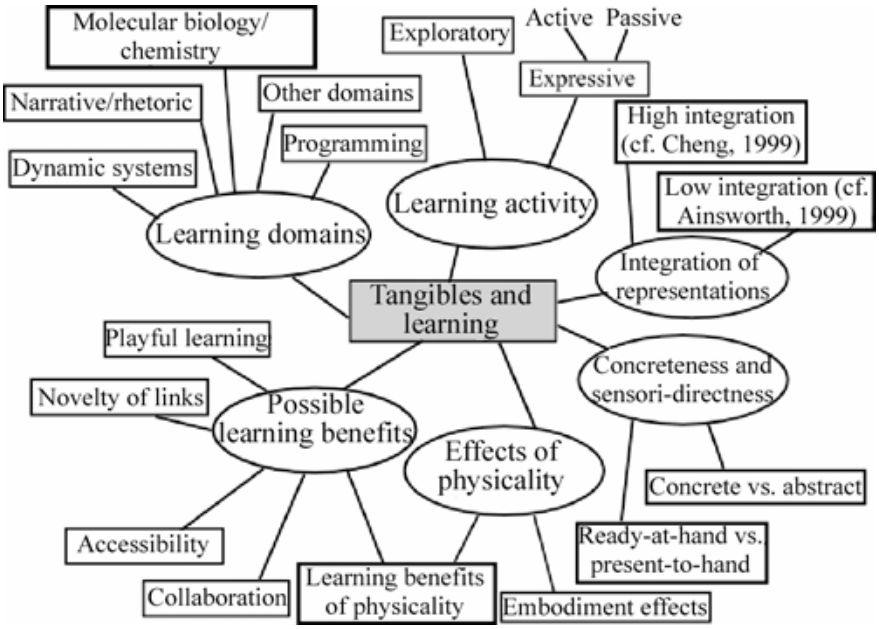

Figure 1: RE skills (iberdrola.com)

Theoretical framework of teaching loses the essence of learning. From my personal experience, I was more interested in a subject when the teacher was more interactive, and she/he had imaginative way of teaching. This shows the valuable “life skills” that they learn by taking the practical tasks. It is difficult to maintain the interest of both teacher and student to the subject being taught because of the monotonicity of the job. Also, the personal energy of the teacher that reflects his/her wellbeing and personal situations. As humans how well we are in dealing with our personal situations reflects at our work, same with the teachers and parents with different responsibilities going on simultaneously.

We discuss our methodology and experiences using the Lego Mindstorms EV3 robotics education kit to teach computational thinking, problem solving, teamwork, and project management skills to numerous primary school children. We taught students how to use motors, sensors, wheels, axles, beams, connectors, and gears to design, build, and program robots. Using a visual programming environment, students learned essential programming components such as control flow, loops, branches, and conditions. We paid close attention to how pupils completed various activities and solved challenges. We offer experimental data that show that our teaching technique, which includes both course content and pedagogy, was effective in transmitting the desired skills and knowledge to elementary school students (Chaudhary, *2016*)

2.1.2 Adoption of Robotics in Early childhood

It is important to understand learning RE is a gradual process. Also, it’s a process of exploring the capabilities of robots and developing creative thinking mindset. The early they start the more they will be able to catch up with the technological developments. Instead of burdening them with all the skills, it is better to let them learn gradually in a fun way and grab their interest at an early age and get them prepared for innovative environment.

Children have high energy and curiosity which can get overwhelming to teachers and parents resulting in suppressing child’s energy and curiosity. So, providing them with tools that can keep them occupied in the most effective and beneficial ways will provide them necessary skills and encourage independent learning and exploring skills. (Espino,2018)

Starting Young

Denis a 7-year-old second grader was spotted in FIRST (biggest robotics competition) event. He wasn't there to cheer on a sister or sibling who was competing in a FIRST competition. His mother and father, on the other hand, are not mentors, authorities, judges, or announcers. Denis is not related to FIRST in any way. And it's because of this that seeing him there was inspiring. When Denis met his tutor, he was learning how to program a Lego crane winch. Denis has been attending these events since he was three years old. Denis is inspired by what he's seen and wants to form the first Jr. Lego League team in his city.

Robotics Education has impact in other areas of life as well such as in breaking gender stereotypes. (Sullivan, 2016). When girls get the same exposure as boys, they tend to lean into engineering stream in their future. School curriculums have impact on shaping gender stereotypes and shaping the mind of students (Terry, 2011).

From playing with robotics toys to learning programming using robots, there are many tools and programs that give educators and parents could use to surround kids with technology in a playful manner.

2.2 Countries working on Robotics Education

21st century skills have been of primary importance for several countries including US, Singapore, Australia, and Finland. The countries are focusing on providing students necessary skills that would help them in the future. Many countries, especially US, south Korea are making 21st century skills the top priority in their educational reform. US market is highly competitive and demands constant renewal, its economy is driven by innovation and knowledge, so the 21st century readiness for every student is crucial for the country.

Robotic research is headed not only by America, Europe, and Japan, which pioneered the robot business, but also by South Korea and China, which have recently made significant investments in the industry, recognizing it as a next-generation growth engine.

At the start of industrial robots in the 1960s, the United States virtually dominated the robot industry. In 1962, Unimation, Inc. installed the first industrial robot at GM's vehicle components factory. Following that, Japanese companies such as Yaskawa, Nachi-Fujikoshi, Fanuk, and others rushed into the robot business one after the other, making every attempt to catch up to the US level of robot manufacturing.
With the arrival of the 1970s, Europe began to encourage the creation of self-contained robots. West European countries created industrial robots that were superior to those made in the United States because of their strong technical capabilities in the field of refined machinery. However, as the twenty-first century approaches, South Korea and China perceive the robot industry as a major future industry and are increasing their investment in response to the acceleration of economic growth in Asia.

Top Countries and Schools in robotics

- South Korea

South Korea takes tremendous efforts to assist children in elementary, middle, high school, and college gain robot knowledge, as seen by the annual launching of robot-related world contests, such as the World Robot Olympiad (WRO).

