The Development of Judging Rubrics for Utah VEX Robotics Competitions

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ABSTRACT

Since 2009 the Utah State University VEX Robotics Team (USUVRT) has been promoting the growth of VEX Robotics Competitions (VRC) in Utah and the rocky mountain region. The VRC is the world's largest and fastest growing robotics competition for middle school and high school students (Innovation First International, Inc, 2013; Robotics Education and Competition Foundation [RECF], 2010; Robinson and Stewardson, 2012). This year the focus in Utah was to create rubrics for judging the Excellence Award. This is the highest award given at a VRC. This paper presents the rubrics created and outlines the process used to develop them.

VEX ROBOTICS COMPETITIONS

The VEX Robotics Competition (VRC) is the largest and fastest growing competition available to middle school and high school students in the world (IFI, 2013; RECF, 2010; Robison and Stewardson, 2012). During the 2013-2014 competition season, there were over 9,900 teams competing from over 32 countries from around the world (RECF, 2014). These 9,900 teams had over 600 local events and opportunities to compete and test their robots throughout the season. The growth of the VEX Robotics Competition throughout the world is shown in Figure 1.

In Utah, VEX robotics began in 2009 with nine teams competing in the first state and region championship. During the 2013-2014 season, there were over 60 teams competing in eight state qualifying events held throughout Utah. The largest event hosted 44 teams. There were 32 teams invited, and all 32 teams competed in the 2014 Utah VEX Robotics State Championship on February 8. Six teams qualified for the 2014 VEX Robotics World Championship from this state championship. The six teams represented the Excellence Award winner (1), Tournament Champions (3), the Design Award winner (1), and the Programming Skills Champion (1). Along with Robot Skills Champion, these awards represent the major awards given at a typical VRC.

These awards are determined through various methods at the tournaments. The Tournament Champion award goes to the teams on the alliance that is able to win the elimination tournament that takes place after the qualifying matches. The two skill challenges that take place separately throughout the qualifying rounds of a tournament. These challenges are known as the Robot Skills Challenge and the Programming Skills Challenge. Every team has the opportunity to compete in both challenges. In both of these challenges, a team's robot is placed on the field by itself and competes to score the most points possible in sixty seconds. In the Robot Skills Challenge the driver(s) control the robot for the entire sixty seconds. In the Programming Skills Challenge, the robot is preprogrammed to operate autonomously for the entire sixty seconds.
Teams are able to qualify for the VEX Robotics World Championships if they are

among the top 30 teams in the world in each of the skill challenges. Continuing the tradition of having some of the best teams in the world, this year Utah had two teams in the top 30 for Programming Skills, including one Design Academy team, ranked 16th, which was mentored by the Utah State University VEX Robotics Team. Utah also had three teams in the top 30 in Robot Skills, with a second Design Academy team being ranked 30th.

The Excellence Award

The Excellence Award is presented to "a team that exemplifies overall excellence in creating a high quality VEX robotics program. This team excels in many areas and is a shining example of dedication, devotion, hard work and teamwork. As a strong contender in numerous award categories, this team deserves to be recognized for building a quality robot and a "team" committed to quality in everything that they do" (RECF, 2013, p. 3). This is the highest honor a VEX team can receive. The guidelines presented by the REC Foundation are broad and allow the people in charge of local competitions to determine their judging criteria. According to the REC Foundation (2013), teams should earn points towards the Excellence Award from four categories:

- Tournament qualification
- Programming Skills Challenge
- Robot Skills Challenge
- Judged performance

A team can earn up to one point in each category for tournament qualification, programming skills challenge, and robot skills challenge. A team is able to earn up to four points based on their judged performance. With this method, a team can earn up to seven points. Judges are then expected to "use their best judgment to choose the team they feel best exemplifies overall excellence when considering top contenders found. . ." (RECF, 2013, p. 4) using the constraints described above.

