

ROBOTICS CURRICULUM FOR EDUCATION IN ARLINGTON: Experiential, Simple and Engaging
learning opportunity for low-income K-12 students.

By

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Abstract

ROBOTICS CURRICULUM FOR EDUCATION IN ARLINGTON: Experiential, Simple and Engaging learning opportunity for low-income K-12 students.

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Engineering disciplines (such as biomedical, civil, computer science, electrical, mechanical) are instrumental to society's wellbeing and technological competitiveness; however the interest of K-12 American students in these and other engineering fields is fading. To broaden the base of engineers for the future, it is critical to excite young minds about STEM. Research that is easily visible to K-12 students, including underserved and minority population with limited access to technology, is crucial in igniting their interests in STEM fields. More specifically, research topics that involve interactive elements such as Robots may be instrumental for K-12 education in and outside classroom.

Robots have always fascinated mankind. Indeed, the idea of infusing life and skills into a human-made automatic artefact has inspired for centuries the imagination of many, and led to creative works in areas such as art, music, science, engineering, just to name a few. Furthermore, major technological advancements with associated societal improvements have been done in the past century because of robotics and automation.

Assistive technology deals with the study, design, and development of devices (and robots are certainly among them!) to be used for improving one's life. Imagine for example how robots could be used to search for survivors in a disaster's area. Another example is the adoption of nurse robots to assist people with handicap

during daily-life activities, e.g., to serve food or lift a patient from the bed to position him/her on a wheelchair.

The idea of assistive technology is at the core of our piloting Technology Education Academy. We believe kids will be intrigued by the possibility to create their own assistive robot prototype, and to make it work in a scenario that resembles activities of daily life. However, it is not enough to provide students with the equipment necessary since they might also easily lose interest due to the technical challenges in creating the robots and in programming them. In fact, achieving these goals requires a student to handle problem-solving skills as well as knowledge of basic principles of mechanics and computer programming.

The Technology Education Academy has brought UT Arlington, the AISD and the Arlington Public Library together to inspire young students in the East Arlington area to Assistive Technology, and provide them easy-to-use tools, an advanced educational curriculum, and mentorship to nurture their skills in problem solving and introduce them to mechanics and computer programming.

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Chapter 1

INTRODUCTION

Engineering disciplines (such as biomedical, civil, computer science, electrical, mechanical) are instrumental to society's well-being and technological competitiveness; however the interest of K-12 American students in these and other engineering fields is fading. To broaden the base of engineers for the future, it is critical to excite young minds about STEM. Research that is easily visible to K-12 students, including underserved and minority population with limited access to technology, is crucial in igniting their interests in STEM fields. More specifically, research topics that involve interactive elements such as Robots may be instrumental for K-12 education in and outside classroom.

1.1 Objective

The main objective of the current research is to develop a Robotics curriculum for education in Arlington for low-income K-12 students. The curriculum so developed is to engage students in an active learning environment. It helps students to do meaningful learning activities and think about what they are doing. The core element of active learning are student activity and engagement in the learning process.

The curriculum should also emphasise on collaborative learning. A significant question is addressed or a solution to a question is formulated by students teaming together in this method of teaching and learning. [1] Students collaborate with their fellow students to complete the explained and assigned task. Students with different areas of interests and strengths, collaborate to find a solution to the task. "It is also based on the view that knowledge is a social construct." [2].

"Collaborative activities are most often based on four principles:

- The learner or student is the primary focus of instruction.
- Interaction and "doing" are of primary importance.

- Working in groups is an important mode of learning.
- Structured approaches to developing solutions to real-world problems should be incorporated into learning.” [2]

The curriculum should focus on bringing out the problem solving capabilities of students, individually and collectively. “The four basic steps in solving a problem:

- Problem definition.
- Formulating solutions.
- Evaluating, verifying and selecting the suitable solution.
- Implementing solutions” [3]

In all, the curriculum should be simple, engaging and appealing to the students by igniting the interests in STEM (Science, Technology, Engineering and Math) fields and attract them toward careers in engineering.

Chapter 2

Thesis Background

2.1 Motivations

AISD: STEM and Learning in East Arlington

“AISD or Arlington Independent School District is a school district based in Arlington, Texas that covers the majority of the city of Arlington and much of the Tarrant county portion of Grand Prairie. The district also serves the entirety of the small towns of Pantego and Dalworthington Gardens which are within the boundaries of the city of Arlington.”[4]

“The AISD, as of 2015, enrolls more than 64,000 students making it the 11th largest school district in Texas. As of the 2014-2015 school year, the Arlington Independent School District has a total of 75 schools, 10 high schools, 13 junior high schools and 52 elementary schools.”[4]

“To continue the goal of being a district with cutting-edge learning experiences, AISD has partnered with The University of Texas at Arlington for a new STEM Academy –science, technology, engineering and math. Students will have the opportunity to earn high school and college credits along four pathways- engineering, biology/biomedical science, computer science and math/science.”[5]

“There are no fees associated with being a part of the STEM Academy. Students in the STEM Academy will have a chance to complete a number of first year STEM college courses prior to high school graduation. Students will also be able to advance their STEM education outside the classroom with opportunities such as internships, mentorships, job shadowing, community service, enrichment programs and summer learning opportunities.”[5]

The Arlington Public Library (The East Branch) has been the home for many social and cultural events. The Youth Technology Centre (YTC) or the LAB, at the Arlington Public Library invites students from across AISD to participate in many

Robotic programs and competitions held there. Programs, for age groups ranging from 13 years to 19 years, are organised and have been well received by the students. The GEAR competition, held annually, is a great hit amongst the Robotics enthusiasts and is supported by the Arlington Public Library. The University of Texas at Arlington has been the venue for the same from the past couple of years. [6]

The Robotics curriculum described here derived from a project in Dr. Gian Luca Mariottini's course. The course, titled "Robotic Vision: Sensors, Localization and Control", gave us the opening for the field of Robotics. It fascinated us from the very beginning. As part of the course work, we were to complete a project involving Robots. A project "EDU-BOT", was a result of all the knowledge gained over the course of the semester. It was aimed at building an interactive, educational gaming module for kids to develop and learn through the creative world of Robotics. The idea being, visual learning is more effective than theoretical learning. Edu-Bot was to cater to the growing need for the upcoming generation to be in par with latest technology. Dr. Mariottini, who was impressed by the same, envisioned a greater purpose off it and eventually involved it in the development of Robotics curriculum for TEA or Technology Education Academy. A competition with a similar base idea of bringing technology to the financially constrained populous; which engages students in active and collaborative learning is WPI-BOT.

"WPI-BOT was conceived with keeping in mind that the existing work have limitations in terms of accessibility, cost effectiveness, some give deficient hands-on experience and most would be barely centred on programming." [7]

"All of the programs that were examined focus on common themes: Showing students how classroom subjects are applied in the real world; teaching engineering through hands-on experience; and encouraging cooperation both within teams and between teams". [6] TEA subscribed to these same ideals. Figure 1. shows the compared programs/competitions. [7] [28] [29]

	TEA	WPI-EBOT	FIRST	FIRST LEGO League	BotBall
Time	12 weeks	4 weeks	6 weeks	8 weeks	7 weeks
Cost	Free	\$800	\$6000-\$60000	\$500+	\$2500+
Grade range	7-12	9-12	7-12	4-8	7-12
Mentors	Yes	Yes	Yes	Yes	Yes
Funding	Arlington Tomorrow Foundation	Schools and companies in the area	Boeing, Bosch, Google, IBM to name a few	Boeing, Bosch, Google, IBM to name a few	iRobot, SOLIDWORKS
Robot kits	Yes	Yes	No	Yes	Yes
Participants enrollment	Through Arlington Public Library	Schools enroll students	Register online by paying	Register online by paying	Register online by paying
Students program robots	Yes	Yes	Yes	Yes	Yes
Programming language	Scratch	C programming language	Lego Programming	Lego Programming	C programming language
Location	Arlington, TX	Worcester, MA	Manchester, NH	Worcester, MA	Lowell, MA

Figure 1. Matrix of Investigated Program

Why Robotics is the way to “Experiential” learning?