As a result, robot learning is gaining popularity among students in South Korea. In general, robot education begins in colleges in the United States and Japan, but in the Republic of Korea, it begins after regular curriculum activities in elementary schools. This is because the ROK's parents believe that in the future, the robot industry will play a critical part in the national economy. Robot education in the Republic of Korea is further distinguished by the fact that it takes place in over 1000 private institutes across the country. Definition, operational principles, manufacturing, and programming are all steps in the robot education process. Various robotic programs are being carried out in South Korea to uncover and promote robotic prodigies through such education, as well as to exchange robotic research results. As part of these initiatives, international robot competitions are held. ROBOT CUP and International Robot Olympiad (IRO), both of which began in 1995 and 1999, respectively, are international robot competitions organized by the ROK. The IRO, in particular, attracts so much attention that over 3000 people from all around the country attend.

The Transformer, Robot Gathering, Robot Biathlon, Traverse, and Hurdle games are played in each of the Olympiad's primary, middle, and high school divisions. The competition was organized every year in Korea, Hong Kong, China, Australia, Singapore, Malaysia, Indonesia, the United States, and other countries. In addition to the IRO, the ROK hosts several other competitions. (Esposito, 2017)

- Korea International Robot Olympiad (organized by Korea Robot Soccer Association (KRSA))
- Robofest Korea (organized by Robot Education Contents Association)
- Robofest Asia-Pacific (organized by Robot Education Contents Association).
- World Robofest (organized by Robofest Committee).
- Korea Intelligent Robot Contest (organized by Korea Intelligent Robot Association).
- World Robot Olympiad (organized by World Robot Olympiad Committee).
- National Youth Robot Contest (organized by Government Youth Commission (GYC)).

Trends in Robotics-related Curricula of Elementary, Middle, and High Schools in Korea: A Review of the 2007, 2011 and 2015 Revised Curricula

Some other countries that are investing in robotics education are Germany, Singapore, Japan, Canada. India is developing a number of government-backed initiatives to spur STEM education in schools, including Make in India, Skill India, Digital India, and Atal Tinkering Labs. The nation has installed more than 1,900 “mini science centres” (MSC) in schools throughout 23 states, with 8,000 teachers capable of educating over a million students. The MSCs provide 80 interactive “plug-and-play” models that allow kids to learn science and engineering in a hands-on way.

Ashutosh Pandit, Founder of STEM Learning, the global social enterprise behind the MSCs, said the idea came from seeing how much students loved to visit science centres.

United States of America:

STEM is at the heart of robotics, and art is inextricably linked to all the STEM components. There have been many initiatives carried out to engage students in technological areas. One of which is in November 2013, a robotics art festival combining robots and the arts was created in Michigan to stimulate interest and engage children in STEM success. In this event, computer-programmed interactive robotics projects were entered by students in the various categories including arts. The event had 13 teams from different countries including US states, Canada, and Mexico. Technological themes were creatively incorporated into the projects. The results of a student survey demonstrate that combining arts and robotics is an excellent hands-on paradigm for learning STEM subjects and computing that also delivers beauty, joy, fun, and creativity(Chung,2014).

Mexico:

Engineers are in short supply in the United States and Guatemala for STEM-related occupations. According to Carnevale et al, the United States had around 2.4 million more STEM jobs available in 2018 than skilled employees to fill them. Universities are not adequately preparing students who want to pursue a career in science, technology, engineering, or mathematics (STEM). If additional STEM activities are not created in the United States to encourage high school and secondary students to pursue STEM jobs, most technology businesses throughout the world will look for engineers in Asian countries (Canek, Chicas and O. Rodasv,2019)

The Ministry of Education (MINEDUC) of Guatemala examines the mathematical performance of graduating students every year. In 2017, 3,879 educational institutions examined a total of 148, 842 pupils. The test included sections on arithmetic, geometry, statistics, and algebra. Only 9.6% of the total number of graduating students evaluated received an acceptable or exceptional grade. In comparison to previous years, there was only a 0.59 percent growth in 2016, and a 4.17 percent increase in eleven years. A total of 158,161 students from 4,083 educational institutions were assessed in 2018. According to the test used to assess mathematical proficiency, 11.44 percent of students scored adequate or exceptional, a rise of 1.84 percent from the previous year (Segura, C. et al. ,2020).

2.3 Skill gap- an issue to address

Companies find it difficult to get employees with required skills, so the skill gap is already started to be an issue to be acknowledged. Students trained in STEM are in high demand and will be in the best positions (Deming, 2019). More than nine million people in the United States work in jobs related to technology, engineering, and science, accounting for more than 6% of the country's total. According to estimates from the US Department of Commerce, employment in these fields has expanded far faster in the last decade than in all other professional fields: 24.4 percent vs 4.0 percent for non-STEM jobs (Zilberman and Ice, 2021). The talent shortage in Europe is considerably more pronounced (O'Dea, 2021). By the end of the decade, it is expected that the demand for engineers will have increased by 14%, and businesses will struggle to fill all these openings. Technological fields will face the issue of skill shortage the most, states Bureau of Labor Statistics of the United States Department of Labor in the report.

Emergence of new professions can be seen, such as drone pilot, talent aggregator, and financial technologist and the trend will only continue in the coming years. World economic forum states "65% of children entering primary school today will be working in the roles that do not exist today" (World Economic Forum,2021). There is a high need to fill the skill gap and prepare the upcoming generations for the foreseen technological environment.

Robotics has a lot going for it as an undergraduate discipline and is a high time to incorporate it into academic curriculum (Gennert,2009). First and foremost, there is a requirement. Robotics education, which entails a multidisciplinary approach, is desperately needed. The second factor is student enthusiasm. Young people are interested in robotics. Finally, robotics is virtually probably going to be the next big thing. Garage start-up enterprises thrive in environments with low entry barriers and a wide range of new product prospects. As a result, we strive to educate innovators who will have the imagination to alter our world, not merely men and women who have the technical ability to design and build robotic systems. Robotics engineering will be in a better position to do so in the twenty-first century than any other engineering discipline.

Robotics symbolizes the much-needed transdisciplinary education, and it is unquestionably the next big thing (Gennert,2009).