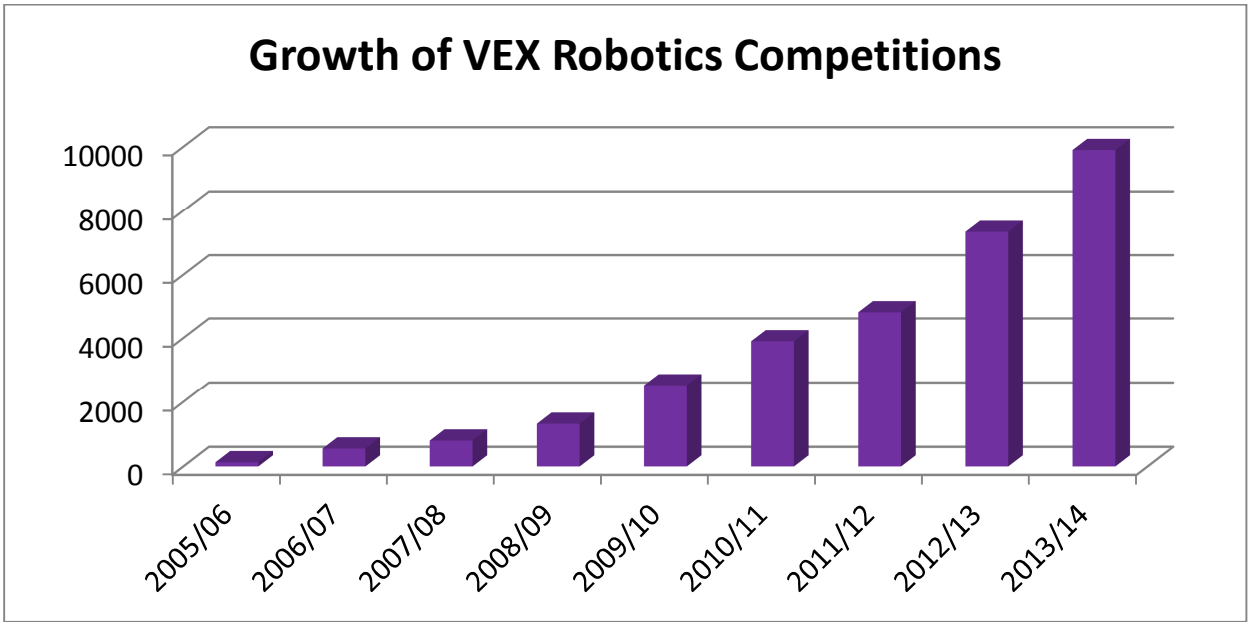

Figure 1. The number of teams competing in VEX Robotics Competitions through the years.

JUDGING IN UTAH

Due to the growth of the VEX Robotics Competition in Utah, there are many teams competing in individual VRCs, sometimes as many as 44. With this many teams competing, more judges are needed to evaluate the teams competing. Judges in Utah VRCs are chosen for a variety of reasons. Head judges are usually chosen for their expertise in robotics or engineering design. Other judges may be chosen because of their influence within the education community. Because of this, not all judges will be familiar with the VEX Robotics Competitions, and may not be aware of what makes a high quality robotics program and team worthy of winning the Excellence Award. Also, there are different judges at each local VRC that qualifies a team for the state championship.

In the past judges would be in a separate room, and the teams would go to the judges to be judged. With this setup, judges did not have the opportunity to see any matches. They would not be able to see the excitement created in the matches, and they would not be able to evaluate robots in action on the field. As noted earlier, the method to determine the Excellence Award described above allows the judges score to count for over half of the points available for the award. For these reasons, a more uniform method for determining the Excellence Award winners was needed. A method that allowed judges to walk around the pit areas to view matches was needed for more detailed evaluations of the robots and teams; therefore an Excellence Award Judging Rubric was created to be used in Utah VRCs.

DETERMINING THE OUTCOMES OF VEX ROBOTICS COMPETITIONS

The first step in developing the judging rubric was to determine the outcomes of successful VEX teams. An Occupational and Task Analysis (OTA) was conducted to determine these outcomes. An OTA uses experts to gain consensus in determining the tasks that are necessary to complete a job or task (Maher and Beach, 1967). The Occupational and Task analyses method has been used in education for over 100 years to determine the skills and tasks to be taught to students. We treated the VEX Robotics Competition as if it were a job, knowing that if students were to be successful in a VRC, certain tasks needed to be performed throughout the VEX season.

A group of successful coaches and mentors of competitive VEX teams were chosen to be on the expert committee. A coach was considered an expert if they had at least one team qualify for the world championships three out of four seasons, and coached multiple teams. The second step of the process was to have each expert create a complete list of outcomes students accomplish during a VRC season. The experts were asked to list these outcomes as task statements using an observable and measureable verb (i.e. calculate gear ratios). The expert committee initially submitted over 580 individual outcomes. A second committee analyzed those outcomes, combining similar statements and rewriting statements to be in the proper form. This second committee reduced the list to 99 total outcomes. The outcomes were also organized into five naturally occurring constructs:

- Mechanical
- Programming
- Design
- Teaming
- Professional Traits

The 99 outcomes were distributed to the expert committee to rate each outcome on a 5-point Likert scale. A rating of zero meant that the task was not performed by

successful teams, and a rating of four meant that the outcome was extremely critical to team success. The complete list of rank ordered outcomes can be found on the Engineering Technology Curriculum Team's (2014) website at etcurr.com.