“Experiential learning is any learning that supports students in applying their knowledge and conceptual understanding to real-world problems or situations where the instructor directs and facilitates learning. Learning through case studies, problem based studies, experiments or simulations in a classroom, laboratory settings enables for experiential learning. (Wurdinger & Carlson, 2010)”. [8]

By engaging in formal, guided, authentic, real-world experiences, individuals:

- Get a deeper knowledge about the subject.
- Develop skills, improve and acquire proficiency through repetition.
- Apply the learned skills and improvise according to the situation. [8]

“Experiential learning teaches students the competencies they need for the real-world success.” [8] Though one can teach a subject in a controlled, safe classroom environment, it is only through applying the knowledge acquired in real world that one gets the real understanding of the learning. “Couple of famous authors, Sullivan and Rosin (2008) argue that the mission for higher education should be to bridge the gap between theory and practice and Bass (2012) suggests that to do this, the educational environment needs to intentionally create rich connections between the formal and experiential curriculums.” [8]

Motivation, offering a congenial environment to quick and effective learning are achieved through experiential learning. By involving students in experiences which they can relate to, for example, blinding a student and navigating him through the room by verbal instructions. Actively involving each student motivates them more. Through constant encouragement and feedback, students are motivated. Experiential learning meets these criteria. [8]

“Experiential learning creates self-directed learners. It is when students face new and unfamiliar situations, they resort to experimenting and eventually finding solutions. This results to self-learning, reflect on their prior knowledge and deepen it through reflection; transfer their previous learning to new contexts; master new concepts, principles, and skills; and be able to articulate how they developed this mastery. Ultimately, these skills create students who become self-directed, life-long learners.” [8]

How does experiential learning work?

David A. Kolb (1984), an educational theorist formulated a cycle of learning depicting the experiential learning process (see Figure 2 below). The three main components, he explains are essential in the learning process, which can be effectively used in our Robotics curriculum.

- Knowledge- facts or concepts about the robots
- Activity- robots usage in the real world.
- Reflection- and devising new applications for the same robot based on the knowledge acquired. [8]

Kolb's Cycle of Experiential Learning

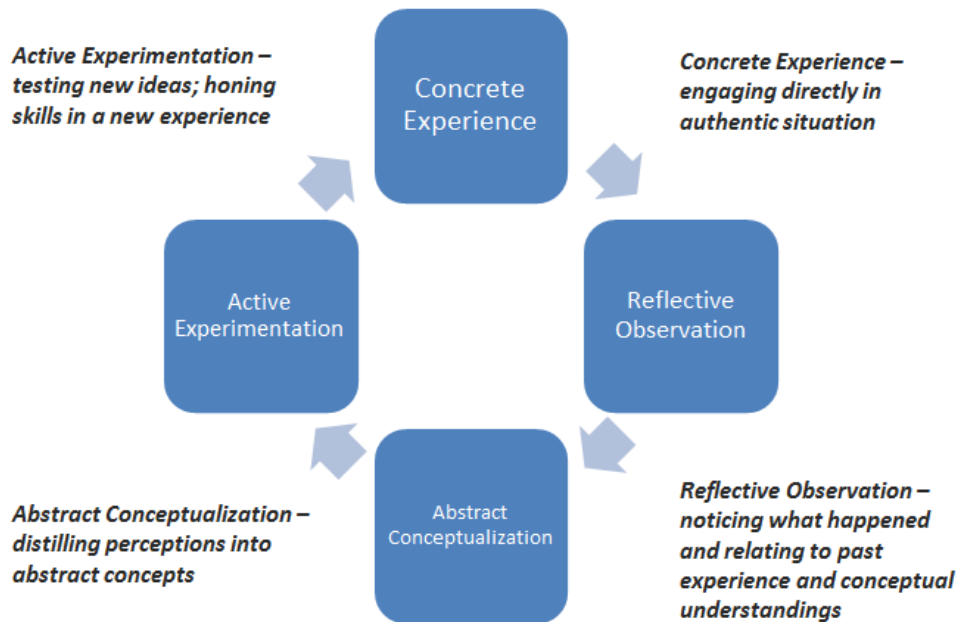


Figure 2. Kolb's Cycle of Experiential Learning

"Kolb's experiential learning cycle include:

- Experience: Every participating student engages in a real-world problem which results in some experience.
- Reflection: Students reflect on their experience with fellow students and mentor. Collaboratively they take notes about the understanding the new experience.
- Conceptualize: Reflection would lead to better understanding of the concept or formulation of a new solution based on the problem.
- Test: Students test their new understanding or solution to check the results." [8]

“During experiential learning, the facilitator’s role is to:

- Select suitable experiences that influence the students
- Pose problems, set boundaries and ensure proper learning.
- Recognize and encourage spontaneous opportunities for learning and discovery of solutions with the inclusion of partners.
- Making the student recognize the connection between different scenarios and solutions.” [8]

“Some forms of experiential learning include:

- Internships – An experience based learning activity which involves collective working, tackling real world issues.
- Student teaching – It is for the to-be teachers learning the art of teaching.
- Community-based research – Faculty and students cooperate with local organizations to conduct studies to meet the needs of a particular community. Students gain direct experience in the research process.
- Practicum – Similar to internship, this form of experiential learning usually is a course or student exercise involving practical experience in a work setting.” [8]

Finally, to answer why Robotics is a way to “Experiential” learning, we are living and learning in a technology rich world and growing rapidly. In the current known world, it is important to be in pace with the technology and develop essential skills to live and work. Involving students in an inquiry based learning where they can collaborate and find creative solutions to robotic challenges will give them the right edge to survive.

“Robots have evolved from assembly lines to facilitate research in labs to being an integral part of education. Some educators have claimed that through hands-on experimentation, robots help youth transform abstract Science, Technology, Engineering and Math (STEM) concepts into concrete real-world understanding.

Recent improvements in cost and simplicity make it possible for students to engage in this kind of hands-on experimentation with robots.” [9]

Robotics is a creative field. It can be developed as the user wants and to his needs. Robotics provides teachers with an opportunity to make students imagine what they want to build and how they want to build it. It leads to new discoveries and also lead students to become active problem solvers. “If students are given the time, space and purpose to tinker with robots and solve open ended problems, this will allow for thought and action to come together, and the opportunity for students to construct knowledge and build theories in individual and collaborative settings. These are critical practices for learning and discovery that have application across all curriculum areas and perhaps may result in harnessing greater human potential in creativity, participation and effort.” (Cathie Howe) [10]. Robotics can provide students with an opportunity to manage projects independently or collaboratively from conception to realisation.

Though literature shows that this is not the only way to engaging in experiential learning (other technology exist) but research shows promising results.

Benefits of After school Programs:

In the current age where technology has taken over every important aspect of life, a child cannot be left to the mercy of schooling alone. They need to be in pace with the recent happenings and specialize in any new field to be ahead of the curve. They have to broaden their horizons, learn more apart from the textbooks.

More than 14 million students leave school every afternoon and waste their rest of the day in unyielding activities, since they do not have access to affordable, after-school opportunities. “According to the National Youth Violence Prevention Resource Centre (NYVPRC), nine out of ten Americans think all youth

should have access to after-school programs, but two-thirds of parents say they have trouble finding programs locally.” [11]

“After-school hours are the peak time for juvenile crimes and risky behaviours, including alcohol and drug use. NYVPRC found that children who do not spend any time in after-school activities are 49 percent more likely to have used drugs and 37 percent more likely to become a teen parent. Kids are also at the highest risk of becoming a victim of violence after school, particularly between the hours of 2 p.m. and 6 p.m. and highest amount between 3 p.m. and 4 p.m., the hour after most children are dismissed from school.” (Lindsay Hutton)[11]

“The NYVPRC characterizes after-school programs as sheltered, organized exercises that meet all the time in the after-school hours and offer kids chances to learn new abilities. The skills can range from innovation and math to perusing and workmanship. Some projects likewise offer open doors for entry level positions, group benefit, or tutoring. These projects have been appeared to enhance scholarly accomplishment, and also diminish the weights on working families. As per the NYVPRC, most specialists concur that after-school exercises can serve as vital procedures for youth brutality counteractive action and mediation, and can likewise help understudies form into mindful grown-ups. A report by the U.S. Department of Education and the U.S Department of Justice shows that students enrolled in after-school programs have lesser behavioural problems and more self-confidence, and can handle conflicts better than students who are not involved with these programs. In addition, according to the Harvard Family Research Project, after-school programs help students from low-income families overcome the inequities they face in the school system.” (Lindsay Hutton) [11]

“Afterschool Programs, have been: making a difference in students’ life by improving academic achievement, keeping kids safe and helping working families.” [12] Afterschool programs strengthen schools and communities by keeping kids engaged.

“Increases academic performance and decreases skipping of school.” [12] Fewer emotional and behavioural problems. Improves leadership skills. Helps keep children physically and mentally active and learn healthy habits. Improved school attendance and engagement in learning. Improved test scores and grades. [13]

2.2 Goals

“Experiential, Simple, and engaging learning opportunity for low-income K-12 kids.”

Every term in the goal set was measured and defined.

