

The Kentucky Bluegrass Robotic Championship: An Affordable K-12 Outreach Program

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Abstract

Preparing students to face the challenges of a technology-oriented society requires support for the efforts of teachers introducing technology concepts at the K-12 level. The Western Kentucky University Department of Engineering (WKU Engineering) recognizes this need and actively supports these efforts. WKU Engineering has conducted a high school student robotics competition for the past five years, involving over 50 teams, approximately 50 teachers and 500 students. The goals are to enhance the capabilities of high school teachers to instruct students in engineering principles, and to give students a meaningful engineering design experience. Most participants live within counties surrounding WKU; this area is rural, economically challenged, and underserved technologically.

High school robotics competitions are neither new nor unique. The BEST and FIRST Robotics Competitions have wider audiences and larger scale than WKU's Kentucky Bluegrass Robotic Championship. WKU Engineering mimics the technical and competitive characteristics of the larger national competitions, while attempting to provide a no cost forum for local students and teachers to participate in engineering. WKU strives to retain the quality and enthusiasm of the other competitions, and to maintain contact between interested high school students and WKU Engineering.

WKU's newly implemented project-based Engineering Department has civil, electrical, and mechanical engineering programs. The department mission is to engage students in project activities that develop a clear understanding of engineering practice. An outreach program with an emphasis on hands-on learning is a natural activity of the project-based mission. The robotics competition is the major WKU outreach focus, with nine of the twelve faculty members participating at some level in 2004.

The current competition costs \$600 per team for returned items (motors, controllers, etc.), \$150 per team for consumed items (building materials), and less than \$500 for the competition surface. With existing returnable supplies for 24 teams, a typical 20 team competition now costs approximately \$5000 (consumables, maintaining returnables, playing surface and student worker costs). WKU Engineering has funded past competitions via external and internal WKU grants, and departmental funds.

Assessment of previous competitions indicated that a primary barrier to participation is the lack of training for teachers guiding student teams. WKU Engineering has developed and provides structured training for the teachers, particularly those new to the competition. The

outcome of training has been greater participation – 2004 had the largest number of new teams since the initiation of the competition. In addition to increasing the competition participation and improving teacher assistance, WKU Engineering is also leveraging the support of WKU engineering students. Paid and unpaid student effort is used to execute the competition, and future efforts will involve WKU students as team mentors.

The WKU Kentucky Bluegrass Robotic Championship is a viable and valuable outreach effort focused on electrical and mechanical aspects of engineering. Once initial startup expenditures are met, the competition is an affordable event benefiting a moderate number of high school students and teachers. Small engineering departments can execute the competition with solid faculty support; a moderate to large engineering department could easily run a competition of this magnitude.

Introduction

Kentucky is a rural US state with a population of 4 million people; approximately 85% of its counties are characterized as rural communities with severe poverty problems. According to the most recent census data, ten Kentucky counties experienced an unemployment rate higher than 10% according to the Kentucky State Data Center, well above the US average of 5.4%. Kentucky's poverty rate was 16%, exceeding the national average of 13%, and median family income of \$34,000 compared to the national average of \$40,000.

WKU is located in south-central Kentucky, where the economic situation is disadvantaged even by Kentucky standards. The majority of WKU students are from adjacent counties, where 14% of the residents were classified as below the poverty level, and per capita personal incomes are below the national median. As a result of these conditions, 80% of WKU students receive some form of grant, loan, work-study, scholarship or tuition waiver financial assistance.

A direct link exists between the education level and the degree of poverty. College enrollment in Kentucky is one-fifth the national average. Only 17.2% of the adults in Kentucky have completed four or more years of college. South-central Kentucky has a particularly high number of first generation college students, with half of the incoming WKU freshman class indicating that their parents do not have a college degree.

Attempts to correct this situation are underway. In 1998, Kentucky introduced the "Education Pays" program to educate the public that a higher education degree is financially beneficial. A component of this program includes a "Strategy for Statewide Engineering Education in Kentucky," developed by the Council on Postsecondary Education in July 2000. In addition to a deficiency in overall college enrollment, only 4.6% of students enroll in Kentucky engineering programs, compared to a national average of 6.1%. The strategy addresses the primary issues of increasing the number of baccalaureate engineers in Kentucky and providing regional access to and productivity through engineering education.

There is a clear need for increasing the number of technologically capable students in Kentucky. The corrective efforts being implemented in Kentucky are not a local issue. The United States is facing a declining number of students expressing an interest, or majoring, in engineering. The American College Testing organization reported that between 1992 and 2003 the percentage of high school students expressing an interest in majoring in engineering

dropped from 9% to 6%, which compounds the recurring problem of the lack of preparedness among US students in math and science. As a result there are a variety of programs addressing these problems, many seeking to team college faculty with K-12 such as the Research Experiences for Teachers program initiated at the National Science Foundation [1], the Future Scientists and Engineers of America curriculum created by the American Association for the Advancement of Science and the National Science Teacher's Association's [2], other programs have a minority population focus [3, 4].

Commonly the initiatives target support for K-12 teachers [5, 6], since preparing students to face the challenges of a technology-oriented society requires support for the efforts of teachers introducing technology concepts at the K-12 level. This support can also be in the form of educational programming [7] or materials [8].

WKU Engineering recognizes this need and actively supports these efforts. WKU Engineering has conducted both high school and middle school student robotics competitions for the past five years. Over this time period, these competitions have involved approximately 100 teachers and teams, and on the order of 750 students – half at the high school level, half at the middle school level. The WKU goals for both competitions are to enhance the capabilities of K-12 teachers introducing students to engineering principles, and to give students a meaningful engineering experience. The focus of the remainder of this paper will be on the high school robotics component, although lessons learned from this portion are being used to improve the middle school program.

A WKU Solution

A multitude of high school robotics competitions are run in the United States. Robotics competitions provide an excellent forum for post-secondary level technical challenges to be introduced to younger students in a challenging and satisfying way. The BEST (Boosting Engineering, Science, and Technology) Robotics, Inc. [9] and FIRST [10] robotics competitions have been in existence for many years, and involve wider audiences and larger scale than WKU's Kentucky Bluegrass Robotic Championship. These competitions can require many thousands of dollars to participate, and typically have external, industrial supporters.