CHAPTER THREE

3 METHODOLOGY

3.1 Research Methods Overview

A researcher goes through many stages throughout the research. The methodology is well described using research onion, it does that effectively. The onion is formed of various layers, the core of which is data collection and analysis. Each layer represents the research processes that have been gone through performing the data analysis at the core (Saunders, Lewis, and Thornhill, 2007). It provides a guidance on how to proceed the research method design. The research onion is adaptable to any and every research methodology (Bryman, 2012). The most outer layer describes the research philosophy. This sets the boundaries for data collection and for data processing techniques (Sahay, 2016).

It is the foundation upon which the research approach is selected in the next layer. The third layer describes the various research strategies, following which choice for research methodology is made in the next layer i.e., the fourth layer. The next layer describes time horizon before the actual data collection and analysis (Saunders, et al., 2007). Research involves processes that are flexible and varies from researcher to researcher. Many researchers start with data requirements for the research questions, using inside out approach and starting from core to going outer layers of the onion (Sahay, 2016).

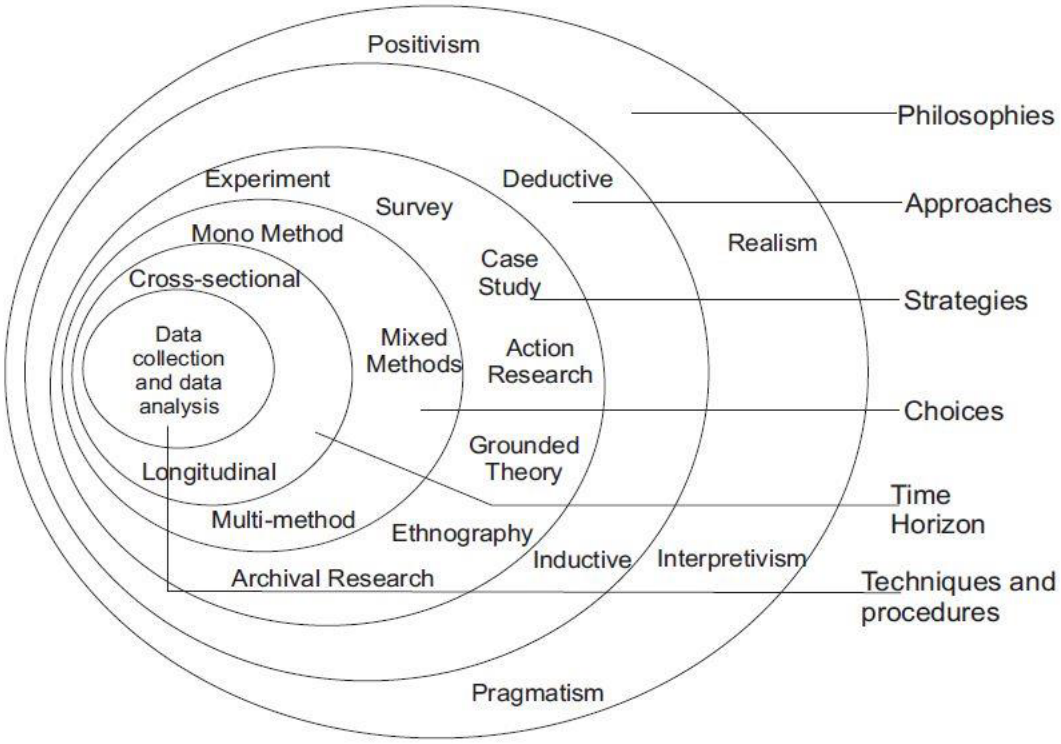

Figure 2 - Research Onion (Saunders, et al., 2007).

The research will use qualitative methodology to answer the research question and its derivatives. Qualitative data requires interpretation of the information collected to identify insights from the data. The research will take an inductive approach.

3.2 Research Philosophy

The researcher's system of beliefs and assumptions about how knowledge is created is referred to as research philosophy (Žukauskas, Vveinhardt and Andriukaitienė, 2018).

This philosophy is influenced by the researcher's worldview and his/her perception of the world, which shapes his knowledge and thus the research. The assumptions justify the way the study will be carried out (Flick, 2011). These factors have a great impact on the study approach and methodologies that a researcher takes (Saunders, Lewis, Thornhill, Bristow, 2019). This voyage of knowledge development in a certain area may lead to the formulation of a completely new and unexpected theory. Whatever the situation may be, a new set of knowledge is created during the research. The recognition of theoretical advancement that is being carried out during the research is

sometimes attributable to the researcher's intuition and not the methodical work such as induction or deduction. Defining research goals and the choosing the best means to achieve those goals are important factors in choosing the research philosophy in the process. Epistemology is made up of what is deemed acceptable knowledge in a field of study. There are three basic methods to choose from a suitable research philosophy while choosing a research. It is the facts or information that the researcher considers relevant and will be used for the research. There are three basic methods to choose from a suitable research philosophy while choosing a research. Ontology is more realistic approach (Saunders, et al., 2019).

According to Saunders & Bristow (2015) there are five key research philosophies that has to be adopted while doing the research in management and business areas: Positivism, Interpretivism, Critical Realism, Postmodernism, and Pragmatism.

- Positivism adopts the natural scientist's philosophical perspective and employs scientific data analysis and hypothesis testing methodologies. Involves observable social facts and yields unambiguous and precise generalized results. It is presumptively true that reality exists independently of the thing under investigation. Positivism is most utilized when determining the source and effect of a relationship.
- Interpretivism is a philosophy that is adopted by a researcher when the result is analysed using a set of previous research and based on that the research conclusion is made. This research takes interpretivism as the adopted research philosophy.
- Critical Realism is concerned with explaining what we see and feel in terms of the basic structures that govern the observable events. It can tell the difference between the real world and the one that can be seen, and it's ideal for case study research.
- Postmodernism challenges generally accepted ways of thinking and strives to communicate alternative viewpoints, emphasizing the significance of language and underlining its insufficiency and partiality. Other methods of knowing and perceiving, which had previously been suppressed, marginalized, and excluded, are given validity by postmodernist researchers.
- Pragmatism emphasizes the importance of concepts in terms of whether they support action; it tries to reconcile facts and values, as well as different

experiences, by recognizing theories, hypotheses, and research findings based on their roles in influencing thoughts and actions, rather than just in their abstract forms.