Experiential: In addition to traditional textbook learning at school, the program involves students in Robotics. As described earlier, “Experiential” learning is defined as the process of learning through doing and experience, and is more specifically defined as “learning through reflection on doing”. “Hands-on-learning is a form of experiential learning but may not necessarily involve students understanding the subject. Experiential learning is distinct from rote or didactic learning, where the student plays a comparatively passive role.” [14]

Simple: The curriculum developed uses the programming language “SCRATCH”.

“It is a free visual programming language and is very easy to use. Scratch is used by students, scholars, teachers, and parents to easily create animations, games, etc. and provide a channel to a more advanced field of computer programming. It is also used for educational and entertainment purposes from math and science projects, including simulations and visualizations of experiments, recording lectures with animated presentations, to social sciences, animated stories, and interactive art and music. No online registration is required to view or modify the existing projects.”[15]

Learning opportunity: The curriculum provides a learning opportunity to the kids enrolled. It involves problem solving concepts, math concepts, and physics

concepts. It is designed to promote Science, Technology, Engineering and Math (STEM) education.

Problems are at the centre of what many people do at work every day. Problem solving consists of using generic methods in an orderly manner for finding solutions to problems. The curriculum aims to instigate the problem solving capabilities within the kids. University of Texas at Arlington (UTA) provides mentors who help kids by teaching the problem solving techniques.

“Becoming confident and competent as a problem solver is a complex process that requires a range of skills and experience. As teachers/mentors one can support this process in three principal ways:

- By choosing the right set of tasks
- By following a structure for problem solving
- By repeatedly providing children with opportunities to improve problem solving skills”

[16]

The mentors, Graduate students at the UTA, all well trained and knowledgeable in the curriculum, guide the kids through the process, from defining the problem to generating alternatives, to evaluating and selecting alternatives to finally implementing the solution/s.

The curriculum is also tied with the “Learning outcomes” of Arlington Independent School District (AISD). Promotion of STEM education and ensuring that students are well prepared to succeed in college. AISD aims at continuing to be the district with excellent learning experiences.

Low Income: The curriculum is sponsored by the Arlington Tomorrow Foundation (ATF) and is free for the kids enrolled.

“In November 2006, The Arlington city council unanimously adopted the Arlington Tomorrow Foundation Program which was the first step in establishing the

public charity and a permanently endowed foundation.” [17] The grant money was productively used for developing the curriculum and acquiring the Robot kits, with which the Arlington children build robots of future.

The article about the Robotics program is detailed on the Arlington city website: <http://www.arlington-tx.gov/arlingtonfoundation/2015/04/14/with-grant-arlington-children-build-robots-of-our-future/>

TEA: Technology Education Academy

The Technology Education Academy, with its novel curriculum is well rooted in addressing all the Motivational goals. It engages high school kids in experiential learning and problem solving. The educational curriculum created teaches students about robotic technology and STEM related problems, in an intuitive and experiential set of activities. It is free and is a well-rounded curriculum for active learning. Students enrolled for the program get to collaboratively work in designing a robot and nurture their skills in problem solving and introduce them to mechanics and computer programming. They will be mentored by UTA mentors at the LAB (Arlington Public Library, East Branch).

Chapter 3

Existing Work

Some of the existing curriculums which touches on the idea of involving robots, engineering, science, technology and math to active learning are described below. Each curriculum has a unique motive which aids in the improvement of critical thinking and problem solving skills of a student.

3.1 Learning Sequence: LEGO Engineering

“Learn to build with LEGO: This succession of exercises presents the essential LEGO framework pieces. It's suitable for tenderfoots and functions admirably with youngsters. It likewise presents the idea of testing and updating.” [18]

- How can we build a sturdy wall?
- Study tower
- Strongest shape
- Sturdy Car: The drop test
- Chair for Mr. Bear

This curriculum introduces LEGO just as our Robotics curriculum.

“Learn about Gears: This proposed group of exercises starts with an investigation of basic hand-controlled rigging trains. The second and third exercises use riggings to diminish the rotational velocity of engine fuelled music boxes and fans. The last three exercises join gears into autos with the goal that they can win a "snail race" or climb steep slopes.” [19]

This learning sequence is appropriate for third grade and above. Students should already have experience with LEGO building and programming.

“A WeDo, RCX, NXT, or EV3 kit is required for all but the “Exploring Gears” activity.” [19]

“Programming is required for the “Fan-tastic” and Music Box activities. The other activities require programming only to turn motors on at a constant power level.”

[19]

- Exploring Gears
- Music Box
- Fan-tastic
- Snail Car
- Mountain Rescue
- Peak Performance

This curriculum focusses on gears and its applications and TEA uses the concept of gears with a theme of Assistive robots.

Science through LEGO Engineering: The following four curricula are designed to introduce students (in Grades 3 to 5) to various science concepts through design-based LEGO projects. The initial set of lessons of each unit engage students in scientific explorations sometimes using the LEGO tool-set. The students are then given an open-ended design challenge where they use the science they learned alongside the engineering design process to design and build LEGO creations that meet criteria that the students can observe and test. [20]

Intro Unit: This series of introductory lessons should be completed before beginning a Science through LEGO Engineering curriculum unit. [20]

Design a Musical Instrument. The Science of Sound.

Design a Model House. The Properties of Materials.

Design an Animal Model: Animal Studies.

Design a People Mover. Simple Machines.

These set of projects encourages students in engineering and building of models with a theme. TEA curriculum engages students in designing and building an assistive robot.

The preparation of this curriculum was partially supported by grant DRL-0423059 from the National Science Foundation. [20]

3.2 Robotics: Assistive devices for the future

“This educational programs module connects with centre school students in outlining, building and programming a LEGO robot that could function as an assistive device for the physically tested people. It presents and clarifies the Engineering Design Process (Figure 3). The students form groups or "companies" that cooperate to make their LEGO robot model. At the end student groups display their items to a board of judges.” [21]

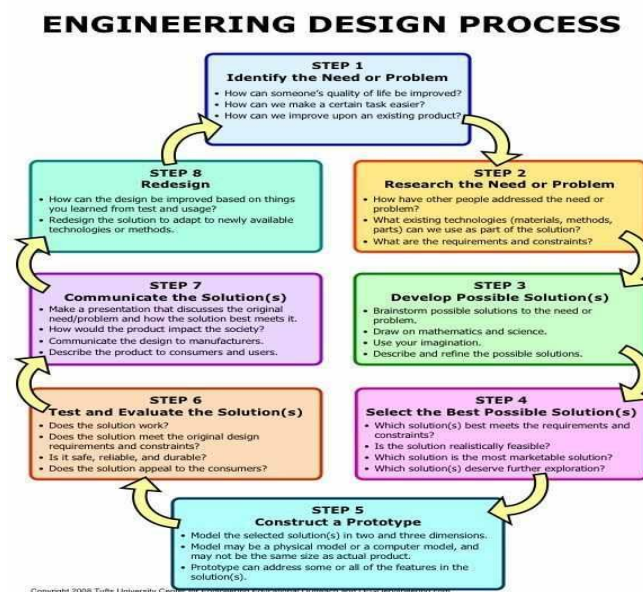


Figure 3. Engineering Design Process

This curriculum offers students the opportunity to design and build an assistive robot and function as one. The robots are built using the ROBO technology set, with

motors and one sensor. The curricula starts with an introductory project to build a wheelchair. Then a series of lessons on motors and sensors. At the end a final project by letting the students chose to invent an assistive device to help the disabled. The robots are programmed using ROBOLAB. [21]

TEA engages its students in building an assistive robot, with various different scenarios in mind. Teaches students about translation and rotation using motors. Usage of sensors, individually and collectively with other sensors too. An interactive, graphical programming language called SCRATCH is used to control the robot.

3.3 Mathematics and LEGO robotics at CIPCE

“The Centre for Initiatives in Pre-College Education (CIPCE) at Rensselaer Polytechnic Institute has published a substantial collection of lessons and units aligned to the Common Core Learning Standards in Mathematics (CCLSM) that make use of the LEGO MINDSTORMS EV3 and NXT.” [22]

“The modules (lessons and units) that form the collection have been designed and taught by accomplished teachers, mentored by CIPCE staff. They are primarily aimed at students in grades 3 to 8, but may be adapted to other grade levels.” [22]

These modules incorporate targets for student learning, including state models, student evaluation and learning exercises. They include EV3 coding, builds, student handouts, assessment rubrics and estimated time frames. [22]

This collaboration was made possible by a U.S. Department of Education’s Fund for the Improvement of Post-Secondary Education (FIPSE) grant. [22]

Three example modules are outlined below, and to view the full collection, visit:
<http://www.cipce.rpi.edu/educationalresourcesmod.html>. [22]

4th grade Measurement & Data – Meter Measurement Module

Key terms: meter

7th grade The Number System – Integers Module

Key terms: integers, addition, subtraction

8th grade Functions – Fixing the Finish Module

Key terms: slope, rate, initial value, y-intercept, rate of change.