In the early years of the WKU Engineering robotics K-12 outreach, WKU was associated with the BEST competition. In assessments made by the faculty in 2002 – 2003, the decision was made to separate from BEST because the costs of this partnership did not match the benefits. WKU strives to mimic the technical and competitive characteristics of the larger national competitions, but to provide a no cost forum for local students and teachers to participate in engineering.

WKU has just completed the creation and ABET accreditation of a new project-based Engineering Department, with programs in civil, electrical, and mechanical engineering. The department's undergraduate-only, teaching and professional practice based mission is to engage students in project activities that develop a clear understanding of engineering practice [11, 12, 13]. WKU Engineering students regularly participate in external competitions; the electrical and mechanical competitions often involve robotics. An outreach program with an emphasis on hands-on learning is a natural activity of the project-based mission. A conscious decision was made by the faculty to make the robotics competitions the

major WKU outreach focus of the department in an effort to avoid diffusing departmental resources in too many directions. While other activities are still undertaken, nine of the twelve WKU Engineering faculty members participating at some level in the 2004 Kentucky Bluegrass Robotic Championship.

The goal of the robotics competition project is to provide high school students with challenging engineering design activities, and their teachers with an activity to instruct these students in engineering principles and robotics. The outcomes to reach these goals include:

- 1) Creating and enthusiasm for and awareness of Engineering
- 2) Providing high school teachers with a hands-on engineering opportunity to bring into their classrooms and building a relationship between these teachers and WKU Engineering
- 3) Instructing teachers in fundamental engineering principles such as project management, team development, elementary electronics and motors, and robot construction
- 4) Creating a positive impression of WKU/WKU Engineering
- 5) Supporting our surrounding region with professional activities that are consistent with the WKU project-based learning model

With these goals and outcomes in mind, the competition is the n designed with the following attributes:

- 1) The competition should be interesting, aesthetically appealing and somewhat relevant
- 2) The competition should be challenging, requiring team effort and significant student effort
- 3) The competition should be doable for all reasonable entrants, but reward success at various levels to allow superior teams to excel

The BEST competition that WKU was formerly affiliated with certainly was outstanding with regard to the 1st and 2nd attributes. The WKU faculty found that the 3rd attribute of BEST was lacking. Too many entrants were unable to score any points with BEST competitions, and we found this to be a disappointing result.

The competition begins for the high school students in late summer when teams are provided with detailed rules about the competition and the materials necessary to construct a robot – a portion of these kits are returned to WKU after the competition. Detailed lists of the materials provided that the teams to not expected to return (consumables) and the materials that are collected after the competition and reused (returnables) are provided in the Appendix. The competition takes place in early November. In previous years this occurred in a local high school gymnasium to accommodate the competition and significant numbers of spectators. WKU Engineering has a new engineering building and this will be the new site for the competition, offering increased opportunities to demonstrate engineering to K-12 students. WKU has provided not only prizes for various aspects of the competition, but also scholarship awards and on-campus engineering experiences for the winners.

This competition is a powerful experience that is a culmination of eight weeks of hard work and dedication. For the past five years, WKU Engineering has sponsored the competition. Each year approximately 10 teams representing up to 100 students have competed. The goal

of WKU Engineering is to increase the number of teams competing, eventually reaching 24 teams. This would impact 200 to 250 students and at least 24 teachers. Each year, many teacher/coaches struggle with the various aspects of the robot project such as project management, team development, and use of the WKU-provided components, which include the electronics and motors. Some years, teams withdraw because of lack of knowledge of the teachers. Several teachers mentioned difficulty in project management, difficulty in forming teams, and lack of knowledge concerning the kit components. Schools that have been successful in the past have found parent volunteers to aid in their robot construction.

With the multiple goals of creating a successful robotics competition that will challenge and interest high school students, facilitating the involvement of under-prepared high school teachers to act as team coaches, and involving the WKU Engineering department in an appropriate way, it has been necessary to apply project management to our overall activities as well. The project timeline is shown in Table 1, including preparation, facilitation on assessment activities. The following sections describe the achievement of the project objectives in greater detail.

TIMING	EVENTS
Late Spring	Notification of competition and workshops to prior teams; additional outreach to potential new participants
Summer	Finalize competitions, assemble materials, construct competition surfaces (using students); modifications to teacher workshops
August/September	Involve WKU students in construction/materials organization activities. Kickoff meeting and 1 st workshops
October	Conduct 2 nd workshops; final preparations for competition with increased student involvement
November	WKU Engineering Robotics Competitions (and practice day one week earlier)
Winter/Spring	Assessment of Teacher Workshops; setting goals for subsequent competitions

Table 1: Competition Timeline

Competition Details

For the past five years, WKU Engineering has sponsored high school and elementary school robot competitions. These programs are designed to teach teamwork, problem solving, project management, and pride in task completion within realistic time and physical resource constraints. Coaches support youth teams and serve as positive role models for the next generation of scientists, engineers, and technologists. The goal is to demonstrate the excitement of advanced technical careers to young people who are nearing decisions on college plans, and introduce younger students to the possibilities of engineering. Based on previous assessment of participants, the philosophy of the competition is that team membership is open to all interested students, and participation is without fee to the students or the schools.

In the competition process, each team designs and builds a radio-controlled machine to accomplish a defined task. The game process begins at a kickoff day in early September, where teachers receive the following:

- ◆ Time frame: The game is limited to an eight-week period to simulate a product time-to-market constraint.
- ◆ Resources: Each team receives an identical box of odd parts, fasteners, materials, and a radio controller for motors. The machine can only be built with kit parts. These kits contain no plans and nothing that looks like a robot. There are no wheels, grippers, arms, or anything else obviously needed to play the game, only raw materials. Each robot evolves from the imagination of the students on the team.
- ◆ Specifications: At kickoff, each team gets a detailed game task description. The games usually cover a carpeted area and involve moving unusual game pieces from one spot to another or turning switches on or off. Scoring is based on lifting an object into a goal or retrieving objects from inside or behind obstacles.