3.3 Research Approach

The deductive approach is the creation of information from general to specific; which means the researcher first builds a broad theory on the subject or knowledge base of the topic, which is then checked against the specific knowledge gained through the research process. While the deductive technique progresses from exact knowledge to a broad basis, the inductive approach works opposite and starts with observations and then creates a pattern from data gathered during the research process. Although this strategy has the potential to generate new ideas, it is true that data collected can be analysed in such a way that they fit into an existing theory. (Bryman & Bell, 2011). When the goal of a study is to figure out the reason rather than to be able to explain why it is happening, the inductive technique is preferable. When the goal of a study is to figure out why something is happening rather than to be able to explain it, the inductive technique is preferable (Easterby-Smith, et al., 2002). This method is more commonly used in qualitative research since it can decrease bias when the researcher is gathering data (Bryman & Bell, 2011). Researchers that use the induction strategy are usually interested in the context in which events occur. In such scenario, they are highly likely to use qualitative data and a variety of data collection techniques to demonstrate various points of view on the subject. While deductive researchers initially make hypotheses based on the readings of existing theories and then implement a research strategy to test them, most commonly employing quantitative methods in data analysis (Saunders, et al., 2019). Adopting a deductive approach usually leads to quantitative data analysis methods, while choosing an inductive methodology leads to qualitative data analysis methods (s) (Sahay, 2016). However, there is a third research approach as well which known as the abductive strategy that alternates between deduction and induction (Suddaby, 2006).

For this research inductive approach was used. As Inductive approach allows the study of a topic first and then draw the conclusion. When the goal of a study is to figure out why something is happening rather than to be able to explain it, the inductive

technique is preferable. This method is more commonly used in qualitative research when the researcher is gathering data. Researchers that use the induction strategy tend to be interested in the context of the event, and they will most probably use qualitative data and a variety of data collection techniques prove the points of view on the subject.

3.4 Quantitative Vs Qualitative Approach

Quantitative research is a study that employs analytical approach, a collection of numerical variables that are statistically examined to determine whether a hypothesis is true. The data used are tangible and can be counted or measured. It is generally assumed to be objective. The fundamental distinction between these two approaches is that quantitative research, as the name implies, focuses on statistics, whereas qualitative research is concerned with why and how, and typically involves the use of words. Qualitative research, on the other hand, is said to be subjective because it focuses on impressions and opinions rather than measurable data (Saunders, et al., 2019). Quantitative research focuses on putting hypotheses to the test using a deductive approach to build a link between theories and research However, the differences go beyond the existence or absence of quantification. Most of these basic disparities arise from their epistemological roots (Bryman, 2012). On the other side, qualitative research takes a deductive approach to the relationship between theories and research, stressing theory formation and shifting the focus away from science and toward individuals and their interpretations of their social world (Bryman, 2012). Quantitative method deals with large amount of data and is known for not being able to manage big amounts of data (Saunders, et al., 2007). Despite the notion that qualitative research does not test hypotheses but rather produces theories, it has been shown to do so (Adler and Adler, 1985 in Bryman, 2012). Rather than driving a gap between these two approaches to research, their differences might occasionally cause one to exhibit characteristics of the other. Qualitative research is frequently applied to investigate the significance and relevance of a social occurrence (Feilzer, 2010). The information gathered during the research is utilized to create a pattern, and draw inferences based on the findings (Saunders, et al., 2019).

3.5 Research Choice

The mono method, mixed technique, and multi method are the three possibilities available to the researcher in this situation. (Saunders, et al., 2007). The mono method uses only one approach, it can either be quantitative or qualitative in methodology but not both. While the mixed method uses both the qualitative as well as quantitative methodologies, but it is done using different datasets; and the multi method approach uses both quantitative and qualitative methods, but with different methods for different sections of the research project, resulting in different data sets that are analysed using qualitative and quantitative techniques (Bryman, 2012). The mono qualitative approach was utilized for this study because just secondary resources that are available on the internet were collected (mono method), and the qualitative research method was used because it is excellent at providing insights into education sector that are difficult to quantify using numbers or quantitative methods. (Stainton, 2020).

CHAPTER FOUR

4 RESEARCH FINDINGS

By doing this research I found that lot of organizations are sharing their teaching practices and outcomes with the robotics education community. This helps in the evolution of robotics education collectively. As the area of Robotics education is in the evolving state, sharing the practices is important and necessary. This research also encourages sharing of the resources

- Starting at early age: The earlier the better. Introducing kids to robots in the form of toys and gradually using DIY projects would help them understand the process of building robots.
- Tangible learning: Kids learn better and faster with tangible objects. Being able to see the impact of the work instantly allows kids to understand their mistakes and work on them and see the results instantaneously to see what the solution of the problem is and what is not.
- Sharing of learning practices with the robotics community is very important at this stage of Robotics education phase and there are many resources and discussion platforms available which can help the robotics Community to collaborate and work together for more impact.
- Constant knowledge upgradation in teacher's, educator's as well as parent's knowledge is required as the technology grows in fast pace.
- Getting kids acquainted with robotics at an early age will prepare them for the future job opportunities.
- Purposeful learning: Not only teaching robotics is necessary but teaching its impact in society is even more important.
- Project based learning: The teaching method generally involves working in groups resulting to sharing of ideas and knowledge.

4.1 Designing a Robotics Class

Robotics Education is known to be a "hot topic" these days, and it entails teaching robot development or using robots to teach a variety of disciplines including programming skills. The field of robotics education is currently in transition and will take years to evolve completely, so there is no best structure that suits every learning environment and has yet to be applied to meet the purpose of robotics education.
Most of the institutes help students get involved in robotics by providing them with pre-packaged cutting-edge robotic toys such as IBM Bricks, Lego Mindstorms, and Do It Yourself toys, which they can use to create robotics projects as part of their school/college activities or contests. These days, there are even Robotics fairs to encourage children's engagement and curiosity.

1. Objective Setting

It has been established that STEM jobs are among the fastest expanding and they are expected to expand even further in the coming years. Teaching STEM and robotics to high school kids has positive outcomes in providing the necessary 21st century skills as well as important life lessons. Setting the goal to encourage them to pursue STEM careers and assisting them in developing the skills will ensure their success.

