Regional Autonomous Robotics Circuit

COACHES MANUAL

RARC
Regional Autonomous Robotics Circuit

I.   What is RARC?

The Regional Autonomous Robotics Circuit (RARC) is a series of three robotics competitions for students in grades 2-12. The competitions build upon one another and allow students to showcase their STEM (science, technology, engineering, and math) and cyber skills by competing against other students in their division (elementary, middle, and Parallax®/high school) in a series of integrated challenges.

II.   How Can I Learn About the Platforms?

A. LEGO® MINDSTORMS® EV3 Robotics

Several online resources offer tutorials including videos that can be found at https://www.youtube.com/. Search *LEGO® EV3* or a specific need like *LEGO® EV3 programming.*

NICERC has several introductory lessons that can be used for entry level programming with the LEGO® EV3 as a part of the Cyber Fundamentals course. Teachers can gain access to these materials for free at https://nicerc.org/curricula/curriculaaccess/ .

B. Parallax® Platforms

Parallax has multiple resources available through its website (www.learn.parallax.com). Coaches may have to search the site, but it's worth the time. For example, Parallax has books that can be downloaded as PDFs for free; look on books or tutorials/pbasic tabs. Additionally, sample code for sensors can be found on the Parallax catalog page. The corresponding lessons for classroom use are available through NICERC as a part of the Cyber Literacy Courses. Teachers can gain access to these materials for free at https://nicerc.org/curricula/curriculaaccess/ .

III.   Recruiting/Starting a Robotics Program

A. Associated Costs and Revenue

    i.   Equipment

Elementary/Middle School Divisions

Ideally, each elementary and middle school team will need a LEGO® MINDSTORMS® EV3 (or NXT) kit, a LEGO® MINDSTORMS® Education EV3

Expansion set, and a laptop. Links to the LEGO® equipment and other RARC equipment can be found on the RARC equipment page.

The minimum hardware requirements for using LEGO® MINDSTORMS® Education EV3 Software are as follows:

- Operating Systems
    - Windows Vista (32/64-bit) with the latest service packs or later versions of Windows
    - Mac OS 10.6 with the latest service packs or later versions of Mac OS
- System Requirements

    - 2GB of RAM or more

    - 2.0 GHz processor or faster

    - 2GB available hard disk space

    - 1 available USB port

    - Minimal supported screen resolution – 1024 x 600

Parallax®/High School Division

Each high school team will need a Parallax® BOE-Bot®, Parallax® Robot Shield with Arduino, or Parallax® cyber:bot and a laptop. Elementary and middle school teams can also compete in the Parallax®/high school level and use these platforms. The platforms, sensors, and other supplies can be found on the RARC equipment page.

- The basic computer system requirements are as follows:
    - Microsoft Windows 2K/XP/Vista/7 or newer operating system

    - An available serial or USB port

    - Internet access

    - Internet browser program
- For more information on the high school system requirements, please visit www.parallax.com/sites/default/files/downloads/28125-Robotics-With-The-Boe-Bot-v3.0.pdf and www.parallax.com/downloads/basic-stamp-editor-software-windows.
- Helpful hint: The Chrome version is better than Mac version.

All divisions will use the 10693 LEGO® Classic Creative Supplement, which is listed on the RARC equipment page, for the competition series.

Other equipment* that is helpful to have includes the following:
- extension cords,
- surge protectors,
- thumb drives,
- cans of World's Best Glass Cleaner,
- binders,
- pencil pouches,
- smaller plastic containers or toolbox to organize robots and parts, and
- other small LEGO® pieces.

*If you ask for donations of these smaller items, you'll be surprised what you will receive!

ii.   RARC Competition Mats

The RARC competition mats are also linked on the RARC equipment page. Each team does not need its own mat. For elementary and middle schools, it is recommended to have one mat for every four teams. Many high schools only purchase one mat.

iii.   Program Revenue

Elementary and middle schools typically charge between $50 and $100 per student for program fees. This fee helps to offset the cost of equipment. However, it is difficult to depend solely on program fees for these costs, especially for schools that are just starting programs. Grant writing can be extremely beneficial. LEGO® Education (https://education.lego.com/en-us) has several science kits to use in conjunction with the EV3 kits. These kits can be used in the regular classroom setting to enrich instruction. Think - using LEGO® robots with the renewable energy kits to help students build their understanding of solar, wind, and hydroelectric energy - exciting grant possibility!