It has been useful for the teams to also be able to see the competition surface (or major components of the surface) on kickoff day, to augment the drawing and specification materials that they are given. An overview drawing of the 2004 competition surface is shown below in Figure 1. Teams are also provided access to more detailed construction drawings. The rules handout from the 2004 competition is included in the Appendix.

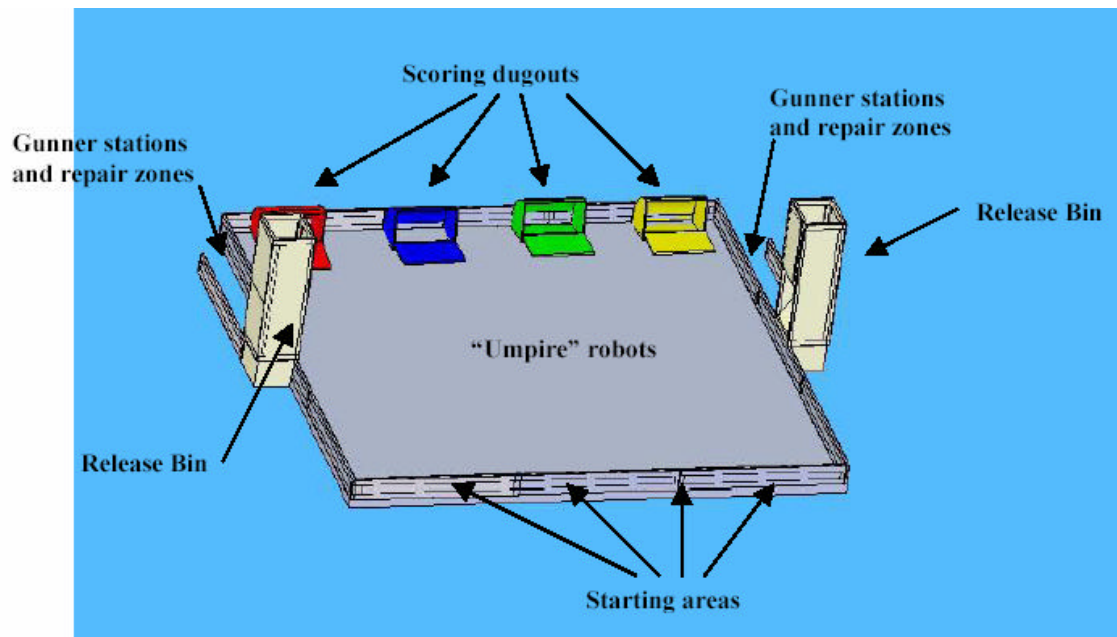


Figure 1: 2004 Competition Playing Surface Drawing

WKU Engineering has augmented the support for this K-12 outreach by continuing to provide an expanded number of competition kits, with no cost for participation, available to greater numbers of teams. The high school teachers act as mentors for the students,

encouraging and guiding them as they design and build their robots, but the students must be the primary decision-makers and builders. Schools provide at least one teacher-coach, administration support, after-hours access to classrooms and shops, and transportation to the competition site. Schools also select their own teams, managing the team size and activities. Prior years competition photographs and teams are shown below in Figures 2 and 3.



Figure 2: Competition Playing Surface



Figure 3: Competition Team

An additional engineering opportunity has always existed with the WKU Kentucky Bluegrass Robotic Championship because high school teams compete in the robot competition while middle school students compete in a LEGOS robot competition – the younger students can see what the older ones are doing. This will be increased with the 2005 competition, which will take place at the newly opened Center for Engineering and Biological Sciences Building at WKU. Now, the K-12 students will get additional exposure to even higher levels of engineering activities. WKU Engineering students will play a larger role in the 2005 competitions, and their ongoing school projects will be on display for the K-12 students.

Competition Budgets

Funding is always an issue with this kind of outreach activity. There is no participation cost for the schools to compete in the robot competition. All funds are provided by various WKU sources. The robot materials kits are composed of two parts: returnables and consumables. The returnables are materials that must be returned each year to be reused. These materials include all electronics, motors, and radio controllers. WKU Engineering currently owns enough returnable sets for approximately 24 teams.

Team consumables are materials that are not returned and include wood, pipe, fasteners, etc. Each year new consumables must be purchased by WKU. The consumables cost approximately \$150 per team (details in Appendix). Table 2 shows two sets of costs: an initial start up from no supplies; and also the expenses necessary to continue to run the robotics competition for 20 teams once returnable material have been purchased.

The returnable portion of the materials kits represents about 75% of the entire cost of the competition. WKU has acquired sufficient kits for 24 teams over the past three years. We are also investigating the materials in both kits (consumables and returnables) with an interest in reducing expenses and complexity to assemble and maintain, while providing the student teams with all materials necessary to create their robots.

ITEM	COST
Consumables (\$150 per team, 24 teams)	\$ 3,600
Returnables (\$600 per team, 24 teams)	\$14,400
Competition playing surface	\$ 500
Competition day expenses	\$ 500
WKU student worker support	\$ 1,000
Initial Startup Total	\$20,000
Consumables (\$150 per team, 20 teams)	\$ 3,000
Maintenance to Returnables	\$ 500
Competition playing surface	\$ 500
Competition day expenses	\$ 500
WKU student worker support	\$ 500
Maintaining Competition Total	\$ 5,000

Table 2: Project Budgets

Now that WKU has returnable kits purchased for 24 teams, we estimate that the 2005 competition, involving 20 teams will cost \$5,000. The university has already pledged half of this cost in recurring funding, so the annual cost to WKU Engineering to continue to operate the competition will be only a few thousand dollars.

Teacher Workshops

Ongoing assessment of competition participants has indicated that a second significant barrier to participation is the lack of training for teachers guiding student teams. To diminish the struggles of teachers/coaches as they supervise the robot competition, WKU Engineering now provides workshops on project management and team development at the kickoff session, and a technical guidance workshop in October. These workshops have reduced the number of teams withdrawing from the competition because of lack of teacher knowledge.

WKU has offered a less-structured technical workshop (coaching clinics) every year that the competition has been offered. Last year the through funding from NASA's Kentucky Space Grant Consortium, expanded workshops were offered as follows:

- An Engineering Design workshop to introduce teachers to the principles of guiding students through the process of creating and evaluating ideas, and making decisions based on design criteria. After this workshop, teachers should be capable of getting their teams started in the conceptual design of their robots.