Standard curriculum:
Robotics is being studied in several fields due to the impact it has had on the media, the industry, and the academy. In many schools' programs robotics is also being used as a teaching tool. In these learning curriculums, students can build robotic prototypes for a wide variety of topics like history, arts, mathematics, learning language, physics, geography etc. So, this generates the need that both, teachers, and students, must have specific knowledge of robotics. In this sense, this work proposes a curriculum for 6 to 18 years old students. Such a curriculum is being applied in the robotics club of the San Pablo Catholic University in Peru since 2014 (R. E. Patiño-Escarcina, 2019)

2. Providing Right tools

Creativity and innovation are important life lessons that helps kids to persevere in the face of adversity. Students can easily detect and correct problems while programming physical robots as they learn what robots can and cannot accomplish. They acquire essential lessons while having fun and developing the skills needed to create precise and accurate instructions.

Robot Kits-

There are many kits available in the market that aim to provide robotics education. Some of the most popular and widely used are Lego Mindstorms. The kit is accompanied with teaching manual and guidelines. Not only this, but there is also a Lego community that helps in dealing with any challenge in the process of set up. They are easy to teach and one of the most popular robot kits that most Schools have adopted. There are many kits available as per the age group, budget, and activities. The research doesn't go into the technicalities of robotics kits as it is more focused on the various aspects of providing learning environment to kids.

An alternative but expensive alternative to Legos is VEX EDR. Some other kits are Cubit STEAM kits, Arduino Uno Kits, R Raspberry Pi Robot & Computer Kits, Makeblock Robot & Airblock Drone Kits.

For smaller budget, Meet Edison Robot is a most recommended kit. It provides the electronics and programming learning and is known to be versatile. It can be used with a variety of programming language including Scratch and Python.

NAO Robot- Combining Theory and Practice

The NAO humanoid robot is an excellent tool for teaching Science, Technology, Engineering, and Math (STEM) principles to students of all ages. Suitable for high school students. This can use sophisticated programming languages in topics like computer science, mechanics, electronics, and control. It gives students hands-on experience by combining theory and practice to explore a wide range of robotics-related topics.

3D Printers- Kids learn more with tangible objects.

Use 3D printed objects to bring STEM to life, ignite curiosity, and keep the students engaged. Work with your students to model real-world engineering issues using 3D designing and ensure students are ready for college readiness through advanced design thinking.

Misty Robot: Programming robots

Misty is an autonomous roaming robot, suitable for children to learn programming as well. They can program to travel about and interact with humans. Students can play around and get creative with the robot's components. The capability of the robot is customizable and can be enhances.

This is a provides a great experience to teachers and students to keep learning about robotics and STEM subjects while having a better grasp of them.

3. Discover online lessons

RobotLAB EngageK12 is a platform that provides a collection of hundreds of lessons organized by age group and robot. Instructors need to discover the methods to teach STEM/robotics project ideas to their pupils.

4. Goal Oriented learning

Competitions provides a platform to compete collaborate and learn from the experience.

There are many robotics competitions that are help worldwide and in 2021 they are being help online. This provides a great opportunity to educators and students to work for a target. The process needs planning, goal setting, setting a benchmark and building a robot as per the competition specification. Along with that, since it’s a teamwork, they develop the skill to work in sync with each other, helping each other achieve their individual goal.

Some of the most popular robotics competitions are listed in the appendix section. Those are the topmost robotics competitions in the world that are held internationally and are great leaning platforms for students.

5. Project based learning

How it is taught is more important that what is being taught. Including interesting fun projects attracts children towards the project. Maintaining their interest in learning is underrated and is a very important factor in the success of the project as well as the aim to instil self-learning skills into them. There are various platforms that share interesting projects along with the guidance on how to make it with tool specifications and coding needed. (Duane Bolin, 2021)

Best project guiding platform that share their experience: These people provide their teaching practices and outcomes as well. A research provides situated learning-based methodology and designed robotics curriculum that can directly be used by robotics tutors and present an organized solution for computing students to study robotics. (W. Wang, *2020).*

6. Practical learning

Learning while doing is a best learning method, practical robotics education provides a platform for learning while also having fun.

Today's students are like to explore new areas and work out of the. Based on this, learnquebec sets a department's curriculum for practical robotics instruction (learnquebec). It aims to nurture students' inherent desire to design/manufacture valuable goods. The core concepts of practical engineering education are discussed first in the article. Then secondly the outline of classes for practical instruction at Ritsumeikan University's Department of Robotics is detailed including robot-making activities. Then, for a joint academia-industry setting, practical education is described. This type of education should aid in the transfer of innovative technology to industry (K. Nagai, 2001)

7. Sharing the Learnings

Best Resources for Robotics Educators: Staying up to date

Since the area is in evolving phase, the challenge for educators and robotics teachers is not going to lessen. There is a high need to be updated with new tools and ways to be able to provide the kids with best resources available.

4.2 Free Online Resources during COVID-19

Tryengineering: providing tools to face adversities caused by COVID-19

Many teachers are seeking for ways to shift their curriculums and teaching to online teaching or home learning as schools close. TryEngineering has a compilation of free tools to assist teachers and parents at this situation of adversity. Many parents and guardians are also looking for online activities to keep their children entertained and educated while teaching from home. To help them continue with providing education to their children/students, a group of professors created the “CoBuild” Facebook community that is accessible from their own homes.

“We started the group to support parents and caregivers through extended school closures with activities they can engage in with their kids,”, an associate professor at Indiana University Bloomington, told Indian University (Adam Maltese).

The concept of distance education has boomed due to the adversity caused by COVID. It has forced tutors to adopt digital technologies to continue teaching. In recent years, distance education has increased significantly in Brazil and around the world, with a 17.6% increase in 2017. Even in regions where a considerable practical workload is necessary, such as Dubai, which has seen an increase of roughly 18.8 students per ten thousand residents, efforts to provide training in educational robots, mostly for students in basic education, are still modest

Extension Project Robôhat; Cerrado of the IFTM is another organization to a free offer to students and teachers of Basic Education from the public education network of the city of Patrocnio, Minas Gerais, Brazil. It is a fully EAD training course in robotics for beginners. It provides certification for a duration of 40hrs. (A.F. F. Silva, *2019*)

A collaborative programme, known as remote exploration program, was built to outreach approach to robotics education in Brazil (J.R. Garner, 2004). This helped teachers to continue their education and their teachings to basic education students.