Parallax®/High school equipment and replacement parts come at a lower cost that may be covered by classroom fees or modest club fees.

Many schools also purchase T-shirts for their robotics programs. The back of the T-shirt can become an opportunity for sponsors to advertise. Many families and local businesses will sponsor a robotics program to have their logo on the back of the shirts. It can be helpful to have set price options for sponsors with different size logos.

B. Administrative Support and Resources

Administrative support is important for a successful robotics program within the classroom or as a club. School protocol will ultimately dictate the operation of your club. Prior to planning your club, meet with your administrative staff. Topics to discuss include expectations of the robotics sponsor, procedures for collecting and spending money (using purchase orders or being reimbursed), and the logistics of meeting after school (room, space, volunteers coming into the school). Ask your principal the preferred method of communication with parents. A good rule of thumb is to always include the administrative staff in outgoing messages to parents.

When speaking with administrators or any potential supporter, high school coaches can focus on the job skills students learn through robotics and the salaries students could potentially earn as a result after high school. Cyber Career cards with potential salaries can be found at https://nicerc.org/2019/03/connecting-cyber-education-to-cyber-careers/. Robotics also builds confidence in students of all ages.

If your administration has questions about what is RARC and how it benefits students, please know there is a short video entitled *How RARC Engages Students* that includes testimonials from administrators, teachers, and students on the RARC website at http://nicerc.org/rarc/.

C. Student Recruitment

There are several ways to send recruitment information to your students such as your school website, sending home information letters, or posting flyers. If your school utilizes DOJO, you can also send messages through that app.

Too often, students do not fully realize what is involved in a robotics program. Teamwork is an important skill as well as focus and patience when trying multiple times to accomplish a task. Not making students aware of what programming really involves before joining the team can lead to behavior problems and even the student not being fully committed, which is problematic for the other team members. Consider having a few **"Introduction to Robotics"** practice sessions BEFORE selecting members. In these practice sessions, you can guide students through building an express robot (instructions online) and have a few mini competitions. For example, one mini competition may be programming a robot to travel through a small maze. Teaching students to go through the maze would require very simple programming (moving forward, backward, and turns), which would take about a week. These **"Introduction to Robotics"** sessions will help to identify students who really can commit to being part of a robotics program and productive members of a robotics team. You can take all students who

participated in the **"Introduction to Robotics"** sessions or even the students who were on the top five teams.

Some schools also use teacher recommendations and grades as criteria.

Make behavior expectations clear for the students. Even though this is an afterschool program for many elementary and middle school students, expectations are important to make the most out of club time and to protect expensive equipment. Consider letting the students set the expectations or at least include them in the discussion.

Many high schools recruit from computer science classes and/or hang posters throughout the school. Parallax® has mini challenges on its website that can be used for an **"Introduction to Robotics"** as well as curricula that can be used in the classroom environment.

D. Parental Support

After you choose your team, you can host a parent meeting to discuss in detail your expectations for the students, club meeting times (prompt pickup), after school snacks, costs, and the dates of any competitions. Keeping parents informed is important. Pending administrator's approval, consider creating a club Facebook page or use the Remind app (https://www.remind.com/). These are both excellent ways to send out reminders and information to parents weekly.

Parents can also utilize the Remind and Facebook tools to keep up with their students' activities.

If parents can assist during robotics club meetings/practice, let them! However, stress that the robotics program is an opportunity for the students to demonstrate their knowledge and skills. Parents should not do the programming for students. Instead, they should teach students about the programming, so students can program on their own. A schedule is recommended so each parent rotates among all the student groups and no parent is ONLY helping his/her child.

E. RARC Professional Development Workshop for All Divisions

Professional development workshops for new and experienced RARC coaches will be offered in Bossier City, Louisiana, throughout the school year. All RARC coaches from private, public, and charter schools and homeschool and afterschool programs are invited to attend these free training sessions. However, space is limited so coaches should register as soon as possible at www.nicerc.org/pd/rarc/.