Developing the Excellence Award Judging Rubric

Using the rank ordered outcomes; an Excellence Award Judging Rubric was created (see *Figure 2*). The outcomes were grouped into five constructs; therefore each construct was built into a separate category in the rubric. According to the criteria presented by the Robotics Education and Competition Foundation, a team could earn a maximum of four points from the judges; therefore the judges rated the team in each construct from zero points to four points. Each category on the rubric had a description; this description was based on outcomes from the expert committee. For example, in the Programming category part of the description mentions the utilization of sensors because several sensor types were rated high by the experts. Judges also look at the design process followed by the teams as part of the Design category.

To assist judges that may be unfamiliar with VEX Robotics Competitions, sample questions were developed as examples. These questions are included as part of the rubric. For example, in the Teaming category, a judge could ask, "What are your team roles?" or "How do you solve team disputes?" These questions were based on the high ranked outcomes determined by the expert committee in the OTA process. The judging rubric also describes how many points teams earn from the other challenges incorporated in the Excellence Award. Teams can earn up to one point for each of the skill challenges. The top ranked team would receive one point, second place would receive 0.9 points, and continuing on with a 0.1 point reduction until the tenth ranked team would receive 0.1 points (see bottom of rubric in *Figure 2*).

Initial Feedback on Excellence Award Judging Rubric

The Excellence Award Judging Rubric was used during the 2013-2014 season at the local VRCs and the state championship for Utah. After each tournament, the judges and tournament managers were asked for feedback regarding the use and implementation of the new rubric. One of the most reoccurring statements was that the rubric was a great tool for the judges to use, but that there were too many teams to fairly evaluate all of them using the rubric. Varying methods of using the rubric were tried at different VRCs. At the 2014 Utah VEX Robotics State Championship, the judges were split into 3 groups with each group evaluating half of the teams. This method did not require every judge to interview every team, but ensured that multiple judges evaluated all teams. This method did received positive feedback from the judges, but there were still too many individual teams for all of the teams to receive a thorough assessment. One judge recommended the development of a way to quickly identify teams into two groups, those with potential to win the Excellence Award, and those that lack the potential; similar to the idea of a go-no-go gauge.

This led to the development of a preliminary rubric to be used during the inspection process that takes place at each tournament. The Preliminary Rubric Judging (see *Figure 3*) was created to quickly score teams based on specific criteria that teams should meet in order to win the Excellence Award. A team can earn up to 10 points based on specific questions asked during inspection. For example, it is nearly impossible for a team to win the Excellence Award without

Figure 2. The Excellence Award Judging Rubric used in Utah VEX Robotics Competitions.

Excellence Award Judging Rubric

Team Number: _____

Team Name: _____

School: _____

VRC: _____

Date: _____

Judging Scale (0-4)

0 = Shows no evidence
1 = Misses expectations
2 = Below Expectations
3 = Meets Expectations
4 = Exceeds Expectations

Category	Description	Judges Score
Mechanical	• Structurally sound and stable • Effective drivetrain • Effective lift mechanism • Effective end-effectors	
Notes:		
Programming	• Utilization of sensors • Program structure (e.g., use of conditional statements, use of functions) • Average autonomous score • Multiple autonomous options • Use of commenting in code	
Notes:		
Design	• Use of design notebook • Ingenuity of design • Strategic design • Followed a design process	
Notes:		
Teaming	• Team has roles for individual members • Collaboration among members • Team is able to compromise	
Notes:		
Professional Traits	• Commitment to team goals • Positive work ethic • Craftsmanship of robot • Maintain professional behavior	
Notes:		

Average Score: _____

Figure 2. The Excellence Award Judging Rubric used in Utah VEX Robotics Competitions (continued).

Suggested Questions to be Used by Judges	
Category	**Questions**
Mechanical	• What are the gear ratios? • Is the robot built for speed or torque? • Are the drivetrains, lifts, and intakes effective? • Is the robot structurally sound and stable?
Programming	• Did you use any sensors? • What are their purposes? • What does your autonomous program do? • Did you use comments in your code? • How many autonomous programs do you have? • What is your average autonomous score?
Design	• Why did you choose this design? • What is your game strategy? • How many design iterations have you gone through? • What design process are you following?
Teaming	• What are your team roles? • Do you communicate effectively with each other? • How does each team member contribute? • How do you solve team disputes?
Professional Traits	• Does the team have a positive work ethic? • How do you prepare for competitions? • How do you work with other teams?