For dealing with such situations, people are forced to adopt new methods to continue their work. Teaching is one such area where this was necessary. A research by Fernandes aims to provide evidence for improving curricula and course suggestions

for Robotics Education (C. C. Fernandes, 2020). Another research describes a new change from traditional mobile robotics classroom (Carlotta A. Berry, 2017)

Robotics Competitions: Platform to showcase skills and interact with people around the world. These are only few among several others.

- RoboCupJunior
- FIRST® Robotics Competition
- International Robot Olympiad

These are some of the best internationally held robotics competitions. Robotics Competitions are a great platform to provide students a competitive environment and teach them to work under pressure. Giving them some real-life skills, this is must for every robotics institute to allow their students to participate and compete in some or the other robotics competition. Running hands-on robot building workshop has been proven very useful (J. T. C. Tan, *2019*). Best robotics competitions are listed in the table in the appendix section. A paper by Berry, summarizes the process of designing a course for flipped mobile robotics course including the results of the newly designed course offering as compared to the traditional one. (C. A. Berry, 2017)

Robotics workshops is another platform for getting a quick access to robotics world. In short duration a lot could be learned. The initial participation could be less, but eventually as the awareness grows; the number of students participation also grows. According to a study, using various courses, workshops, and the opportunity to compete in national and international competitions promotes students to pursue a STEM-related higher education job in the near future, thus encouraging new careers through robotics competitions (Rodrigo Canek,2020).

1) Summer Camps

   There are several summer camps that are held to provide robotics education to students while having a playful and collaborative environment as well. Few of the best ones are listed below.

- ID Tech Camps
- Space Camp
- NASA Student Opportunities
- Funtech
- First Robotics

2) Resourceful websites:
    - NASA Robotics: https://robotics.nasa.gov/
    - Project based impactful learning: https://www.wise-qatar.org/about/ :

    Sharing projects through their website:
    https://www.wise-qatar.org/project/mymachine/
    Head Quartered: Belgium (Ecuador, Mexico, USA, Portugal, France, Belgium, Slovakia, Slovenia, Norway, South Africa, Mozambique, India)

3) Educators/Blog
    - Maureen Reilly
      website: https://www.maureenreilly.com/

She is a robotics tutor and believes in sharing her learnings and practices. She provides all the details about the projects she teaches in her robotics institute through her website and any new projects that she comes across.

4) Online Robotics Communities
    - Team Titanium
      website: https://www.teamtitanium.org/

Robotics Communities are the reason of growth of robotics awareness in the locations around the world that does not has physical access to the leading robotics education institutes and research. There is still a need to establish more such communities and strengthen them with more resources and technology to help them spread the message. the International Journal of Engineering Education, offered some insight into the current trends in robotics education. A variety of robotics programs that can be

provided at the bachelor's degree level are detailed, as well as how they fit in with current programs. Finally, the need for the robotics community to strengthen itself by establishing its body of knowledge through collaboration is stressed. (G. T. McKee, 2007)

5) Online Forums
    - robotshop.com
      website: https://www.robotshop.com/community
    - ROBOTC
    - Robot Reviews
      website: http://www.robotreviews.com

Sharing the learnings and applications through online forums. For the Robotics Education area to grow and evolve, it is important to share the practices and learning experiences. This can be done through various online platforms on the internet.

4.3 Robotics Education with purpose

This schools sets an example in providing robotics education with purpose.
Every year the school design and build 125-pound robot to compete in the robotics competition- First Robotics. The school has gained a special attraction and was awarded in white house for helping the community and serving needful people by providing robotics solutions. The school helps in volunteering, mentoring youth and spreading awareness and excitement for STEM learnings to kids of all ages.

High School Students Build a Custom Power Wheelchair for 2-Year-Old

Real time project:
Cillian Jackson, 2, was born with a rare genetic abnormality that makes walking and even crawling difficult for him. He must be carried around by his parents to explore as all children do. However, this limits his freedom for move around freely, and, as a result, his quality of life. Unfortunately, powered wheelchairs for children are very expensive, and getting them reimbursed by health insurance is challenging.

Cillian's parents sought assistance from the Farmington High School robotics team, who were able to create a bespoke motorized wheelchair that allows Cillian to explore on his own.

Farmington school Robotics Team:
Starting with a normal Power Wheels ride-on vehicle, the high school robotics team developed the wheelchair with help from the GoBabyGo! organization, which provides comparable services. The standard ride-on, on the other hand, had a variety of flaws that would have made it difficult for Cillian to use. It was made for 5-year-old children; therefore, it wasn't the right size for someone Cillian's age.

Challenge:
Because Cillian's symptoms were like those of someone with cerebral palsy, the original controls required a lot of force to operate, which would have proved tough for him.

Solution:
The robotics team solved the first issue by replacing the original seat with one from a bicycle carrier. Cillian's new seat is the appropriate size for him, and it also includes a built-in harness to keep him upright. After that, they focused on refining the controls. They achieved this by 3D printing a unique joystick that requires very little effort to operate. This was connected to the ride-original on's motor wire, allowing for smooth operation. Cillian may now go on his own adventures and even chase after the family's corgis.

Figure 3: Customized wheelchair by high school robotics team(gobabygo)

Practices from school:

- Making an Impact in the community

A university of Delware organization that helps children with disabilities by providing them mobility through DIY style toy vehicle modifications.

The year is spent in designing and building robot, which is only one part of what the school aims. The school aims for a bigger purpose of showing students the impact that they can have in the society using technology and creative ideas.

- After School Robotics Club: Rogue Robotics

Founded in 2008, the school has started after school robotics club that targets to build a 120-pound robot from scratch to compete in the robotics competition. The robots are built from scratch and as per the requirements of the robotics competition every year. 6 weeks is dedicated to build the robot every year.

- Project based learning

Real time project enhances creativity skills as the school aims to provide solutions to specific issue. Since the projects might not be implemented in the past, it must be built by thinking outside the box. Thus, innovative thinking is developed into the students.

- Competing in Robotics Competition

The school provides a platform for students to collaborate and interact with some of the best robotics team. This allows to explore the many possibilities a project provides. A competitive environment sets students for facing unexpected challenges and solving them under pressure of performing in an international platform.