- A Technical Facilitation workshop devoted to the particular details and challenges of the actual competition. Teachers will be led through all of the steps necessary to construct functioning devices, and given suggestions for offering effective guidance to their teams. After this workshop, teachers should be capable of helping their teams construct their robots.
- A Project Management workshop geared towards making future competition teams more effective. Techniques for organizing time, people and activities will be presented. This will be coupled with shared experiences from the teams as they near completion of their current robots.

Through the implementation of the coaching clinics, the teachers were assisted with valuable engineering project skills and engineering content. By better equipping the teachers with knowledge, the students are expected to have a more enriching experience, which may begin a foundation for an engineering career. Also a higher team participation rate was expected because teachers will be able to guide their students through completion of the project. Samples of some of the workshop handouts is shown in Figure 4.

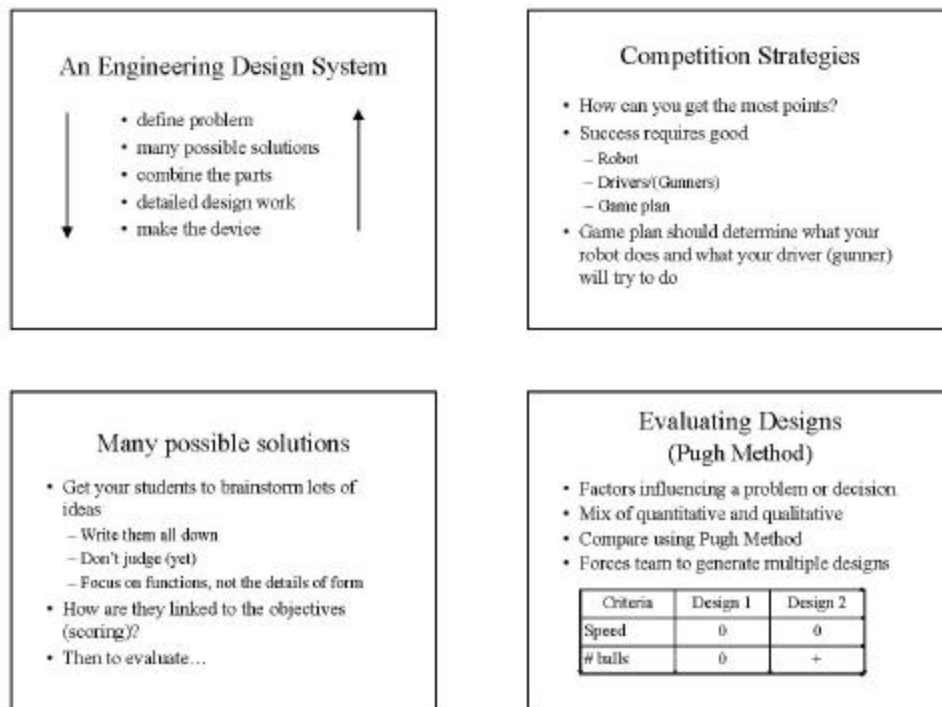


Figure 4: Examples of Teacher Workshop Handouts

WKU Engineering has surveyed workshop participants and based on their comments have made minor adjustments workshops. The material provided will be largely the same in 2005, however we are streamlining the handing out of material on kickoff day to allow time to combine the Engineering Design and Project Management workshops into a single workshop. The Technical assistance workshop will still be held later in the overall competition sequence, once teams have begun to build their robots. The 2005 workshops planned are shown in Table 3.

Workshop Topic	Timing	Audience
Engineering Design and Student Organizing	Early September	Teachers from all teams
Technical Facilitation	Early October	Primarily teachers from new teams

Table 3: Planned 2005 Workshop Schedule

These workshops are being used as the model for the middle school LEGOS competition that runs concurrently, and WKU Engineering plans to offer similar workshops to the LEGOS team teachers.

Assessment

WKU Engineering has considerable experience in assessment of learning outcomes as a result of our ABET accreditation activities. This experience has been used to evaluate the success of the teacher workshops and overall competition effectiveness. For the 2004 workshops and competition, teachers were surveyed to better understand their weaknesses and needs, and the ways that the workshops could be most effective. (Included in Appendix.)

Key competition modifications resulting from assessment information include:

- Keeping the competition no-cost for schools
- Keeping the timing of the event the same (September kickoff, November competition)
- Modifications to the complexity of the competition
- Potential reduction to the materials being provided to each team

Assessment has also led us to not making a few considered modifications. We had discussed the interaction of WKU engineering students or local industry supporters as team mentors. Based on the input from the high school teachers about the way that they actually implement the competition construction, this does not seem like a particularly feasible plan. Instead, we plan to involve our students in the competition preparation, and as role models for the high school students.

In addition, internal assessment by the WKU faculty has led us to make plans to augment the 2005 competition with additional engineering design activities. This will include additional design activities during the competition to showcase the new WKU engineering facilities.

Conclusions

During the five years that the WKU Kentucky Bluegrass Robotic Championship (or the earlier BEST competition) has been run by WKU Engineering, it has been a viable and valuable outreach effort. Although it is focused on electrical and mechanical aspects of engineering, it is mostly a hands-on engineering design and problem solving experience. WKU has funded the initial startup expenditures over five years, which have matched the

interest level of regional high school teams. WKU is now at the stage where the competition is an affordable event for us, benefiting up to 100 high school students and 20 teachers.

The activities meet outreach goals of promoting enthusiasm and awareness for engineering, as well as a positive impression of WKU Engineering. The activities are consistent with the WKU project-based learning model, and they allow us to impart professional skills such as teamwork, engineering design, and project management to high school teams. Finally, the competition provides a forum for WKU to assist high school teachers with their efforts to teach engineering and also builds a relationship with these educators.

In the future, we intend to continue the robotics competitions, as well as consider adding other projects to this outreach effort. This could include demonstrations of WKU student activities, investigations of workshops or summer camps, as well as intellectual competitions and virtual activities as a part of the Kentucky Bluegrass Robotic Championship. Based on our experiences, we believe that a small engineering department such as WKU Engineering can execute a similar competition with solid faculty support; a moderate to large engineering department could easily run a competition of this magnitude.

