Engagement in Practice: University & K-12 Partnership with Robotics Outreach

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1. Introduction

In an effort to increase K-12 students' interest and readiness for STEM careers, Alachua County School District in Florida started an initiative in 2015 to introduce students to STEM through VEX robotics classes and/or clubs at every school throughout the district. The school district and University of Florida's Herbert Wertheim College of Engineering have collaborated through this robotics initiative to create pathways for students from K-12 to Engineering. One of these pathways includes creating an in-class mentorship program powered by university volunteers to help teachers in Alachua that have limited experience with engineering design and robotics. This paper will describe the efforts to form a university volunteer program, VEX Volunteers. The VEX Volunteers consist of undergraduate engineering, computer science, and education majors to assist teachers in robotics classes across Alachua. In addition, we will report on initial findings from the VEX Volunteers program pilot and its classroom impacts.

2 Background

2.1 REC & VEX

Starting in 2010, the Robotics Education & Competition (REC) Foundation, an organization that is responsible for organizing the VEX Robotics Competition (VRC), started exploring ways to incorporate their robotics hardware and competitions into 5th - 12th grade classrooms [3]. VRC is an international competition that allows students to learn about engineering design and programming to build remote controlled and autonomous robots to compete for challenges that change yearly. Through REC's recently partnership with two school districts, one being Alachua, the VEX Robotics Curriculum and hardware are now being integrated into classrooms through district-wide robotics initiatives to promote STEM education. Each district then runs their own district competition as a qualifying event for the VEX State and World Competitions. In general, VEX Teams work their way through school, district, and state tournaments to qualify for the world championship during the competition season. Teams advance after consideration of their documented design process, performance in the tournament, and STEM based research project. Founders of local VEX teams are responsible for securing funds, estimated to be $2,500 [2], and mentorship. The access to mentorship is heavily reliant on support from local businesses, and university groups. For a district-wide initiative, garnering enough support and mentorship can be more challenging than individual teams finding a generous benefactor and passionate volunteers.

2.2 District Lead VEX Robotics Initiative

Alachua collaborated with the REC Foundation to introduce students to STEM through robotics classes and/or clubs at every school throughout the district. The goal of the K-12 district-led five year initiative was to implement the VEX robotics curriculum in all 36 public schools in Alachua. REC provided teachers in the school district with a two-week training workshop to familiarize the teachers with the VEX Robotics learning platform. The goal of this training was to teach the 41 teachers about robotics, programming and engineering design science since most teachers did not have any previous experience in these areas.

After the training, each teacher was expected to teach the robotics curriculum in their school and prepare their students to compete in the district competition at the end of the fall semester. Teachers were given the flexibility to implement the robotics curriculum differently at their school to meet the needs of their students, classrooms, and grade levels. As such, students in elementary schools participated in the VEX curriculum once a week during their normally scheduled time for science. In most elementary schools there were multiple teachers who taught the VEX curriculum at different times during the day. As the competition date became closer, teachers often allowed students to work on their robots outside of the weekly scheduled time.

In middle school, the VEX curriculum was taught as an elective course usually by a single teacher and students attended the course five days a week. In addition, most middle school teachers taught at least 2-3 robotics classes. While most middle school schools in the district offered the robotics class as a semester long course, some middle and all high schools chose to prepare students for the district VEX competition as an extracurricular club. However, several middle schools provided students with a two semester course experience which focused on mechanical and engineering design in the fall and programming in the spring.

2.3 Robotic Volunteer Programs

Several universities have created support programs for various robotics competitions, afterschool clubs, and classroom interventions that provided suggestions for the design of the Vex Volunteer Program. Purdue University has a student organization, Purdue FIRST Programs (PFP) that focuses on organizing mentors to help FIRST (For Inspiration and Recognition of Science and Technology) Robotics teams in their local area [4]. They also created a class, FIRST Leadership, where students gained opportunities to develop their leadership and management skills that are vital for the team to succeed. [5]. PFP mentors help with engineering concepts, public relations, animation, and gathering student prepared materials for award submission [4]. Texas Tech University provides training courses to both teachers, and undergraduates who serve as mentors to local GEAR (Get Excited About Robotics) teams [6]. These programs look to provide technical resources to local robotics teams in the form of undergraduate students. They also develop the undergraduate engineering students by teaching them the technical skills needed to help with GEAR. University mentors assisted the students and the teachers during the robotics classes and after-school meetings during the 6-week period for the GEAR program. The design of the VEX Volunteer Program leverages, the elements of mentorship, and technical skill development found at programs in Purdue and Texas Tech University discussed in this section.