Each module is focused on different age grouped students. And the complexity of these modules are based on the grade level. They focus only on teaching math concepts. TEA curriculum teaches concepts of math along with physics, engineering and technology.

3.4 Dr E's MINDSTORMS and WeDo Challenges

“Ethan "Dr. E" Danahy is a computer science professor at Tufts University. He researches innovative uses of technology in education to promote creativity and diversity of student solutions, encourage documentation, and facilitate collaboration. Dr E has quite recently included another test site, Dr E's MINDSTORMS Challenges, to run with the current WeDo Challenges site. Both locales highlight month to month robotic challenges comprising of open-ended issues that urge students to utilize their imagination and critical thinking abilities. Students from around the globe video their answers and transfer them to the Dr E's locales. [23]

Dr E's challenges are the brainchild of Ethan Danahy (Dr E) and the sites are run by the Centre for Engineering Education and Outreach at Tufts University. [23]

3.5 MIT curriculum uses LEGO bricks to teach science concepts

“The Edgerton Centre at the Massachusetts Institute of Technology (MIT) has curriculum for teaching science concepts using LEGO bricks (not robotics, just bricks). Portions include Chemical Reactions, Photosynthesis, Understanding, and DNA. The curriculum can be downloaded from the website; they centre also sell classrooms sets that include the LEGO bricks and other related materials.” [24]

These set of curriculum is directed in teaching science concepts alone and uses just the LEGO bricks. No engineering or building of robots are involved as in TEA curriculum.

3.6 STEM curriculum from Georgia Tech

“The Georgia Institute of Technology (Georgia Tech) has posted their new SLIDER curriculum, Science Learning Integrating Design, Engineering, and Robotics. Outline and execute an issue based mechanical robot educational modules as a setting for eighth graders to learn material science and thinking abilities, and as an approach to build student engagement, motivation, aptitude, creativity and STEM interest.” [25]

“Conduct exploration to decide the viability of the project over all educational programs improvement parameters. Decide how students draw in the material crosswise over ethnic, socio-social, sex and geographic (country, urban, and rural) lines. Aligns with NGSS disciplinary core ideas, cross cutting concepts, and practices. Uses engineering design scenarios to engage and motivate students. Highlights LEGO Mindstorms Kits to drive outline and engagement. Stresses where science and designing adjust amid critical thinking.” [25]

The curriculum uses LEGO to investigate force, motion and energy. It has two curriculums focusing on potential and kinetic energy and transfer of energy & force and motion. [25] TEA teaches about forward, backward motions and rotational motions.

3.7 An Attraction Toward Engineering Careers: The Story of a Brooklyn Outreach Program for K-12 students

“Part of the exploration exercises of the Dynamical Systems Laboratory (DSL) at the Polytechnic Institute of New York University includes the configuration and execution of submerged vehicles for marine studies. Under the support of the National Science Foundation (NSF) Faculty Early Career Development (CAREER) award grant,

major efforts have been devoted to the guidance and control of gregarious fish using biomimetic robots. The robots planned and amassed in the DSL imitate live fish swimming and are effortlessly worked utilizing a remote control, making them a characteristic showing instrument for use with K–12 students.” [26]

It was targeted to local public schools for participation so as to have an impact on underserved populations whose access to engineering and science experiences may be limited by financial and cultural barriers. [26]

Interactive Robotic Fish for Outreach:

“The robots planned and gathered in the DSL copy live fish swimming and are remote controlled, making them a characteristic teaching tool for use with K–12 students. The robots included secluded elements that gave students an opportunity to compare and test their own designed caudal fins.” [26]

The activity involves:

- A student making a replica fin based on observation
- The student tests the fin in the pool and is helped in fitting the fin to the robot.
- After the trial, the student is guided by a high school student at the research station, about the significance of robotic fish in the DSL’s research.
- After this the student is at the engineering station to see and handle disassembled robot parts, including circuit boards, servomotors, IPMCs, and plastic hulls. The student can get their doubts cleared here.
- Finally the student fills out the survey. [26]

“A total of 62 students from a fourth-grade class and a sixth-grade class were surveyed before visiting the aquarium, and 50 students participated in the fun-science activity.” [26]

This program like TEA is directed to the low-income student group. It is a single class of 75mins length including a tour of the NYAQ. Students make caudal fins for robotic fish inspired by live fish in the aquarium. They assemble the robot fish parts and attach their designed fins and race against each other. [26]

Chapter 4

TEA CURRICULUM

4.1 Novel Development

TEA, The Technology Education Academy was a brain-child of Dr. Gian Luca Mariottini. The inspiration for this project for him was when he was invited to talk about robotics to students who frequent the LAB at the Arlington Public Library, East Branch. He was an instant hit and was impressed by the kids and the facility there. He wanted to develop a curriculum so that kids not only simply play with robots but they also get passionate about the technology, about mathematics, about team working and problem solving. The things, which are important for when a kid wants to go to college.

The Technology Education Academy has brought UT Arlington, the AISD and the Arlington Public Library together to inspire young students in the East Arlington area to “Assistive Technology”. Provide them easy-to-use tools, an advanced educational curriculum, and mentorship to nurture their skills in problem solving and introduce them to mechanics and computer programming.

4.2 TEA Program Overview

The entire program was carefully divided into 4 parts, with each part sequentially following the last.

- Part 1: Class Structure
Enrollment, Students and Mentors, Timeline
- Part 2: Class Topics
Ice Breakers, Phase1, Phase 2 and Phase 3
- Part 3: Equipment and Tools
- Part 4: Study

PART 1: TEA Class Structure

Class Enrollment

- Students will go through The LAB at the East Arlington Library to register for the program.
- Students need to pre-register to enroll for the month's activities which will be held every Thursdays.
- For that duration, classes will be closed.
- Classes for the subsequent month will have open registration again to enroll.
- The Lab in the East Arlington Library will advertise registration in their events calendar.

Students and Mentors

- Class size will consist of 30 students or less.
- Every team consists of 5 members.
- Team assignments will be given on the first or second lecture.
- Within each team, students will be divided into Electricians, Mechanics and Programmers.
- Teams will be built based on exercises given that test creativity, range of knowledge and age. Each team will consist of one student from grades 9-12 and one student from grades 7-8.
- Each team will be assigned a mentor to help them through the project
- The mentors will be volunteers from Dr. Mariottini's and Dr. Tiernan's class.
- The mentor will know all the details for the day's events and will help the team they have been assigned to complete the task within the time.

Class Timeline

- 15mins: Every class will begin with attendance and an Ice-breaker activity to get the students warmed up and prepare them for the day's lesson.
- 60mins: This time will be used to do the main activity for the day which involve the theme of Assistive Technology.
- 15mins: Every class will end with a closing activity to summarize the lessons for the day and to give the students insight into the next week. A short test or an activity will be conducted which will be used to assess the progress of the day.

PART 2: TEA Class Topics

Ice-Breaker Activities

Ice breaker activities will be intended to help form a group, and help the group members adjust amongst themselves and form a team. In addition, these activities prepare the students for the activities covered in the current or following sessions.

For example, we propose the use of the following for the team members to understand each other:

- Who is an Engineer?
- Science Fiction
- SCRATCH based applications
- Flow



Figure 4. Ice-Breaker Activity

Ice-Breaker activities example

“Who is an Engineer”

- This Ice-Breaker can be used at the start of the program.
- Have the students draw on a piece of paper the image of a Scientist or Engineer. Emphasize that perfection is not important and stick figures are just as good.
- Have them pass the paper to a classmate and they will create a list of similarities between their own drawing and their classmates drawing.

“Science Fiction”

- Robots are generally associated with science fiction and the future.
- Once the groups have been formed, we ask them to pick cards which have some of the famous fiction robots and ask them to introduce their group as the robot.

“SCRATCH based applications”

- SCRATCH is not exclusively for programming. It provides visuals to so it can be used to create animated stories.
- Once the teams are formed we ask them to build a sandwich with a set of ingredients in the right order.

“Flow”

- Flow would mean a set of activities done sequentially in an order
- Ask them to list the activities done from waking up in the morning to heading out for school.

PART 2: TEA Class Topics

The 12 week program is divided into three phases of 4 weeks each. In each phase a milestone is achieved in terms of learning. Phase 1 involves robot design and realization, Phase 2 concentrates on sensors and Phase 3 about robotic arm.