The 2019-2020 workshop dates will be available by the beginning of the school year. Registration will open four weeks prior to each workshop.

2019-2020 Professional Development Workshops:

August 2019
9:00 a.m. - 1:00 p.m.

Introduction to RARC and Unpacking Your Robot
Elementary and Middle Schools (LEGO® EV3)
Parallax® High School
    (Parallax® BOE-Bot®, Parallax® Robot Shield
    with Arduino, and Parallax® cyber:bot)

September 2019
9:00 a.m. - 1:00 p.m.

Basic Robot Moves (includes attachments & troubleshooting)
Elementary and Middle Schools (LEGO® EV3)
High School
    (Parallax® BOE-Bot®, Parallax® Robot Shield
    with Arduino, and Parallax® cyber:bot)

January 2020
9:00 a.m. - 1:00 p.m.

Using Sensors
Elementary and Middle Schools (LEGO® EV3)
High School
    (Parallax® BOE-Bot®, Parallax® Robot Shield
    with Arduino, and Parallax® cyber:bot)

April 2020
9:00 a.m. - 1:00 p.m.

Grant Writing
All grade levels

IV. Robotics Club Logistics

A. Time Commitment

Recommended time for club meetings is twice a week (Monday-Thursday) after school for one hour. If a competition is scheduled and approaching, you may want to increase to three times per week.

B. Recommended RARC Practice Schedule/Format

Teams will need to be able to store and organize their notes and handouts. Some schools give each team its own binder. At the front of each binder, the team has a pocket pouch to keep thumb drives and other small pieces the team needs. Other schools use a portable plastic file folder tub and give each team its own file folder to keep its information organized.

Below is a sample practice schedule for a club that meets from 3:00-4:00 p.m.:

- 3:00-3:10 - Students eat a snack (very important after a day at school) and take a few minutes to socialize with each other to refresh from the day at school. Snacks should be consumed AWAY from all robotics equipment including the mat!
- 3:10-3:20 - Discuss with teams the tasks they need to focus on for practice today. Teams gather their robots and equipment, and then teams can discuss how they plan to accomplish these tasks. All plans should be written down. Writing down the plan helps to keep all team members on task.
- 3:20-3:50 - Teams work on tasks (programming, running the robot, building parts for challenges, solving cypher). Teams should take notes and, if possible, video record their progress. Videos can be uploaded to student Google accounts.
- 3:50-4:00 - Teams clean up and debrief with teacher/coach.

For high school teams, make step-by-step small goals and focus on the harder aspects of the competition first during practice sessions. For example, learn the sensor first and then work on movement. Below is a list of high school skills that should be explored early.

- Robot vocabulary
- Resistor color codes
- Understanding binary
- Base 2 vs. Base 10
- Understanding the instructions that come with sensors
- Circuit diagrams and schematic drawings
- Ohm's Law
- Series vs. parallel circuits

C. Recommended Team Member Roles

Teams can be comprised of three to six students. Suggested team roles are listed below. However, every team member should be able to handle two different roles. This is important for backup purposes such as students getting sick on competition day.

- Team Captain - This person is the leader for the group. He/she is responsible for handling the robot at the competition mat, communicating with the judges, and calling time when the robot has completed the tasks. The team captain is also responsible for keeping members on task.
- Lead Programmer - This person is responsible for programming the robot. This person is also responsible for making sure all programs have been saved AND a backup has been created.

- Builder - This person is responsible for building the robot and the attachments needed for the competition.
- Materials Manager - This person is responsible for making sure all materials are ready for the team and all materials are put back at the end of the day. The materials manager will make sure the mat is set up with all needed pieces prior to the run. This person is also responsible for making sure the robot is charged.
- Timekeeper - This person is responsible for keeping time for each run of the robot and for watching time during practice sessions.
- Video Recorder - This person is responsible for taking video of the robot runs and uploading the video for the team.
- Scorekeeper - This person is responsible for recording on the scoresheet from the competition guidelines the team's score during practice runs and at the competition. The scorekeeper can compare which tasks were and were not accomplished as the judge reviews the official scoresheet with the team. This way the team will have a better idea of its score at the end of each round on competition day.