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STACY WILSON

Stacy Wilson has been at WKU for nine years, first with the EET program and contributed greatly to the creation of the new EE program. Her area of expertise is controls systems but she has taught a wide variety of classes across the curriculum. She received the 2005 WKU Public Service award, and has been active in outreach and gender equity activities including the high school robot competition and Girls in Science Day.

KEVIN SCHMALTZ

Kevin Schmaltz has been at WKU for three years, after serving as the Lake Superior State University MEChair. He has a combined 17 years of engineering experience in industry and teaching. He was the 2000 Michigan Governing Boards Distinguished Faculty and 2001 University Distinguished Teacher. He teaches various thermo-fluid courses, and coordinates the freshman, sophomore, junior and senior project courses.

APPENDIX

Qty	Description
1	4 channel transmitter
1	transmitter charger
1	instruction manual for radio control
1	7 channel receiver
3	Servo w/o horns or screws
1	8" servo extension wire
2	4 arm servo horn
2	6 arm servo horn
2	large round servo horn
2	small round servo horn
8	rubber grommets
8	brass spacers
8	servo mounting screws
4	black servo horn screw
2	Speed Controller
1	instruction manual for speed controller
1	24" servo extension wire
2	Battery (1500mAh)
1	Charger for 1500mAh batteries*
1	Y – Harness
1	Y - Harness-Switch -Fuse assembly*
1	male connector with wire
2 each	Motors, large and small
4	micro switches
1	Robot Box **** Part of tether kit
1	Tether Box**** Part of tether kit
1	Tether Receiver Box**** Part of tether kit
1	Tether "Pit" Cable**** Part of tether kit

Table A1: Returnable Materials

Qty	Description
1 each	15/32"; 11/32"; 7/32", 2'X4' plywood, BC grade
1	1/4" X 48" hardwood dowel
20 ft.	1/2" Schedule 40 PVC pipe ** cut into 4, 5 ft. pieces
10 ft.	3/4" Schedule 40 PVC pipe ** cut into 2, 5 ft. pieces
10 ft.	1" Schedule 40 PVC pipe ** cut into 2, 5 ft. pieces
10 each	1/2" PVC 90degree elbow; 1/2" PVC tee; 3/4"; PVC 90 degree elbow; 3/4" PVC tee
6 each	1" PVC 90 degree elbow (slip) and tee
5 ft.	4" PVC pipe (Schedule 40, DMV or sewer)
4 oz	Regular PVC cement
8 ft.	1" X 4" #2 whitewood ** cut into 4, 2 ft. pieces
4 each	2.5" X 5/8" and 2" X 3/8" iron ZN, corner angle bracket w/ screws
2	hose clamp, #4 1/4"-5/8" diameter
10 ft	3/4" metal pipe hanger tape, 24 gauge
2	zinc plated utility hinges w/ 12 #8 wood screws 3"H X 2.5"W X 0.083"
1	extension spring for heavy doors 13/32"OD, 0.0625" wire diameter, steel
3 ft	No. 14 jack chain
4	4-6 stud spade terminals 22-16 AWG
16 ft	18 gauge, 2 conductor, unshielded cable
10	11" natural cable tie
5 ft	3/4" nylon sticky back Velcro (hook and loop)
misc	60 ft vinyl electrical tape, 3/4"; 60 yds all purpose duct tape, 2"
800 ft	No. 18 nylon Seine Twine
0.20 oz	nut/bolt locker (eg. Loctite, On the Spot, etc.)
4 oz	carpenters wood glue
1 oz	5 minute Epoxy
2	Aluminum grid for 5 gallon bucket
1	1/4"-20 threaded rod, 3' long
25	1/4"-20 hex Nut
1	3/8"- 16 threaded rod, 3' long
20	3/8"- 16 hex nut, zinc
100 each	#8-32 X 1 1/4" #8-32 and machine screws
20 each	#10-32 X 1 1/2" machine screws, round head and screw nuts
10 each	#4-40 X 1" machine screws, round head, zinc and screw nuts
100	#8X1" sheet metal screw, hex head
10	#4 X 3/4" wood screw, zinc plated, slotted drive, round head
* 100	#6X1" wood screws, flat head, zinc
20 to 30	1/4" SAE flat washer; #8 medium split lock washer; 1/4" medium split lock washer
30 each	#10 flat washer, zinc 3/8" lockwasher medium split,
6	Snap-Plug Terminals, insulated, male
4	Mini Snap Acting Switches, 10amps
3	piano wire (2' pieces), 14 gauge (0.063")
1	12"X17" Irrigation Control Valve (ICV) cover
1	1/4" and 1/8" polypropylene sheets 12" X 24"
1	0.5" Thick X 6" Wide X 6" Long Aluminum Bar Stock
1	6" X 6" turntable, zinc-plated, 500 lb. load cap.
1	12" X 24" X 0.063" Aluminum sheet
1	bicycle inner tube (26" X 1.5" - 2.0")

Table A2: Consumable Materials

Play Ball!