Phase 1: Goal

The goal is for each team to come up with a basic design of a robotic platform. The robot must be able to move front, back and turn on place. Also, the robot has to climb stairs to reach 2nd floor, etc.

- Build the robot using LEGO Mindstorms to replicate and improve the design obtained by the team.
- Application: A car-like robot that follows lines on the floor leading to a goal destination (e.g., person in bed)

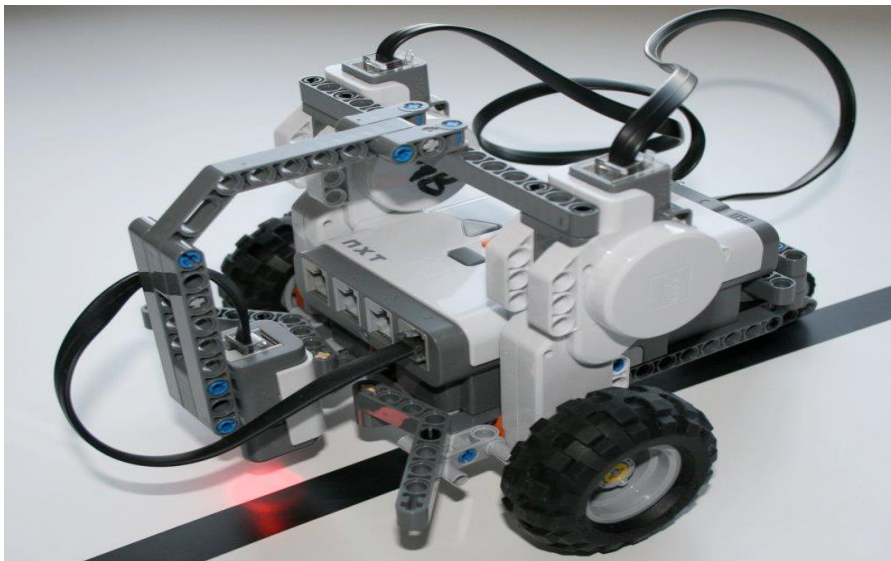


Figure 5. Building a Robot

Phase 1: Week 1

- GOAL: To be introduced to Assistive Technology and to know each other. A basic model of the robot will be built.
- Ice-Breaker: Assign each student in group and ask them to imagine and design what an assistive robot could be.
- Main Tasks: Each student presents the design to the others. Then mentor will show pictures of famous robots (e.g., Jonny 5 from Short Circuit –this helps for caster wheel). Mentor helps refining that design in team.
- Learning Outcomes:
 - Participants will explore team-working.
 - Participants will explore basic robot structures.
- EQUIPMENT and STEPS:
 - Find a video/picture of situations where assistive robot can help (health, monitoring, search/rescue, etc.).
 - Create 1 slide to print in colour for each student (4/team) that contain many parts of robots (4 wheels, 4 arms, 4 legs, 2 tracks, 4 hands, 2 heads, gripper.) Students will use scissors to cut, and then glue parts together to create a robot.
 - Create slides with videos of famous robots used for assistive tasks.
 - Have another slide made by each member in colour with robot parts and ask each member to come together to create a robot.

Phase 1: Week 2

- GOAL: Create groups based on week 1 and design robot structure with LEGO.
- Ice-Breaker: Introduce the assistive Robotics challenge (person in bed). Have them do in team a “LEGO” like mimic of robot on paper (cut/glue).

- Main Tasks: Build a structure with the EV3 Lego Mindstorms. Simple software can be done on EV3, like move, colour detection.
- Learning Outcomes:
 - Participants will explore team-working.
 - Participants will be introduced to purpose of programming and describe the advantage of graphics icon programming.
- EQUIPMENT & STEPS:
 - Create teams; Team selection is key!
 - Let students use LEGO EV3 Mindstorms Kit to assemble robot structure.
 - Select 1 or 2 kids/team to be the computer scientists: they will use EV3 Scratch to control motor, e.g., to allow robot to move forward.

Phase 1: Week 3

- GOAL: To finalize robot model by converging to a good design with the mentor's help.
- Main Task: Improve the robot prototype and get a final model ready. Scratch will be used to program some motion actions.
- Learning Outcomes:
 - Participants will learn problem solving and write flow diagrams.
 - Participants will design and build a mechanical system.
 - Participants will learn about use of loops in programming.
- EQUIPMENT and STEPS:
 - Participants will explore how to interface Scratch with robot and command it (back & forth + loops).
 - Let rest of team converge to final prototype and integrate with software.
 - Do motion on robot.

- Have a way to assess whether they learned about flow diagrams - Giving a test at the end with another example (get out in the morning).

Phase 1: Week 4

- GOAL: Students will finalize structure and program the robot to navigate (A->B navigation) to help person at need.
- Ice-Breaker: Use tape on ground to solve path problem (grid and obstacles). Then pick a member, blind him, command him only with rotation of 90 degree + translation
- Main Task: Finalize robot structure. Program the robot with Scratch to move from the start to the end on the path. The mobile platform is finalized.
- Learning Outcomes:
 - Participants will learn about path planning and relate it to geometry concepts (straight line segments, angles etc.)
 - Participants will explore graphics-icon programming.
 - Participants will learn about physics concepts (constant-velocity model) angular velocity (wheel radius, distance etc.), and fractions.

Phase 2

- GOAL: The goal of Phase 2 is to let each team explore the use of sensors in their own projects.
- Learning Outcomes:
 - Learning about sensors will increase problem-solving skills (reactive behaviour of a system, compared to pre-programming and thus larger sensitivity to environmental changes).
 - Perception is strongly related to geometric reasoning.

Phase 2: Week 1

- GOAL: Students will have the robot move in the arena over a coloured path.

- Main Task: Program the robot to move from the start to the end in the path. Math and physics are now used to control the correct velocity “v” to get the robot reach destination in “t” secs.
- Learning Outcomes:
 - Participants will learn about path planning and relate it to geometry concepts (straight line segments, angles, etc.)
 - Participants will explore graphics-icon programming.
 - Participants will learn about physics concepts (constant-velocity model) and fractions.
- EQUIPMENT and STEPS:
 - Need tape to draw grid on ground.
 - Teach the simple math behind robot translation and rotation.
 - Use these to explain $x=v*t$

Phase 2: Week 2

- GOAL: Students will learn about touch sensors, integrate in robot, and use them for navigation.
- Ice-Breaker: Blind a participant and ask him to move to a destination only using his/her hands (Roach Game!). Only one hand to start and then both hands.
- Main Task: Equip the robot with antennas connected to touch sensors. Program the robot with two touch sensors for understanding left or right and navigate in maze.
- Learning Outcomes:
 - Participants will learn about the use of conditionals in programming.
 - Participants will relate robot design with nature.
 - Participants will learn about sensors and their use.

- EQUIPMENT and STEPS:
 - Let the students create antennas (straws) attached to robot's touch sensors.
 - Let them explore a flow diagram for doing that.
 - Create a small maze and use that to show the robot moves inside the maze.

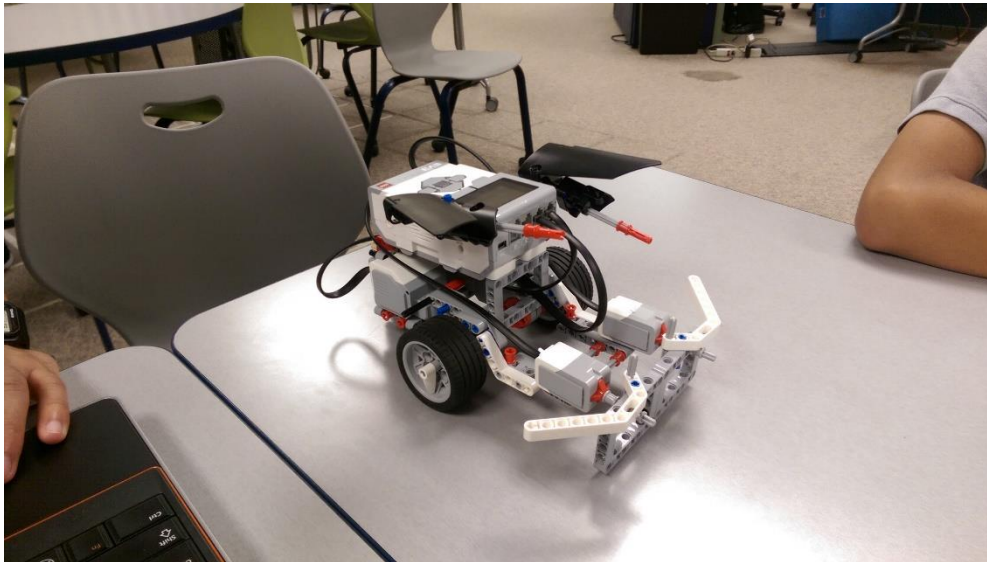


Figure 6. Robot built as a roach

Phase 2: Week 3

- GOAL: Students will learn about ultrasonic sensors, integrate in robot, and use them for non-contact obstacle avoidance.
- Ice-Breaker: Do the same game of blinding a person, but now guiding with voice when is too close to obstacle.
- Main Task: Equip the robot with the ultrasonic sensor. Use it for obstacle avoidance, similarly to what done with touch sensors.
- Learning Outcomes:
 - Participants will learn about problem solving.