Coaches may consider allowing students to take turns at the different roles during practice and during competition rounds. For example, one student may be the team captain during the first round and the scorekeeper for the second round.

High school teams typically have fewer members than elementary and middle school teams, so all high school students should be utility players. High school coaches should encourage all students to know and practice writing code. Codes developed during practice sessions can be merged, or the students can learn from one another. All high school students should also understand circuits and troubleshooting.

## D. Robotics Club Helpful Hints

- It is tempting to download programs through Bluetooth® because it saves time. However, this can lead to teams with only one person who understands the programming because while one person is at the computer, the others are disengaged. Let the students physically take their robot back to the computer so the entire team can discuss programming changes.

- Practice with the mat on the ground. Although it's tempting to put the mat on a table, practice time will be more efficient if the mat is on the ground.
- Clean the wheels and mat daily using World's Best Glass Cleaner! Even the smallest amounts of dust and dirt can cause the robot not to perform as intended. Please note the Sumo mat should only be cleaned with a damp cloth.

- High school teams should always have extra robotics pieces (resistors, capacitors, etc.). Remind students to be careful with parts as losing/breaking/blowing up pieces (example: circuits) cost money.
- Always make a checklist of what to bring to a competition.

E. Team Building Exercises
- Program Your Robot – This is an activity for two combined teams (about 10+ students). Set-up an obstacle course that is a mix of barriers the students must navigate and tasks they must do (examples: put a ball into a cup, step over a string, etc.). Assign one student to act as "robot," and blindfold him/her. Please note it may help to have an adult act as the first robot. Position four or five "programmers" along the course to direct the "robot" with directional words. Tell the robot to do EXACTLY as the programmer tells him/her. The objective of this exercise is to teach the students the importance of clearly and exactly communicating what the robot must do.
- This site has great team building activities that involve blocks (LEGO® blocks can be substituted):http://hthu.net/site/wp-content/uploads/2015/01/Leadership-Team-Building-Blocks.pdf

F. Sample RARC Competition Tasks
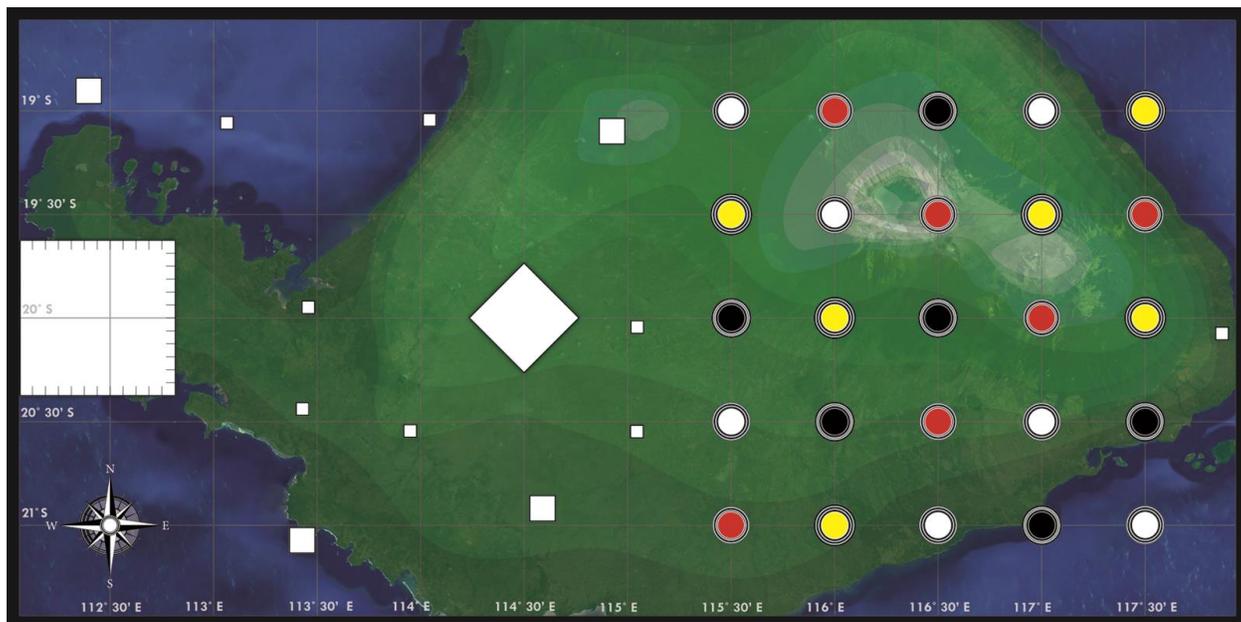
Elementary/Middle School Divisions
Description: Your team of programmers, engineers, and robotics experts have landed on the island with your robot to find that a supply drop has gone wrong.