2004 Kentucky High School Robotics Championship

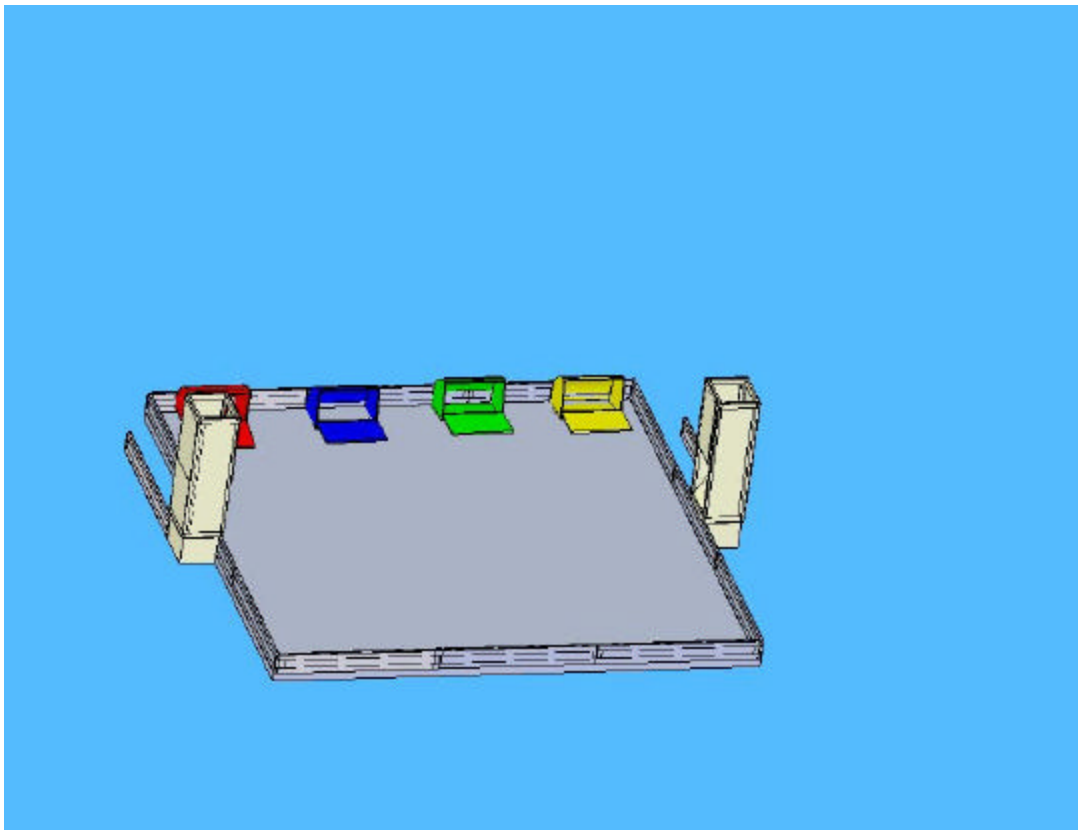
Sponsored by

Western Kentucky University
Department of Engineering

Kickoff Meeting: September 11, 2004

Practice Day: October 30, 2004

Competition Day: November 6, 2004



Objective

Sports competitions in the future will be very different from today's baseball, football and basketball games. By using specially designed robots in place of slow, weak humans the games will be far more interesting to watch. But to get to this point, we need clever designers to create the best robots for these new ball games. Are you up to the challenge?

The WKU Engineering Department has created a new game that will challenge the skills of robot designers. The game will test the speed and agility of your robots, and also test the design and strategy of the team. A ball field of the 22nd century has been constructed, and you are invited to compete. We are counting on you aspiring engineers!

The competition, should you choose to join us, is to build a robot that can quickly and accurately gather and place a variety of sports balls, while avoiding the competition. You have only 8 weeks to design, build and test your robot before the games begin.

1.0 Robot Construction Constraints

The robot materials you have been provided with are made of two parts: Returnables and Consumables. Material lists were provided with the materials. With the following exceptions, your robot must be constructed entirely from the materials provided (including all fasteners):

- 1.1 Lubricants may be used for lubrication only.
- 1.2 Paint and stickers or decals may be added as decorations only.
- 1.3 Non-functional decorations (excluding strobe lights) are permitted. Non-functional means that it does not aid the robot in performing the game.
- 1.4 You may solder electrical wires using your own solder; however, we have provided connectors for your use and encourage this. Soldering for structural support is not allowed.
- 1.5 Springs and plastic may be heated and reformed.
- 1.6 No welding is allowed.
- 1.7 Tape and/or adhesive may not be used for mounting the return R/C items. This includes using Velcro on the battery.
- 1.8 Materials may not be changed chemically, with the exceptions that strings may be singed to prevent loose ends and that resin and hardener can be mixed to make epoxy.
- 1.9 Returnable motors may not be opened for any reason (such as to change gearing or re-wind the motor armature).
- 1.10 Replacement parts may be available (in limited numbers) upon a request with justification. Otherwise, lost or damaged kit materials may be replaced only with identical components purchased by the team.
- 1.11 You are only permitted to use items on the Kit Lists. If your team accidentally receives a kit with extra parts, you are not permitted to use these extra parts.

The following statements apply to the energy, size, weight and safety aspects of your robots:

- 1.12** Robot energy must come solely from: electrical energy from the single onboard battery; spring energy from springs provided; potential energy from elevated mass on the robot; or energy from stretched rubber (as long as it will not fly off if broken).
- 1.13** Robots must fit unconstrained within a 2' by 2' by 2' cube at the start of the competition.
- 1.14** The robot must not weigh more than 24 pounds, including the battery and all parts and devices of your robot.
- 1.15** Safety is the most important aspect of the competition and will not be compromised.
- 1.16** Power supplies, batteries, charger and control system may not be tampered with.
- 1.17** Items that detach from the robot and fall to the playing surface are allowed.
- 1.18** Drivers and gunners must wear safety glasses (provided at the event) during the games.
- 1.19** Except for a power drill/driver and soldering iron (gun), no other power tools (including battery operated) will be allowed in the pits. Common hand tools are allowed. The power drill/driver may not be used for grinding or sawing. Illegal tools will be confiscated for the day.

The following statements apply to various aspects of your robots:

- 1.20** Machines can clamp to the playing surface, but not to other robots.
- 1.21** Robots may not gain traction through the use of chemical adhesives, or altering the playing surface.
- 1.22** Damaging the playing surface may result in disqualification
- 1.23** Machines must display a prominent team/school name logo.
- 1.24** During the games the robots may only be controlled through normal operation of the radio control system.
- 1.25** Although robots must begin each game within the specified starting space, they may unfold and change size during the competition.
- 1.26** No substitute robots are allowed. Modifications are allowed between rounds but still must meet design and construction rules. Competition judges must approve modifications, and incidence of non-compliance may result in forfeit by team.
- 1.27** Robots must stay at the competition site between check-in time and the start of the competition.

The following statements apply to the control system of your robots:

- 1.28** The transmitter, receiver, servos, speed controllers, batteries, battery chargers and power supplies may not be altered in any way. This includes putting labels or rubber bands on the transmitters; internal, reversible modifications; and cutting the antenna.
- 1.29** Two exceptions regarding modifications are: servo horns may be removed and modified; motor speed controllers may be tuned to adjust the null point and maximum speed (following procedures given in the instructions)
- 1.30** The receiver, battery, servos, speed controllers and wiring harnesses are the only components of the control system that may be attached to the robot.