- EQUIPMENT and STEPS:
 - Let the students mount the ultrasonic sensor and display values. Show them only with a sensor in hand what are distance values when sensor between two walls and rotating. Let them arrive to the solution.
 - Let them explore a flow diagram for doing that.

Phase 2: Week 4

- GOAL: Students will learn about colour sensors, integrate in robot, and use them for line-following navigation.
- Main Task: Equip the robot with the light sensor. Use it for line following (black/white) until the robot reaches the goal.
- Learning Outcomes:
 - Participants will learn about problem solving.

Phase 3: Goal

- GOAL: Students will learn about robotic arms, and their use in helping people at need.

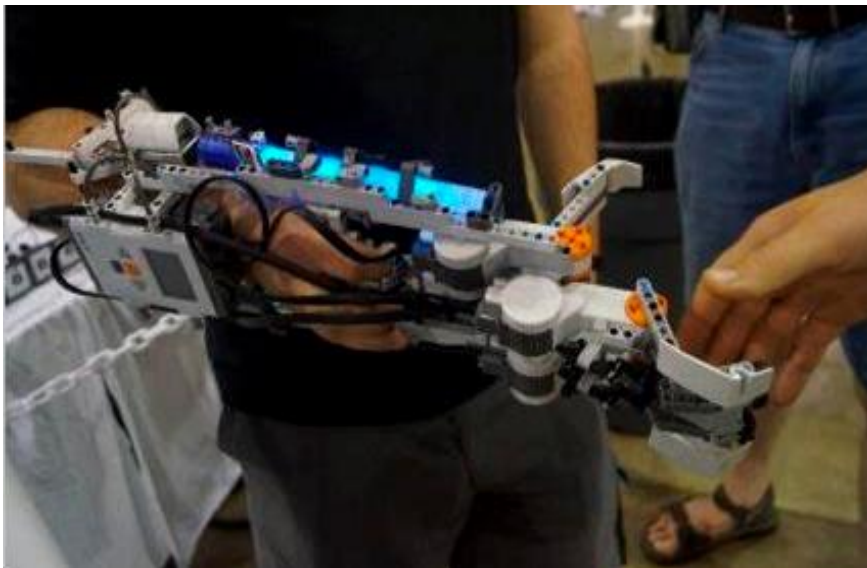


Figure 7. Robotic Arm

- Learning Outcomes:
 - Participants will learn about gears, gear-ratio.
 - Participants will learn about different Degree of freedom in the robotic arm.

Phase 3: Week 1

- GOAL: Students will learn about prosthetics and robotics.
- Ice-Breaker: This Ice-Breaker will introduce students to the task (grasping bottle and hand it to person, serve food w/ spoon, etc.)
- Main Task: The team will be presented with several material (movie clips, magazines, etc.). Together, they will decide and assemble the structure they think fits the goal.
- Learning Outcomes:
 - Participants will explore team working to achieve goal.
 - Participants will explore modern robotic structure, and problem solving through design new architectures.

Phase 3: Week 2

- GOAL: Program robot motions.
- Main Task: Design a robotic arm. Implement code to rotate links of a specified angle.
- Learning Outcomes:
 - Participants will explore robust robotic arm structures.
 - Participants will explore how to program gears and their concepts.

PART 3: Devices Used

- EV3 LEGO Mindstorms Kits
- Laptops
- SCRATCH software
- USB Wi-Fi dongle

- Micro SD card

Software and Hardware:

The robots are built with the LEGO Mindstorms EV3 kit. It comes with couple of large motors and a medium motor. Also a colour, touch, ultrasonic and an infra-red sensor. The laptops used to program and control the robots have to be equipped with the SCRATCH 2.0 offline editor software. It is used to program the robot and requires an extension to connect with an external hardware. A helper-app extension is added to it for communicating with LEGO Mindstorms EV3. It helps in reading sensors and controlling motors. A USB dongle connecting to the robot is required to connect with the local network over which the commands from the laptop are sent to control the robot. A Micro SD card is needed to install a version of LeJOS, a tiny version of Java Virtual Machine. It overrides the EV3's Mindstorm to help connect with SCRATCH 2.0 editor.

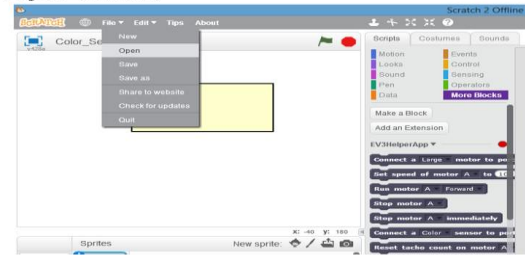
PART 4: Study

- Attendance will be taken every class lecture.
- Students will be quizzed on the learning outcomes for the day.
- This will give mentors the opportunity to assess the knowledge of their group and determine if additional training is required the following week.
- On the last lecture of the class we will give the students the same series of questions that were given on the first day.
- This will allow us to test the effectiveness of the training and range the knowledge of the students from beginning to end.
- We will also give students a critique sheet to give us feedback that is anonymous.

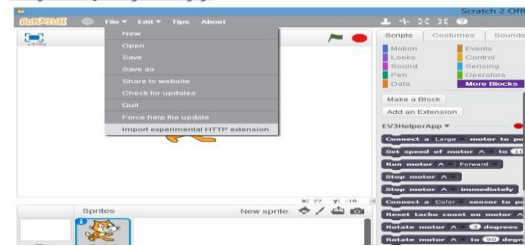
Configuring Scratch with EV3: Bot-Cards:

Bot-Cards are small hand-outs given to the students to help them through the programming of the assigned task. Students refer to them as it forms a template. The idea of “Bot-Cards” was derived from the flashcards from Enchanting. [30]

Open Scratch



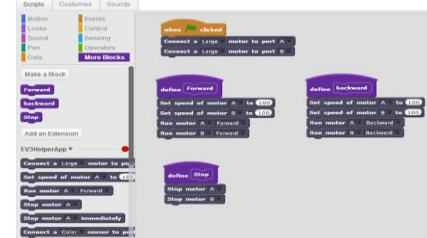
Import HelperApp



Start your code:

1. Open Template

Open the Template for Forward, Backward and Stop actions.



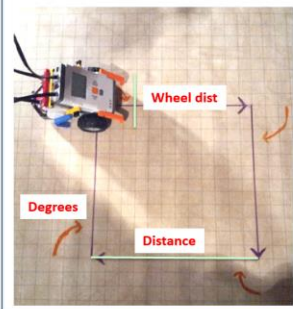
2. Add a sensor

Open Scratch. Import the helper-app. Connect desired sensor to a port.



Square (Polka) Dance

GOAL:
Move robot on a square



$$\text{Time} = \frac{\text{Velocity}}{\text{Distance}}$$



GET READY

Connect motors to Port A and Port B.
Measure variables of the Robot.
Set variables in the code

TRY THIS CODE

1. Setup Variables & Sensors



2. Create code



DO IT !

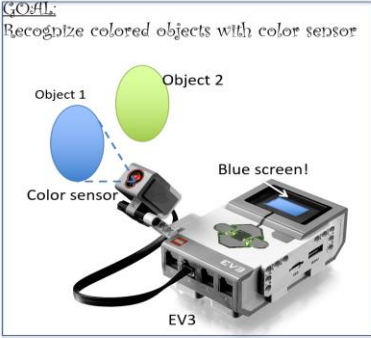
Place the robot where to start
Click the button.
Tune it nicely to dance on square

GO FARTHER

Think of other shapes you can get your robot to dance
(e.g., triangle tango dance).
How would you implement it?

Recognize Colored Objects

GOAL:
Recognize colored objects with color sensor



GET READY Connect Color Sensor to port 1
Write code below!

TRY THIS CODE

```

when clicked
  Connect a Color sensor to port 1
  switch costume to costume1
  forever
    if Sensor 1 = 6 then
      switch costume to costume1
    else
      if Sensor 1 = 7 then
        switch costume to costume2
          
```

DO IT ! Click the button.
Pass sensor over a blue object

GO FARTHER Try to have your robot to recognize more colors
(for example 1:Black, 3: Green, 6: White)

Approaching an object

GOAL:
Navigate robot until close to an object



GET READY Connect motors to Port A and Port B.
Connect Distance sensor to Port 1.
Set Distance to the object.