Many of the pieces needed to complete your tasks have been scattered by a recent storm.

Objective 1: Collect the scattered supplies (loosely scattered, not conjoined) and bring them to home base.
- Some pieces will be located in the white square at 21° S and 113° 30' E.
- Some pieces will be located in the white square at 19° S and 112° 30' E.
- A total of 16 colored pieces will be placed within the two white squares (8 into each square).

Objective 2: Builders will need to sort the pieces that are returned to home base into their energy groups (solar, wind, nuclear, or fossil fuel). Use the robot to deliver the blocks (can be loose or conjoined) to their assigned areas so that they are touching their respective circles.
- Wind energy components consist of yellow blocks and must be returned to any yellow circle
- Solar energy components consist of white blocks and must be returned to any white circle
- Fossil fuel energy components consist of red blocks and must be returned to any red circle
- Nuclear energy components consist of black blocks and must be returned to any black circle.

Scoring: *Touch and reset penalties apply.*
- ❏ +10 points for each individual airdrop block (when unassembled) that is correctly delivered to the correct location, according to color
- ❏ -5 points for each individual airdrop block (when unassembled) that is not delivered to the correct energy circle
- ❏ 0 points if a block is not within home base when touched by a team member

Parallax®/High School Division

Description: Deploy oil resources to target oil production locations on the island and return home.

Objective: Starting with no more than six binder clips in home base, move binder clips from home base into the red circles.

Scoring: Binder clips standing upright and fully within the filled-in circle will receive full points. Only game pieces placed in red circles will be scored. No more than one binder clip may be placed within each red circle.

❏ +50 points for upright placement of each binder clip fully within a red circle

❏ +25 points for placement (not upright) of each binder clip fully within a red circle

❏ +10 points for upright placement of each binder clip partially within a red circle

❏ +5 points for placement (not upright) of each binder clip partially within a red circle

❏ -100 points penalty for each binder clip touched by a team member when not within home base - The team incurs the point deduction, and no points are awarded for that clip.

❏ -100 points penalty each time the robot is touched outside of home base during play - Time does not stop or restart during a touch penalty. The robot must be immediately returned to home base if touched outside of home base. A robot is considered in home base if both drive wheels are inside the home base boundaries.

G. After Competition Debrief

The days right after a competition are very important for debriefing and reflection. This is a time to discuss the positives from competition as well as what can be improved. Out of frustration it can be easy for team members to blame each other for mishaps. To prevent this from happening and potentially destroying a team, consider allowing each team member to share how he/she feels and what he/she can improve for the next competition. This becomes his/her goal. Then the other team members share how they can help the first team member achieve that goal. This makes everyone responsible and helps strengthen the team. Always emphasize teamwork and camaraderie.

Sometimes, looking at the scores can be deflating for students. Encourage students to not only look at their team score, but other teams' scores as well.

Usually, they will see that very few points separate them. This is a good opportunity for teams to discuss strategy and how they could have earned an extra 10 or 20 points. Turn this from deflating to motivating!