3 VEX Volunteer Program

3.1 Goals and Objectives

Data collected by the second author during the evaluation of the first year of the district's robotics initiative (2015-2016 AY) showed that teachers wanted additional assistance from volunteers to help students in their robot design process and troubleshooting. In addition, most robotics classrooms in the district had 4-6 small groups (20-24 students) and it was often challenging for a single teacher to support students and troubleshoot technical problems as multiple groups were working independently and experiencing different challenges that often arose simultaneously. These challenges combined with the general difficulty of managing young students created a hectic atmosphere that hindered the productivity of students. Thus, the aim of

the VEX Volunteer program was to provide assistance to teachers and students through providing more face time to the individual groups and assisting with classroom management. We envisioned the role of volunteers as making sure that students were making progress developing a design for their robot, properly documenting their design process (an important factor in deciding awards at the competitions), troubleshooting issues as they arise, and facilitating a healthy group dynamic where all members can provide input and ideas.

3.2. VEX Volunteer Program Structure

The VEX volunteer program was divided into two segments, training and volunteering. The training was designed to empower the volunteers to assist teachers with robotics project team management and students with group mentorship as they learned about the engineering design process and designed robots for the VEX competition. The training aimed to provide guidance to volunteers in four areas - introduction to VEX competition & robotics kits, advice for working with children, mechanical design, and Robot C programming. The training was provided for an hour and a half once a week. The training started three weeks prior to volunteers entering the classroom. The training sessions included lessons in Computer Aided Design (CAD), programming, and techniques used to assist teachers in student engagement. Since recruitment for the program was aimed at majors in mechanical engineering, computer science, and education, the training was meant to fill in gaps in volunteers technical knowledge not covered in their degree requirements. For example, Mechanical Engineers were introduced to programming autonomous robots and Computer Science students were introduced to mechanical design and CAD. The training was organized by a group consisting of the authors on this paper, an undergraduate engineering student, CS Education researcher, and the K-12 Coordinator for engineering outreach from the university. Building on the suggestion of prior research [4] we aimed to send volunteers into classrooms as interdisciplinary small teams with at least one student majoring in Computer Science, Mechanical Engineering, and Education. By grouping students into small teams we hoped to provide support for the volunteers to persist in their volunteering commitment throughout the semester. In addition, we hoped that teachers would also use the experience of the volunteers to strengthen gaps in their own knowledge and to provide needed support for students. We expected volunteers to work in the classroom at least two days a week for 1-2 sessions per day for 6-8 weeks.

4. Research Study Design

The descriptive study reported in this paper aims to explore the roles university volunteers can play in robotics classrooms with teachers of varying technological backgrounds. This study describes the initial findings from our integration of the VEX Volunteers into three school in the Alachua robotics initiative. This study is part of a larger evaluation of the VEX Volunteer Program pilot and will help us form an initial set of roles that volunteers can play in the Alachua robotics initiative. These findings will also help in the continual refinement of the VEX volunteer program.

4.1 Volunteer Recruitment & Participation

We held two recruitment informational sessions and visited engineering courses to recruit university students for the VEX Volunteers Program. From these efforts, we recruited a pool of 22 volunteers who completed our online application. Due to time conflicts between students' schedules and when schools needed volunteers, not everyone was able to participate in the

program. Scheduling volunteers to visit classrooms was challenging because university students needed to have at least two free periods to accommodate travel to and from the school. This dropped our volunteer corps down to eight by the time that the final volunteer schedule was made.

Demographics. Of the eight volunteers in the VEX volunteer program, we had one CS major, one education major, two industrial and systems engineering majors, two aerospace, and two mechanical engineering majors. Of those volunteers, we had one freshman, two sophomores, one junior, two seniors, and two graduate students. Four of the volunteers were female, and the other four were male.

Classrooms. VEX volunteer classrooms were chosen based on school rankings, distance from the University of Florida, and the schedules of the classes and volunteers. The volunteers were grouped so that there was enough vehicles between the volunteers to get to the schools. After considering these factors, three schools were chosen. One was a middle school, and the other two were elementary. Four volunteers went into one of the elementary schools, while two volunteers went to each of the other schools. Vex Volunteers averaged 2 hours a week in the classroom working with teachers and students.

4.2 Data Collection

In order to explore the role of volunteers in classrooms, three forms of data were collected. Volunteers were asked to complete a daily log in order to see what areas they were helping in and to gain a sense for their impacts in the classroom. Six of the eight volunteers filled out at least one log form, and a total of 19 logs were submitted, an average of about 3 submissions per volunteer. During the period that the volunteers were helping in the classes, we collected data from volunteers during two focus groups. Due to scheduling only 5 of the 8 volunteers participated in the training sessions and focus groups. At the end of the program, a post-survey was given to the volunteers in order to see the frequency of their classroom visits, how the volunteers helped in the class and how the volunteers benefited from the program. Due to several data collection challenges, we only received completed surveys from three volunteers.