TRY THIS CODE

1. Setup Variables & Sensors 2. Create code

```

when clicked
  Connect a Large motor to port A
  Connect a Large motor to port B
  Connect a Distance sensor to port 1
  forever
    if Sensor 1 < 10 then
      Backward
    if Sensor 1 > 10 then
      Forward
    Stop
          
```

DO IT ! Click the button.
Point the sensor at object.

GO FARTHER Try using this code to follow an object.
Can you make your robot fast enough?

Figure 8. Scratch Bot-Cards for the help of Students

4.3 Sustainability

The TEA program was organised and run by the UTA Mentors, who are basically graduate and undergraduate students from Dr. Gian Luca Mariottini's class or Dr. J. Carter M. Tiernan's class. They were all part of the curriculum building and were well aware of each nuances of the program. Going forward, the program will be handled by the mentors at the Arlington Public Library, East Branch. A knowledge transfer session will be held and the mentors at the Library will be trained to every detail of the program. Ms. Marla Boswell, a Program Specialist at the Arlington Public Library, East Branch will head the program.

Chapter 5

Discussion and Conclusion

The 12 week Pilot program held between March, 2015 and May, 2015 at the Arlington Public Library, East Branch was a grand success. With an enrollment of 26 students, distributed equally among age, the program was well received by the students. The class was full within hours of enrollment being made available.

A few highlights from the Pilot program:

- 26 students enrolled.
- 5 Mentors, 3 volunteers from UTA and couple of Interns from the Library.
- A pre and post questionnaires were handed out to the students at every class.
- Students were divided in a measured way of learning ability, knowledge and age
- Attendance was taken at the beginning of every class
- 5 mentors were allotted to the 5 divided teams
- A competition at the end of each topic brought in a sense of team work among the students
- A certificate of completion was handed out to each student on the last class
- A complete hit amongst the participating students.
- 100% retention.
- A brief report praising the Program was published in the local Newspaper.

<http://www.star-telegram.com/news/local/community/arlington-citizen-journal/article21571464.html>

Words of few students:

- Sergio Gonzalez: "How some robots work and the word assistive robots"
- Zach: "That there are more ways than I thought to use Robots".

- Uwais Khan: "Learned how to program the EV3 and how to build a robot to make it efficient"
- Hernan Barajas: "Build a robot with EV3 and program it with Scratch"

The interactive robotics-based outreach activity that was designed to ignite the interests of K-12 students in STEM fields and attract them toward careers in engineering was a success. The activity engaged middle school and high school students of the East Arlington area. The robots included modular features that allowed participants to design and test their own inspired Assistive robots. The impact of the activity on the participants was assessed using surveys given to the students before and after participating in the activity.

Survey results showed a clear impact of the activity in bringing a positive perception of engineering professions, increased interest in STEM careers, and the openness of these careers to the students. This success can be attributed to the following elements:

- the use of visually attractive and interactive robots,
- active involvement of students in real-world inspired designs,
- the integration of robotics and assistive technology,
- an informal setting for STEM learning at the Arlington Public Library,
- the participation of an age and gender diverse high school students, and
- The distribution and presentation of the curriculum prepared by UTA mentors.

Things we learned:

- Robots have the pull that can be used to excite students about STEM concepts.

- Robotics activities in themselves will not improve STEM academic performance, but if robotics technologies are presented correctly, and the STEM concepts are properly embedded, then robotics provides an excellent platform to teach kids about STEM.
- Robotics in itself contains a wealth of opportunities to teach meaningful content. But doing that, it's not trivial.
- Well-based lessons to the proper audience, and a teacher who can support students who are learning by doing, can work wonders.
- A combination of high engagement, the ability to teach each student at his or her level and pace, provide opportunities for greater engagement and learning.
- "It is absolutely worth it, and the hardest fun ever had!" (Julie Dobrow, Huffpost Education).

How to Improve?

The main focus of the entire curriculum was to promote STEM education through Robotics. The motivational goals of achieving Simple, Engaging and Experiential learning could be done through other technologies too.

- Extending to other technology other than Robotics.
 - Literacy resources
 - Mathematics resources
 - Science resources
 - Technology resources etc.
- Promoting diversity.
- Equal race and
- Gender ratio

Appendix A

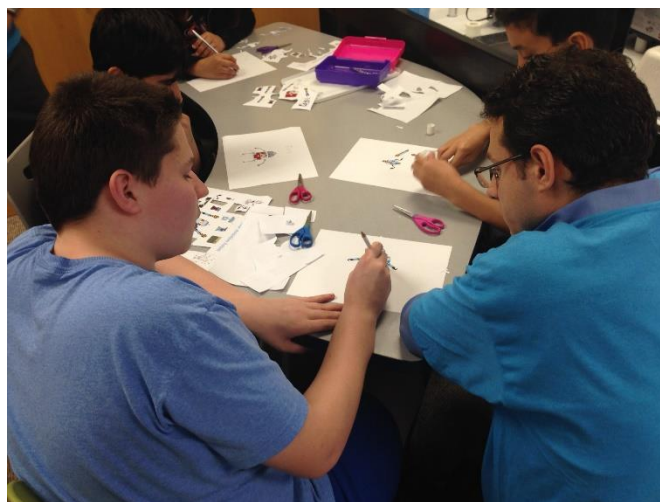
Students & their survey/learning outcomes

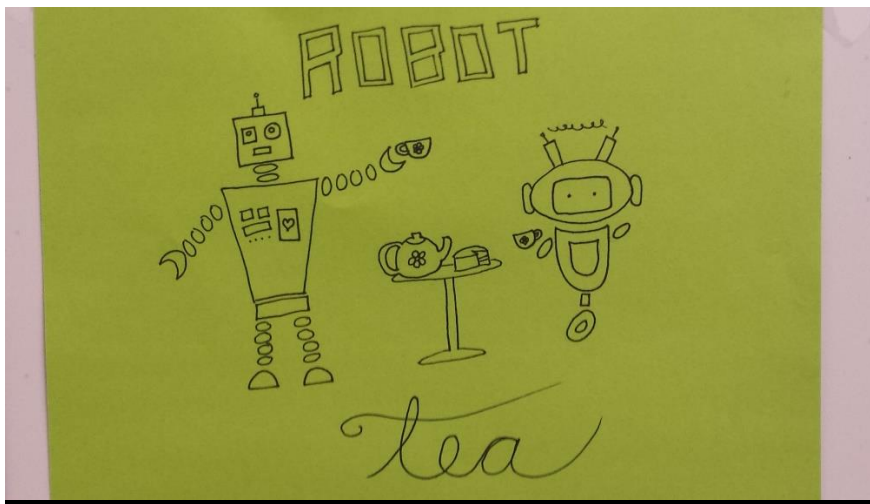
Appendix A

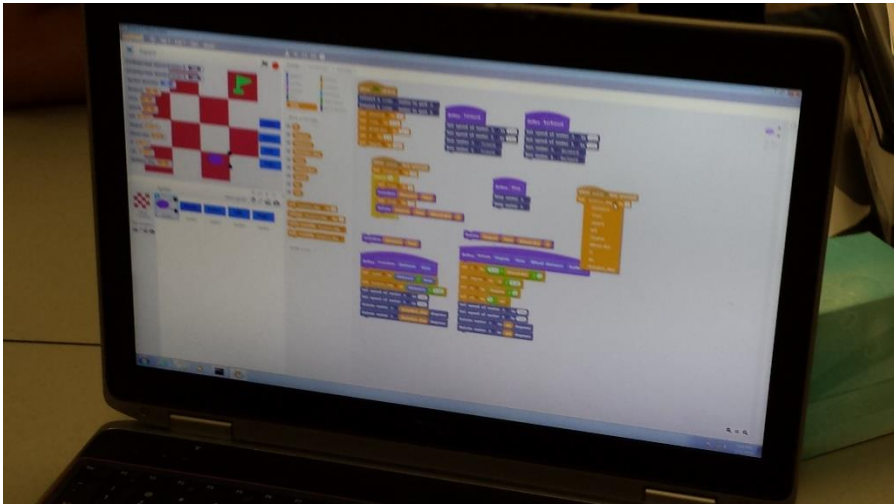
<i>Student Name</i>	<i>Comment on “what new did you learn?”</i>
• Chase Crowe:	The innovation of robots recently
• Mason Jones:	Assistive Robots
• Julisa Chavez:	What a robot can do
• Jacob Scanlan:	Robots assist in everyday life
• Eli Rios:	Robots help in many places
• Jacob Rogers:	I learned how robots work
• Hayden Potts:	Some uses for robots
• Rumays D:	A robot is something that moves, has sensors, and has a computer or brain
• Isaiah Andrews:	I learned that robots can be cars
• Assiya D:	To imagine before you build and what robots are
• Sergio Gonzalez:	How some robots work, and the word assistive robots
• Michael Carriveau:	How sensors are used to detect
• Uwais Khan:	I learned how to program the EV3 and how to build a robot to make it efficient
• Jerrod Rhodes:	That robots can be simple or very complicated
• Emiliano Camancho:	I have learned how to use a programmer