H. Classroom Tips and Connections

For the high school classroom, consider implementing some of the following ideas:

- It's okay to let students gravitate towards programming or circuits or constructing or logging data. However, ask the students to rotate through each role. Give all students a chance to write code, build circuits, design solutions, or make observations and recommendations.
- Keep it simple! A complex solution isn't always better. Sometimes, accuracy is better than speed.
- Encourage students to consider additional solutions. While the first may seem good, other solutions may prove equally worthy.
- Begin to challenge students to think about solving challenges modularly. Use the four pillars of computational thinking:
  - Decomposition;
  - Pattern recognition;
  - Abstraction; and
  - Algorithm design.
- Master the following navigational challenges
  - Straight line travel - understand that it may require the motors to operate at slightly different speeds in order to travel a perfectly straight line. One motor may naturally move faster or slower than the other – it's the students' job to make observations about this and make the necessary changes in code to correct this. Understand code that makes one robot go perfectly straight will likely not make another go perfectly straight because they each have different motors.
  - Varying degrees of turns
    - 90° turns
    - 45° turns
    - 30° turns
    - Sometimes you don't need to turn a full 90° in a direction; sometimes you need less than that. A fun way to master varying degrees of turns is to attach markers to the robot and have then drive around on butcher paper to draw different geometric shapes. Four 90° turns make a square. What makes a pentagon? Hexagon? Octagon? Triangle? What values make a larger or smaller shape that is similar?

- If students can calculate the distance covered in one-wheel rotation (circumference), encourage them to measure distances on the mat and employ numbers of revolutions to get to target destinations. This encourages the use of Algebra in their programming.
  - For example, if it's 2.5 feet to the target, and the wheel circumference is 7 inches, have them solve the problem:
    - $7x = 29$
    - $x = 4.14$ (or approximately 4 rotations)
- Document, document, document!
  What does each function or block of code *do*. What does the value mean? If the value is higher or lower, what affect does it have? If one team member is sick or absent, it is important that others can continue without him/her there, especially on competition day.
- Keep backup copies of code when changing values so there are copies to refer to if too many changes are made that negatively affect performance. It's also possible to run the old code to compare with the new code's performance.

I. Beyond RARC: Other Robotics Club Activities

- Field trips
- Guest speakers in STEM fields
- Community service
- STEM/robotics night at schools
- Friendly competition with another school
- Classroom curricula with the mat as a classroom tool

RARC Preparation Daily Goals - Template

Today I want to accomplish:

My plan to achieve this:

REFLECT: Did you accomplish your goal? What did or did not help? Changes that need to be made?

Focus for next robotics meeting/class?

Today I want to accomplish:

My plan to achieve this:

REFLECT: Did you accomplish your goal? What did or did not help? Changes that need to be made?

Focus for next robotics meeting/class:

RARC Competition Checklist - Template

Teacher box items	check
Team roster with emergency phone numbers on clipboard	
Copies of all permission slips	
Copies of competition release forms, if required	
1 extra-long extension cords	
2 surge protectors	
1 roll black electrical tape	
1 roll painters' tape	
1 new can of "World's Best Glass Cleaner"	
3 new yellow cleaning rags	
2 clipboards	
3 black sharpies	
3 ballpoint pens	
1 extra stopwatch	
1 extra computer charger	
1 extra programming cord	
1 small box of tissue	

Items NOT placed in teacher box

	check
Competition mat (roll gently and secure gently with a large rubber band)	
Laptops in laptop bags (6)	
Double check laptops in bags (6)	
Ziploc® bags with LEGO® pieces, PVC coupler, other supplies for practice at mat (2)	
1 extra robot kit for every 2 teams (for spare parts)	

Individual team box checklist (1 copy per team)

TEAM NUMBER: _____

Your robot (turned off)	
Any additional attachments for your robot	
Thumb drive with backup files	
Robot charger	
Robot programming cord	
1 pen	
1 pencil	
1 stopwatch	
1 ruler	
Copy of most recent competition guidelines	
Team notes	

Each team member needs to sign below when your box is ready.

_____

_____

_____

_____

_____

_____

RARC Competition Box Labels - Template
(print on colored paper)

Team _____

Bot #: _____ Comp #: _____

Members: _____ _____

_____ _____

_____ _____

Team Captain: _____
****

Team _____

Bot #: _____ Comp #: _____

Members: _____ _____

_____ _____

_____ _____