Overall Excellence Award Scoring Rubric				
Rank	**Qualifying Score**	**Programming Skills Score**	**Robot Skills Score**	**Judging Score***
1	1.0	1.0	1.0	0-4
2	0.9	0.9	0.9	0-4
3	0.8	0.8	0.8	0-4
4	0.7	0.7	0.7	0-4
5	0.6	0.6	0.6	0-4
6	0.5	0.5	0.5	0-4
7	0.4	0.4	0.4	0-4
8	0.3	0.3	0.3	0-4
9	NS	0.2	0.2	0-4
10	NS	0.1	0.1	0-4
11-…	NS	NS	NS	0-4

NOTES: * judging score points, 0-4, based on score from reverse side.
NS = No Score

Figure 3. The Preliminary Rubric for Judging.

Preliminary Rubric for Judging

(to be completed during inspection)

Team Number: _____
Team Name: _____
School: _____
VRC: _____
Date: _____

Points	0	1	2
Do you have a design notebook? (includes drawings/sketches, calculations, and who made what contributions)	☐ No notebook	☐ Minimal documentation	☐ Good documentation
What is your gear ratio for:			
driving?	☐ Poor or no response	☐ Plausible response	
lifting?	☐ Poor or no response	☐ Plausible response	
Do you have an autonomous program for:			
each starting tile?	☐ No	☐ Yes	
programming skills?	☐ No	☐ Yes	
Are the following types of sensors incorporated in the design?			
digital (e.g., bumper, limit)	☐ No	☐ Yes	
analog (e.g., encoder, potentiometer)	☐ No	☐ Yes	
Is the robot mechanically sound and well made?			
structurally	☐ No	☐ Yes	
fit and finish	☐ No	☐ Yes	

Total Points: _____

keeping a design notebook throughout the season; therefore a team can receive up to two points for their design notebook. It was also seen in the outcomes, that teams should be able to calculate gear ratios. Teams can also earn one point for knowing their driving gear ration, and another point for knowing their lifting gear ratio. Teams earn additional points based on questions related to their programming, use of sensors, and how mechanically sound their robot is built. Using this preliminary rubric, judges are able to have a list of the top 10-15 teams at the VRC. The judges can then focus their evaluations using the Excellence Award Judging Rubric on those top teams. These teams can give a formal presentation and still allow time for the judges to observe and question teams during the match play. An additional benefit of the rubric is the ability to share judges' scores and comments with teams; his allows teams to better self-asses and improve throughout the season.

CONCLUSION

The VEX Robotics Competition continues to grow throughout the world and the state of Utah. With this growth comes the reasonability to objectively and efficiently judge the teams worthy of winning the Excellence Award, the highest award given at a tournament. Using an Occupational and Task Analyses, the outcomes of students participating in VRCs were determined. These outcomes were used to develop the Excellence Award Judging Rubric. The rubric was used in determining the Excellence Award winners at Utah VRCs. After receiving feedback from judges and tournament directors, a preliminary rubric was developed. The Preliminary Judging Rubric was used to narrow the number of teams to be evaluated using the Excellence Award Judging Rubric.

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REFERENCES

Engineering and Technology Curriculum Team (2014). *Robotics*. Retrieved from http://etct.ete.usu.edu/robo/vex-umrvrc.html

Innovation First International. (2013). VEX competition overview. Retrieved from http://www.vexrobotics.com/competition?ref=home.

Mager, R. F., & Beach Jr, K. M. (1967). *Developing vocational instruction*. Belmont California: Pitman Learning Inc.

Robotics Education and Competition Foundation, (July, 2010). *Robotics and STEM education*. PowerPoint presentation for corporate and government sponsors.

Robotics Education and Competition Foundation, (2013). *VEX Toss Up Game Manual: Appendix D Awards.* Retrieved from http://www.roboticseducation.org/documents/2013/06/toss-up-appendix-d-2.pdf

Robotics Education and Competition Foundation, (2014, April 10). *Re: April 2014 Team E-mail Blast [Electronic mailing list message]*. Message sent to VEX Robotics Competitions Event Partners.

Robinson, T.P. & Stewardson, G.A., (2012) Exciting students through VEX robotics competitions. *Technology and Engineering Teacher, 72(2)* 15-21.