4.3 Data Analysis

Data was qualitatively analyzed to better understand patterns in volunteers' roles in the classroom and context of the classroom environments volunteers participated in. The free response questions from the daily logs and post-survey were inductively coded in order to identify patterns of volunteer support of teachers across the three schools and patterns of volunteer support of students. The categories were then quantified to identify the highest areas of impact and priority. The focus groups were used to contextualize the responses from the daily logs. During the focus groups, volunteers were asked to describe how the teachers were running the classes, class dynamics, and the roles volunteers played in the classroom.

5 Findings

In exploring, the roles university volunteers play in robotics classrooms, we used data collected from volunteers' daily volunteer log, post-survey, and weekly focus groups. In all three of these data collection tools, we asked "how did [volunteers] help the teacher", and "how did [volunteers] help the students" each day. The top three activities volunteers reported engaging in

to support teachers were robot troubleshooting/repair (n=7), school competition (n=5), and organization (n=5). The focus group discussions revealed the difference in curriculum used in the middle and elementary schools. The elementary schools were focused on completing the initial build of the clawbot before their school competition. The clawbot is the first robot students build in the VEX Robotics curriculum. In the middle school we volunteered in, there were more structured lessons with mini-challenges in between. The following table summarizes the different roles VEX volunteers played in the classroom as compiled from evaluating volunteer responses in the focus group, daily logs, and post-survey.

	Vex Volunteer Roles		
Grade Band	**Team Project Management**	**Mechanical Design**	**Engineering Design Challenge**
Elementary School	Clawbot Building Process	None	None
Middle School	Customized Robot Building	Supplemental Lesson Creation	Battle Bot Competition

One common thread between both the elementary and middle schools is the teachers needed help keeping the kits organized. Managing the hardware provided in the kits in addition to other teaching duties was often challenging for teachers. Teacher were often responsible for managing 30+ base kits, and any add-on kits they choose to use. Often challenges managing the base robotics kits resulted in less frequent use of the add-on kits leading to less access of customizable parts for students. Thus, teachers sought assistance from the volunteers to help organize the kits to make finding pieces easier for the students.

6 Discussion

Our results show that the inclusion of volunteers in the robotics classrooms helped the teachers provide assistance to the students. Unfortunately, the roles that we thought the VEX volunteers would play in the classroom were not necessarily the roles that they ended up taking while volunteering. Most volunteers provided assistance to teachers by keeping the kits organized. This was a benefit to students as it provided them with access to essential parts. The technical expertise volunteers were able to provide in the classroom depended on how the teacher taught the robotics class. The elementary schools volunteers helped more with making sure the students were able to get through the clawbot instructions. Thus, the elementary volunteers were tasked with helping the students through a set of build instructions as opposed to using the technical skills they learned from the volunteer training. However, the volunteers in the middle school had opportunities to teach content from their major. We believe this was possible because the middle school teacher we worked with had prior programming experience and had previously mentored FIRST Lego League (FLL) after-school robotics teams for several years. Thus, the teacher elected not to follow the VEX provided curriculum and was better able to leverage the expertise of the volunteers to engage students in mechanical and engineering design activities. Thus, the middle school volunteers had the opportunity to come up with lessons and challenges based on their mechanical designs background. Despite the varying usage of their technical expertise, the volunteers saw their help contributing positively to the classroom.

The findings from this study differ from previously reported findings from university robotics volunteers in that the structure of the classroom limited the types of roles, university students were able to play in supporting students and teachers. [4] Describes university robotics volunteers as taking active leadership roles in after-school programs and robotics classes as well as usage of technical expertise to teach students engineering concepts.

6.1 Limitations

One limitation of this evaluation is the size of the pilot cohort. We look to fix this by growing the program to have more volunteers to survey in future studies. We also only focused on gathering responses from the college volunteers to get an initial understanding of how they would be used in the classrooms. Future studies will include collecting data from students and teachers in the classrooms to gain a better understanding of the effectiveness of the program as a whole. For the pilot cohort, Thursday evening was chosen because of the availability of the trainers (one for each of the different training components). The time of the week limited participation in the training since not everyone who was interested in volunteering was available to make these meetings. This limited our ability to engage all volunteers in focus groups and to engage them in the training modules.

7 Conclusions

Moving forward, we look to grow the VEX Volunteer program. Adding more volunteers would give a broader perspective of the robotics class implementation in different schools and how they can help in classes. We also look to collect data from sources other than the volunteers to provide a more robust outlook on the program.

8 References

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