- 1.31** The supplied connectors must be used to connect the motors and electrical devices to the speed controllers. Only one battery per game is allowed.
- 1.32** Each team is given two good batteries. One should be used while the other is being recharged. Replacement batteries will be given upon proof of valid failure (battery meltdown during recharging is not valid). Team owned batteries may not be used during the competition.

2.0 Game Floor Layout

The playing surface will be a 24 ft by 24 ft square, where four competing robots will try to score as many points as possible during a 3 minute game. Each robot team will have its own starting area, gunner station, repair zone and scoring dugout that are detailed below and in Figure 1. *The playing field and competition specifications will be reviewed on kickoff day.*

- 2.1** 24' long wooden walls define the outside boundary of the field, enclosing a 24' by 24' playing field surface constructed of carpet. Robots may not leave and then return to the playing surface during a game. Robots that touch the ground outside the playing surface will be required to remain motionless for 20 seconds.
- 2.2** Two release bin towers are located on the sides of the playing surface, outside the boundary walls. They will dump a variety of balls onto the playing surface at the start of each round. Balls that are knocked out of the playing surface will become out of play.
- 2.3** Each robot will begin the game in its own 2' by 2' starting area, and the driver must remain in a 2' by 2' driver's box behind the starting area.
- 2.4** Each team has its own scoring dugout. The dugouts are 3' wide and 2' deep, with a 3' wide by 2' long ramp leading from the playing surface floor to the scoring dugout. It will be possible to push some balls into the dugout, however others must be lifted into the dugout.
- 2.5** Each team will have a gunner person who will remain in the team's gunner station area and operate a ball-shooting gun during each game. The gunner will fire balls with the team's colors that can be gathered by any robot for bonus scores. Balls that are shot out of the playing surface will become out of play.
- 2.6** Each team has its own robot repair zone. The repair zone is 3' by 2', and a robot in the repair zone may be adjusted by the gunner during a game.
- 2.7** Two autonomous robot "umpires" will be roaming the playing surface. You are advised to avoid these robots, however they are part of the playing field. The two umpire robots will have their own "brains" and will not be remotely controlled. They will have sensors to make them stop before they run into your robot.

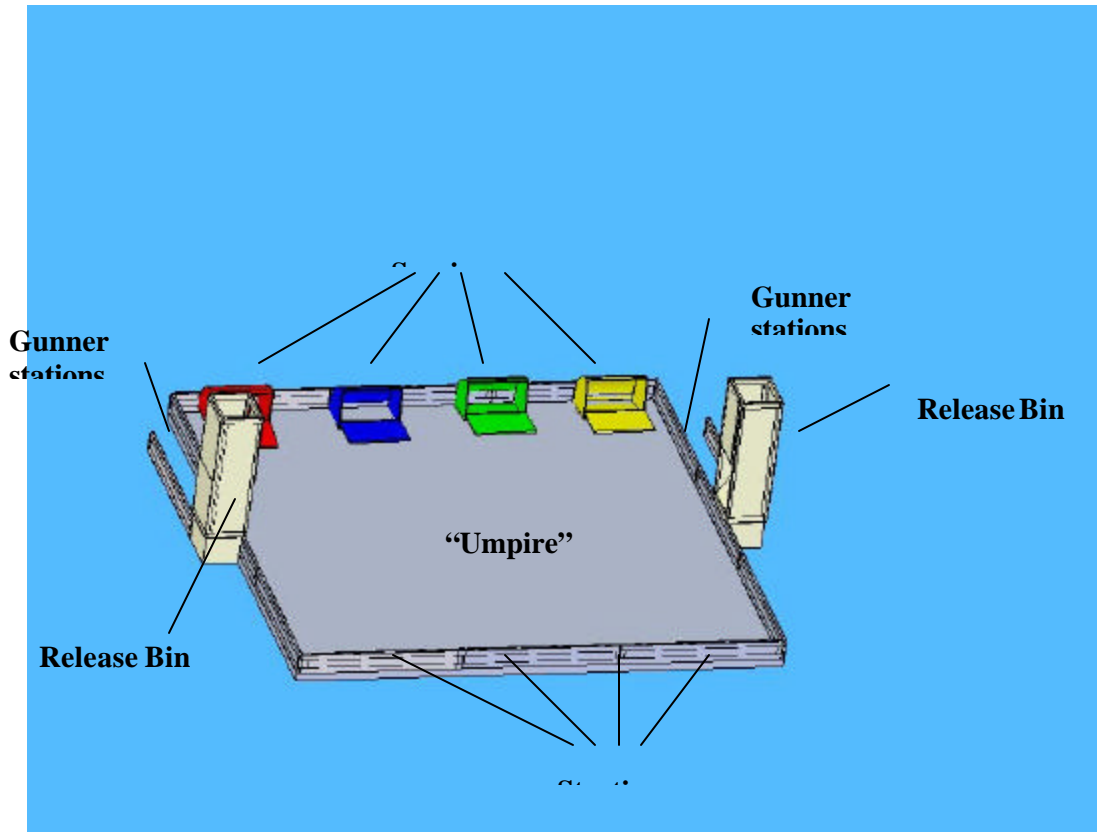


Figure 1: Layout of Playing Surface
 (Detailed drawings of the various components of the playing surface are available on the competition website.)

3.0 Starting Play

In order to assure that the games take place in a quick and orderly fashion, teams will adhere to the following rules during each game.

- 3.1 All teams must check in their robot at least one hour before the competition begins for final inspection by the judges. Teams must submit a driver and gunner list at this time.
- 3.2 Four teams will compete in each game, with team-color starting positions randomly assigned and posted for all preliminary matches. The list of teams for each game will be published at the start of the competition.
- 3.3 Team members must wear appropriate shoes for a gym floor.
- 3.4 Only one team driver and gunner are allowed around the playing surface during a game. The robot, driver and gunner will be called to a waiting area when the preceding game is started. Then all four teams will move to the playing surface for their game.
- 3.5 Before the start of a game, each robot must be completely within the 2' x 2' square starting area. A maximum of 30 seconds setup time will be given to the teams.
- 3.6 The driver and gunner must remain in their respective areas during the entire game.