- Sharing resources

The complete documentation of development guide has been shared by the community with all the specifications and tools used in the process. This is a very helpful resource for robotics educators to build a similar project to involve their students in community and provide them a purpose to learn robotics.

They provide with the resources used in their projects such as

Modification guide
3D printing Files
codes

- Providing guidance

An online discussion community is set up to help others clear the doubts and overcome challenges that come while building robots.
The school has a community that is open to anyone to join and provides a discussion platform for students as well as robotics tutors.

4.4 Parents' Involvement:

Building a robotics environment around kids will ensure they start grasping the "building" and "creative skills" from early age. This will help them to gradually learn more advanced levels (programming and machining) at later stages at school.

DIY at home
Do it yourself (DIY) projects are highly interactive and playful. It doesn't stress the kids and do not demand much attention, as its capable of grabbing the attention itself.

Figure 4: DIY projects(researchparent.com)

Using homemade objects will develop creative thinking. How household items can be used: innovative thinking, resourcefulness and how one thing can be used in multiple ways. There are curriculums designed for the purpose of providing engineering education Via Robotics, Mechatronics, and Automation Projects. (D. J. Cox,2006).

In today's time, we are seeing transformation in education sector, at least the transformation has been started with the incorporation of information and communication technologies as a valuable support for the formation of digital skills and significant learning. In an article by Gonzalez, they discussed how educational robotics may be integrated into the classroom to help students meet curriculum goals while also developing additional skills including programming abilities and computational thinking. It provides a comprehensive result of the integration for the 2016-2017 academic year.131 early childhood education pupils were studied who attended a concentrated educational centre in the autonomous community of Castilla y León. It describes the results as resources employed, the teaching-learning activities created, and the level of acceptability of educational robotics in the classroom as they were stated by instructors and students attending the session (Y. A. C. González, 2017). Playful learning is hugely encouraged to grab students' attention and thus instilling creativity skills into the students.

Parents play primary role in moulding the skills of their kids as they are the one who are around the kids more than anyone else.

CHAPTER FIVE

5 DISCUSSIONS

The past research papers provide a clear evidence on the importance of providing Robotics Education to students. The most important ones of those are the skill gaps that has already started to be recognized by many companies dealing with technology, let alone robotics technology. Robotics education is not only helpful for professions particularly building robots, whether it be domestic or industrial robots, but it will help in developing necessary skills that can be used in other areas as well. Some of those skills are programming skills, innovative and creative skills. The skill is needed and can be applied to all age groups.

The technological world is full of open opportunities, some of which have been discovered, while many of which are yet to be discovered. In this time, preparing the coming generation to have an innovative and open mind approach is of utmost importance. The skill that Robotics education provide could be applied in many different areas in many ways and that is what makes the area so innovative and interesting.

Not only in academic and professional areas is a need for robotics technology skills. But there is a high need of the same to manage day to day lives as well as enhancing people's lifestyle. Since robots has already started to penetrate every house, it is not going to be long when we are surrounded by robots. Knowing the technology would allow people to hold the command over it and use it in a way that is beneficial instead of getting commanded by the technology itself.

Research findings showed how robotics education can be applied in multiple environments including home, playgrounds, schools, and summer camps. It is time to strengthen the robotics education society and build more awareness and platforms for those who are interested.

The research allowed to find many gaps in the field of Robotics education. There are not many research papers published on robotics education. But the discussion on the topic is active in social media platforms and blogs. Teachers are sharing their implementation plans and curriculum to help other tutors follow the steps. Since the

area is still evolving, there is a high need to share the resources so that everyone in the field can grow together.

Many schools and institutions are sharing their learning practices which are directly applicable to start a robotics institute. Coming generation needs to be prepared for the new era and technological advances. Who all are the supporting elements that kids learn from- Parents at home, teachers in schools, summer camps or afterschool clubs, collaborations while competitions? Starting at young age would be helpful.

For best results, kids need to be in an environment supporting technology, creativity, and problem-solving skills, which robotics education provide. Robotics Education helps kids develop various skills such as creativity, innovative thinking, problem solving skills which are not only helpful for their career but also those are important life skills. As a result of changing professional career opportunities due to technological disruption, the coming generation needs to be prepared for new unknown career opportunities.

CHAPTER SIX

6 CONCLUSIONS

6.1 Summary

The research gathers the updated practices that robotics institutions or schools are implementing in today's date. Sharing of resources proved very necessary for the growth in the area of robotics education, as this area is still in growing phase. There are many people in robotics technological society who strongly believe in that and thus share their part of knowledge and learnings with the world through various online platforms including websites, blogs, you tube channels and twitter. So, the learnings shared by them is directly applicable by any robotics institute around the world. The resources shared includes the curriculum followed by the institution, projects made by the institute with very detailed description of how to build the project and what all tools and technologies (hardware and software) to be used to build the project. Not only this the forums discussed in the paper can be used to clear the doubts and barriers faced by any robotics teacher.

6.2 Limitations of the study

The research data were most of the online resources. This includes few of data from personal blog so the point of view of that article might be biased, intentionally or unintentionally. Although it was not specified but the websites or articles may be impacted by sponsorships if any. Online articles tend to promote a particular product if the intentions are not clear. So, few of the articles might be under social or personal biases.

The research is only based on secondary resources and this research didn't take the views of robotics instructors on what are their implementation strategies and learning from robotics background. from personal was conducted in a time bound environment. The topic is in evolving phase is still going on and due to that the

6.3 Practical implications

The research paper is rich with useful resources that robotics instructors could directly use to start a robotics program. It provides ongoing projects and a way to find the most updated projects and resources. So even in future the paper can be used by robotics tutors or educators to find best websites or blogs and forums where the updated information about newest technological innovations are published. The forums provided in the paper can be used by the robotics instructors to discuss and clear the doubts they might have in their own organization regarding any project. The paper discusses many aspects that should be carried out to get the best results. Additionally, there are many projects that robotics institution takes on to provide project-based learnings, which are discussed in this research paper as well.