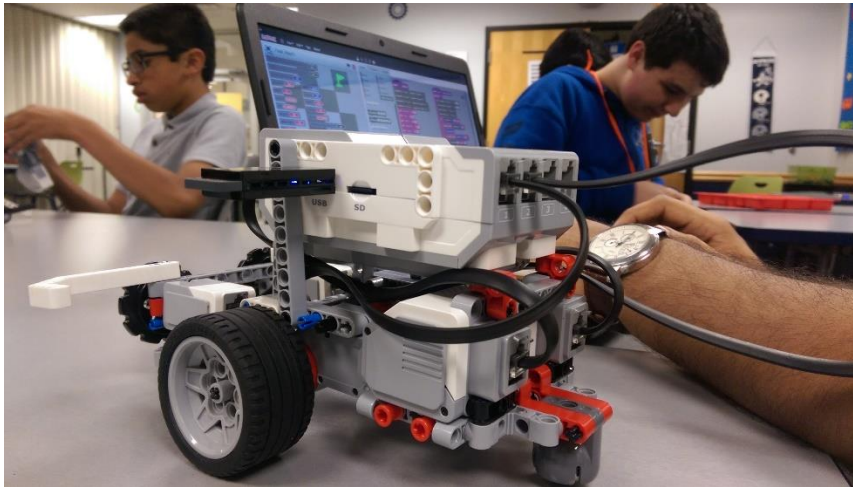
Appendix B
Pilot Program Photos & Praises that followed

Appendix B









George P. Bush 
@georgepbush



Following

.@UTArlington professor launches after school robotics program for 8th-12th graders bit.ly/1BsgqSc #STEM #TXeducation



Appendix C

Software installed on Laptop and SD card

Appendix C

Software's to be installed on laptops:

Scratch 2.0:

Link: <http://scratch.mit.edu/scratch2download/>

In the above link click the appropriate link to download the Scratch 2.0 version for the required operating system. Once it is downloaded double click the downloaded setup file to install the Scratch 2.0 Offline editor.

JDK 1.7.0_71 and JRE 7 (32 bit):

Link: <http://www.oracle.com/technetwork/articles/javase/index-jsp-138363.html>
<http://www.oracle.com/technetwork/java/javase/downloads/jre7-downloads-1880261.html>

In the above link, under JDK SE 7 section, click to download appropriate version of the setup file. Double click to install the JDK and JRE. Once the installation is done set environmental system variables for both JDK and JRE.

For guiding installation and setting environmental variables for JDK and JRE check this link <https://www.youtube.com/watch?v=FzKcJK68z2k>

GitHub:

Link: <http://git-scm.com/download/win>

Click the above link to download Git 1.9.5 version and then run the setup file to install the GitHub. Check whether the environmental variables is set properly to run the GitHub without any error.

Software's to be installed on SD CARD:

LeJOS 0.8.1 beta version:

Link: <http://sourceforge.net/projects/ev3.lejos.p/files/0.8.1-beta/>

In the above link select the second option, LeJOS 0.8.1 beta version 32 bit to download the appropriate LeJOS for the EV3.

JDK 8u31:

Link: <http://www.oracle.com/technetwork/articles/javase/index-jsp-138363.html>

In the above link select JDK 8u31 link and in the list select JDK 8u31 i586.exe link to download the appropriate JDK version.

JRE 7:

Link: <http://www.oracle.com/technetwork/java/embedded/downloads/javase/javaseembeddeddev3-1982511.html>

In the above link go to “Oracle Java SE Embedded version 7 Update 60” and click “ejre-7u60-b19-ejre-7u60-fcs-b19-linux-arm-sflt-headless-07_may_2014.tar.gz” to download the appropriate JRE file.

LeJOS installation on SD Card: Once all the files are downloaded, now install the LeJOS 0.8.1 beta version in the system. As the installation is finished it starts the SD Card Utility. Insert SD Card using Card reader into the system and then install the OS as follow:

- Select Refresh to refresh the drives available in the drop down list box.
- Select the SD Card drive from the list.
- Select the downloaded JRE file from the option.
- Now click create to create the bootable SD Card.

For reference, check this video: <https://www.youtube.com/watch?v=NyoF0Ws6SkY>

EV3 “helper-app” extension from GitHub repository:

Once the GitHub is installed, open GitHub and type, “git clone

<https://github.com/koen-dejonghe/ev3-scratch-helper-app.git>” to get the code of the

project from the GitHub repository to the local file system. Once this is done open the file location of ev3 helper app and type,

```
“/gradlew bootRun”
```

This will start the ev3 helper app extension and it will try to connect with the first EV3 available in the network to which it is connected. If this is the first time running, and you are behind a firewall, then execute this,

```
“/gradlew -Dhttp.proxyHost=www.proxy.host -Dhttp.proxyPort=8080 bootRun”
```

Next, on the same computer start the Scratch 2.0 offline editor. Press SHIFT, and click on File. At the bottom of the drop down menu you should see 'Import Experimental Extension'. Click that and import the file ev3-helper-app.s2e in the scratch/extensions folder of this app.

Now you should be able to use sensor values and to control motors from Scratch.

“Helper-app” Extension. Creating Scratch2.0 Extensions:

“Scratch 2.0 can be extended to control external devices (e.g. robotics kits, musical instruments) and to access data from external sensor hardware (e.g. sensor boards). A Scratch 2.0 extension extends Scratch with a collection of command and reporter that can be utilized to communicate with a specific device, its blocks appear in the "More Blocks" palette.” [27]

“Browser security restrictions, limits the Scratch 2.0 from communicating with hardware devices directly. Therefore, hardware extensions is required to interact. A helper app, a separate application user must install and run on their computer. Scratch then communicates with the helper app via HTTP requests, and the helper app corresponds with whatever hardware is tried to connect.” [27]

“Extension description file:

The extension description file format is one that lists the protocol and rules used to communicate between Scratch extension helper apps, and also the extension

development process of the helper-app. An extension description file is a text file in JSON format (www.json.org) that describes the extension. By convention, a Scratch 2.0 extension file ends in .s2e.” [27]

“The JSON object in the extension description file contains within all the necessary details of the extension file. It includes the extension's name, the TCP/IP port number used to communicate with the extensions helper app, and a list of Scratch block specifications.” [27]

Here is an example:

```
{ "extensionName": "Extension Example",  
  "extensionPort": 12345,  
  "blockSpecs": [  
    [ " ", "beep", "playBeep"],  
    [ " ", "set beep volume to %n", "setVolume", 5],  
    [ "r", "beep volume", "volume"],  
  ]  
}
```

“An example extension named "Extension Example" is shown above, which connects to its helper app on port 12345. The "blockSpecs" field describes the extension blocks that will appear in the "More Blocks" palette. In the example, there are three blocks: (1) a command block which plays a beep; (2) a command block which sets the beep volume; and (3) a reporter (value-returning block) that reports the current beep volume setting.” [27]

Communicating with the helper app:

“A helper app extension runs in the background, and is ready for use by Scratch projects that uses that extension. Each extension described has a unique port number on which it connects with the hardware. Scratch looks for the helper app at the given port number on the local computer.” [27]

“Scratch uses HTTP protocol to communicate with the helper app. Once connected, Scratch sends commands to the helper app and the helper app sends sensor values and status information back to Scratch via HTTP GET requests. Since the HTTP is a universal standard protocol, any browser can be used to test and debug helper apps.” [27]

Building and Testing Extensions:

Here are the steps to create and test a Scratch extension:

- Create an extension description file
- Create your helper app and start it
- Open the Scratch 2 Offline Editor
- Import the extension description (shift-click on "File" and select "Import Experimental Extension" from the menu)
- The new extension blocks will appear in the More Blocks palette.
- Test the extension and iterate! [27]

Python, Node.js, Java, C, etc. or any such language which supports server sockets can be used to write the helper app. [27]

The Scratch Team may assign socket numbers for popular extensions to avoid possible conflicts. Any unused socket number over 1024 is available for use now. [27]

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BIOGRAPHICAL INFORMATION

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