4.0 Match Play

The rules for each game will be as follows:

- 4.1 Each game is 3 minutes long and is played with 4 teams.
- 4.2 There are three phases to the competition, a preliminary round-robin competition, a semifinal playoff among the four top-seeded teams, and a final game against the two top-seeded teams from the semifinal. During preliminary competition, each team will play eight games against randomly selected opponents.
- 4.3 Semifinal teams will be seeded based on their average score from the preliminary round-robin competition. Final game teams will be determined based on semifinal scores. Seeding ties will be resolved using the greatest point score in any round-robin game as the tiebreaker.
- 4.4 The team that scores the most points in the final game is the competition winner.
- 4.5 At the start of each game, 48 baseballs, 12 mini-soccer balls and 40 plastic golf balls will be released onto the playing surface from the release bins. Teams will gather as many of the balls as possible and place them in their scoring dugout.
- 4.6 In addition, during each game the team's gunner can fire as many of 20 colored golf balls as they wish onto the playing surface from a team gunner station. These balls can also be gathered and placed in the team's scoring dugout. Any team can attempt to gather any ball on the playing surface.
- 4.7 Robots may have minor repairs performed during the competition by moving into the team's robot repair zone in front of the team gunner. Only the gunner is allowed to touch the robot and no additional materials can be added to the robot during the game. No tools or additional materials are allowed in the Gunner Station area or Repair Zone. The gunner may not lift the robot out of the playing field, but may turn the robot around. Repairs may only be given when the team's judge gives the gunner the OK to touch the robot.
- 4.8 If two robots become entangled, so that neither can move, the referee will enter the field and disentangle them. The decision to disentangle machines is subjective and left to the discretion of the referee. Time, in the match, does not stop while the referee is untangling the robots.
- 4.9 If a robot become disabled during a game it will be left on the playing surface until the end of the game, regardless of where it comes to rest.
- 4.10 Team members must remain off the field until referees have finished determining the score for the match.

5.0 Scoring

The table below shows the scoring opportunities per team.

Object	Number of Balls	Diameter and weight of balls	Points per Ball
White golf ball	40	1.5" diameter; 0.01 lb.	1
Baseball	48	3" diameter; 0.3 lb.	5
Mini-soccer ball	12	6" diameter; 0.3 lb.	10
Colored golf ball	20 per team	1.5" diameter; 0.01 lb.	2 for own color; 5 for other team's color

Judges will tally the scores from each team at the end of each game.

6.0 Game Strategy (Offense)

The objective of the competition is to score more points than your opposition. This can be achieved by scoring as many points as possible. With this offensive viewpoint in mind, the following apply:

- 6.1** Robots should be as quick as possible and capable of gathering and placing a variety of balls to score as many total points as possible. Agility is also valuable in order to counter defensive strategies.
- 6.2** Robots may accidentally touch other robots, however it is not permitted to intentionally strike another robot. If judges believe intentional collisions are taking place, the team will be warned. Subsequent intentional violations will result in a 30 second penalty where no robot motion is allowed.
- 6.3** Gunners should try to provide team colored golf balls for their own team only, however drivers should also try to gather the colored golf balls from other teams.
- 6.4** Gunners may not launch their colored golf balls directly into the team scoring dugout. Only balls placed in the scoring dugout by the team robot will count.

7.0 Game Strategy (Defense)

The objective of the competition is to score more points than your opposition. This can be achieved by limiting the scoring of your competition. With this defensive viewpoint in mind, the following apply:

- 7.1** Robots are permitted to intentionally interfere with the activities of another robot, however this does not include touching other robots. See Rule 5.2 above.
- 7.2** Robots are not allowed to enter the repair zones or the scoring dugout ramps of other teams.
- 7.3** In the semifinal and final games, intentional blocking is not permitted.

All referee decisions are final!
There will be no videotape reviews and no appeals.
(This isn't the NFL or the Olympics...)

Teacher Questionnaire for 2004 WKU HS Robotics Competition

In an effort to improve the robotics competition and to make it easier for you to lead your student teams in the future, we ask you to fill out this questionnaire and return it to one of the WKU engineering faculty members **TODAY? PLEASE! BEFORE YOU LEAVE!! OR ELSE YOU WILL FORGET TO DO THIS!!!**

Your school: _____

Your name: _____

Names of students participating on your team this year:

(if you have coached teams in previous years, on the reverse side please give us the earlier students' names as best you recall.)

For the below questions, give us a score of 0 (strongly disagree) to 10 (strongly agree) and any comments you think are relevant.

1. ____ The competition is at the right level of difficulty/challenge for my students.

What technical changes would you suggest for future competitions?

2. ____ There is a proper amount of materials provided to build a robot.

What changes would you suggest for future competition materials/supplies?

3. ____ We were able to get helpful guidance from WKU about competition questions in a timely fashion.

What would you suggest WKU do to better help you for future competitions?

4. ____ The timing of the competition worked well for my students (early September kick-off, early November competition).

What timing changes would you suggest for future competitions?

Please answer these questions to give us a better sense of how you executed the competition.

1. What is your goal for your students to get from this competition?
2. What types of students are on your team (grades, from what common classes...)?
3. When did you really start coming up with a viable robot design?
4. When did you really start building your robot?
5. What times of the week were most robot activities taking place?
6. What is your guess of the number of hours spent on design? On construction?
7. What was your source(s) of expertise necessary for building a functioning robot?
8. Did you experience an EZX-R Speed Controller failure?

If yes, do you attribute the failure to a (a) Faulty part; (b) Improper wiring instructions provided with part; (c) Inadequate WKU Engineering technical support.

If yes how did you solve the problem? (a) WKU Engineering provided replacement part; (b) Ordered from Tower Hobbies or similar source; (c) WKU Engineering technical support
(d) Other, please explain

Thanks for filling out this survey. Hope your team exceeds your expectations today, and that we see you again next fall!

Students who participated on teams from:

Nov. 2003: _____

Nov. 2002: _____

Nov. 2001: _____