6.4 Avenues for future research

The research could be extended to include the views of robotics instructors who are implementing robotics education in a day-to-day basis which could not be done in the present research due to the access constraint. And time constraint was another issue to be taken care of while doing the research. Getting the views of robotics teachers working in schools or any kind of robotics institution or program will provide more insights and open new doors to understanding the learnings and challenges that is faced by them. There is a regular need to provide updated innovations in robotics education since the topic is in evolving phase.

CHAPTER SEVEN

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APPENDIX

	Curriculum	Competitions	Internships
K to 5th	**Squeakland** Let younger children try their hand at programming. + More information **ImagiBotics** Robotics classroom activities, articles, and interviews at Imagiverse + More information **Pre-K-12 Engineering** Standards-aligned engineering activities for grades Pre-K to 12th Grade. + More information **Make Your Own Rover** Eleven activities designed to help students learn about	**RoboCupJunior** + More information **Trinity Fire-Fighting Robot Contest** + More information ***FIRST*® LEGO® League Junior** Designed to introduce STEM concepts to kids ages 6 to 10 + More information **Robofest** Robofest is an annual autonomous robotics competition focusing on learning STEM for students in grades 5 - 12. + More information ***FIRST*® LEGO® League** Immerses kids in real-world science and technology	**ID Tech Camps** + More information **Space Camp** + More information

	robotics. + More information **Classroom Robotics on the Web** Lessons, materials, and rubrics developed in a Texas classroom using RoboLab. + More information **Imagine Mars** Students explore their own community and decide which arts, scientific and cultural elements will be important as they develop an ideal community on Mars. + More information **Build a Nanorover** Learn how to make your own balloon-powered nanorover! + More information **Robotics Activities** Design, build and program a real robot using sensors, controllers and	challenges. + More information **Storming Robots** Storming Robots offers classes for those interested in participating in robotics competitions, robotics technology clubs, computer programming classes, etc. + More information **EARLY Robotics** Engineering And Robotics Learned Young (EARLY) is a program that exposes our youth to engineering. EARLY provides 7 to 12 year olds the opportunity to participate in a robotics competition every fall and spring. + More information	

	actuators. + More information **Robotics Starter Kits for Educators** A guide to different robotics kits. + More information		
6th to 8th	**ImagiBotics** Robotics classroom activities, articles, and interviews at Imagiverse + More information **Pre-K-12 Engineering** Standards-aligned engineering activities for grades Pre-K to 12th Grade. + More information **Make Your Own Rover** Eleven activities designed to help students learn about robotics. + More information **Imagine Mars** Students explore their own community and	**BotBall** + More information **RoboCupJunior** + More information **Trinity Fire-Fighting Robot Contest** + More information **Battlebots IQ** + More information **Robofest** Robofest is an annual autonomous robotics competition focusing on learning STEM for students in grades 5 - 12. + More information ***FIRST*® LEGO® League** Immerses kids in real-world science and technology	**ID Tech Camps** + More information **Space Camp** + More information

	decide which arts, scientific and cultural elements will be important as they develop an ideal community on Mars. + More information **Robotics Activities** Design, build and program a real robot using sensors, controllers and actuators. + More information **Robotics Starter Kits for Educators** A guide to different robotics kits. + More information **Robotics Academy Camp-on-a-Disk** + More information **Botball and Computer Science Curriculum** Curricular materials to promote hands-on learning. + More information	challenges. + More information **Storming Robots** Storming Robots offers classes for those interested in participating in robotics competitions, robotics technology clubs, computer programming classes, etc. + More information	

	Multi-unit Robotics Curriculum Give students meaningful exercises that introduce or reinforce applied physics and mathematics concepts. + More information		
9th to 12th	**Pre-K-12 Engineering** Standards-aligned engineering activities for grades Pre-K to 12th Grade. + More information **Robotics Starter Kits for Educators** A guide to different robotics kits. + More information **Robotics Academy Camp-on-a-Disk** + More information **Botball and Computer Science Curriculum** Curricular materials to promote hands-on	**BotBall** + More information **RoboCupJunior** + More information **Trinity Fire-Fighting Robot Contest** + More information **Battlebots IQ** + More information **BEST Robotics** + More information **FIRST® Robotics Competition** + More information **Robofest** Robofest is an annual autonomous robotics competition focusing on learning STEM for	**NASA Student Opportunities** + More information **ID Tech Camps** + More information **Robotics Boot Camp** At San Jose City College + More information **NASA Summer High School Apprenticeship Research Program (SHARP)** + More information **NASA MSFC Robotics**

	learning. + More information **Multi-unit Robotics Curriculum** Give students meaningful exercises that introduce or reinforce applied physics and mathematics concepts. + More information **IntelliBrain-Bot** Java-programmable educational robot. + More information **GEARS Educational Systems** Robotics platform with projects and suggested curriculum. + More information **Battlebots IQ** Educational lessons about robotics. + More information **Robotic Autonomy Activities** A series of exercises intended to explore	students in grades 5 - 12. + More information **Storming Robots** Storming Robots offers classes for those interested in participating in robotics competitions, robotics technology clubs, computer programming classes, etc. + More information **FIRST® Tech Challenge** + More information **VEX Robotics Competition** + More information	**Academy** + More information

	principles of autonomous robotics. + More information **Robotics Programming** Simulate robotics missions and learning BASIC programming. + More information **Robotics Technology Curriculum** Select activities to suit the learner from elementary to advanced and manual robot control to computer program modes. + More information **Stamps in Class** Introduction to topics such as microcontrollers, analog and digital, and advanced robotics. + More information **EST Foundations** The EST Foundations curriculum is comprised of project		

	based lesson plans to introduce students to engineering. Students will explore the new product development process, how marketing impacts engineering, and careers in engineering and science. There are eleven fully developed one-week modules. + More information		
BA/BS	**List of universities offering robotics programs** + More information **Autonomous Multirobot Systems** Key issues and current research in autonomous multirobot systems. + More information **General Robotics Course** Overview of robotics in practice and research. + More information	**Trinity Fire-Fighting Robot Contest** + More information **Battlebots IQ** + More information **Collaborative Research Experience** For women in undergraduate computer science and engineering + More information **RoboCup** + More information	

	CMU Undergraduate Minor in Robotics Focus on robotics. + More information **Universities** Study and research programs in robotics. + More information	**VEX Robotics Competition** + More information	