Engagement in Practice: Developing Local School System Partnerships for Large-Scale Engineering Design Challenges, the Get Outside And Learn (GOAL) Program

Dr. Vincent Nguyen, University of Maryland, College Park

Vincent P. Nguyen is a Senior Lecturer at the University of Maryland, College Park. He is a founding member of the Environmental and Socially Responsible Engineering (ESRE) group who work to integrate and track conscientious engineering aspects throughout the undergraduate educational experience across the college. His efforts include formally integrating sustainability design requirements into the mechanical engineering capstone projects, introducing non-profit partnerships related to designs for persons with disabilities, and founding the Social/Environmental Design Impact Award. He manages several outreach and diversity efforts including the large-scale Get Out And Learn (GOAL) engineering kit program that reaches thousands of local K-12 students.

Jennifer Bishop, University of Maryland, College Park

Jen Bishop is the Assistant Director - Outreach and Recruitment for the Women in Engineering Program at the University of Maryland, A. James Clark School of Engineering, where she draws upon her 10+ years of STEM and Maker education experience to inspire future engineers. Jen has a Bachelor's degree in Anthropology from the University of Texas at Austin and a Master of Library and Information Science degree from the University of Maryland College Park.

Dr. Paige E. Smith, University of Maryland, College Park

Paige Smith, Ph.D. is the director of the Women in Engineering Program in the A. James Clark School of Engineering at the University of Maryland. She has over 20 years of experience with recruiting and retaining diverse populations in engineering. Under Paige's leadership, the Women in Engineering Program has received many awards for retention and outreach programming. From 2017-2020 she served as the Program Director for Broadening Participation in Engineering in the Engineering Directorate at the National Science Foundation. While at NSF she also served in a two-year rotation as the Implementation Team co-lead for NSF INCLUDES. Paige is a Past President of the Women in Engineering ProActive Network (WEPAN). Paige earned her Ph.D. and M.S. in industrial and systems engineering and B.S. in engineering science and mechanics from Virginia Tech.

Rebecca Kenemuth

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Abstract:

This engagement in practice paper addresses the development of school system partnerships for the Get Outside And Learn (GOAL) program. This outreach program provides hands-on physical componentry and design challenge curriculum that engages middle and high school students from historically underrepresented and first-generation-college populations. The program was initially conceived during the height of the COVID pandemic, and over 5000 kits have been manufactured and distributed in the first 2.5 years. A major feature of the kit program are culminating events, the scope of which varies from large (600-700 participants) to small (60-100 participants). Challenge events provide a venue to familiarize participants with the University of University of Maryland (UMD) and pathways toward higher education while building excitement and school spirit in a team-based engineering competition.

This paper discusses the rapid development of two major school system collaborations in neighboring counties of UMD. The first consideration is the integration into the school system's curriculum and building the program within the schools' existing infrastructures. One school system implements the kits through a two week summer bridge program for students entering 9th grade, and the second incorporates the kits into their coursework during the academic year. The UMD team provides implementation support to teachers and administrators. Teacher co-development of the componentry and curriculum is a major program characteristic. Another element of discussion is the progression of the culminating event logistics through the evolution of the COVID restrictions spanning implementations of fully online, hybrid, in-person off-campus, and finally toward in-person on-campus events. The funding structure and necessary on and off campus partnerships are presented along with current challenges. Future growth directions and expansion are described, including additional school system integrations, future co-development with stakeholders, teacher support communities, an online resource library, program evaluation, and international expansion.

Introduction to Get Outside And Learn (GOAL):

The Get Outside And Learn (GOAL) program offers fun hands-on STEM experiences that promote the exploration of mechanical concepts and provide opportunities for creative problem solving. The program objective is to encourage the pursuit of STEM education among historically underrepresented and first generation middle and high school students.

The GOAL program provides participants a kit that encourages hands-on STEM exploration, and the program extends well beyond the low-cost physical componentry. GOAL includes specific curricula, activities, and design challenges that allow students to not just observe physical phenomena, but interact with the system's components to create and experiment with physical configurations. The curricula and explorations are tied to K-12 Next Generation Science Standards (NGSS), and GOAL provides teacher support and school system integration. Engineering is still an emerging curriculum in many public K-12 schools, and the GOAL program exposes students and teachers to high-quality engineering experiences that involve making and testing solutions.

A fundamental aspect of GOAL programming is the inclusion of culminating events wherein multiple classrooms come together for challenges and competitions. These events motivate connectedness to content and offer opportunities for discussion and collaborative design. Events are used to build connections to UMD and include information sessions regarding pathways for admissions and transfer, familiarizing students with pathways toward higher education.

Figure 1 illustrates the GOAL activities over the past three years. Over 5000 kits have been distributed to middle school (MS) and high school (HS) students. The implementation has been primarily through two neighboring school districts, and those experiences are discussed within this paper. Several culminating events have been conducted. These initially began as online and hybrid events, and evolved to small-scale (60-100 student) and large-scale (600+ student) in-person events. Working closely with the school systems, the GOAL programming focused on classes and schools with significant populations of historically underrepresented and first-generation students. Self-reported data from the 2021 event (~700 students) showed participants identified as 73% Black/African American, 15% Latino/Latina/Latinx/Hispanic, and 59% female, and 43% of the students indicated they did not have a person in their immediate family who attended college. GOAL is actively working to expand to additional local school systems, and explore other mechanisms of programming including an international collaboration with a school in Nigeria.

	Spring 2020	Summer 2020	Fall 2020	Spring 2021	Summer 2021	Fall 2021	Spring 2022	Summer 2022	Fall 2022	Spring 2023	Summer 2023
Implementations		V1: 750 PGCPS	V1: 750 MCPS		V1: 750 PGCPS	V1: 750 MCPS		V2: 750 PGCPS	V2: 770 MCPS	V2: 750 MCPS	V2: 750 PGCPS
						V1: 30 DCPS		V2: 20 to CPA	V2: 50 Nigeria	V2: 20 Holy Child V3: 20 Holy Child	V2: 100 SoMD
Design	ad hoc V1					CPSS240 V2	ENME401 V2			ENME401 V3	
Events		PGCPS V1 online (750)			PGCPS V1 hybrid (750)		MDday V2-test on-campus (200)	PGCPS V2 (650)	MCPS V2 on-campus (100)	MCPS V2 on-campus (60)	PGCPS V2 on-campus (750)
							MCPS V2-test on-campus (65)			MDday V3-test-on-campus (~150)	SoMD (100)
										Holy Child (20 V2, 20 V3 test)	

Figure 1 GOAL activities over the past three years.

There have been two versions of the GOAL kits to-date with the third version currently in design. In addition to the downstream impact with the implementation of the kits and programming, the program redesign provides unique upstream impacts for undergraduate education at UMD. In fall 2021, the design, testing, manufacturing, and implementation of the GOAL program was integrated into two undergraduate courses and a service-learning group. Through these activities, undergraduate students are provided with the unique real-world experience of bringing a product to the public domain, including stakeholder engagement, end-user testing, mass-manufacturing, and assembly. More importantly, GOAL presents an opportunity for UMD students to actively work toward equitable educational access, a complex problem providing impact experienced directly within the students' own local communities, both geographic and professional. This involvement grants our engineering undergraduates direct agency toward solving a local "grand challenge", empowering them to utilize their skills to connect with their communities and engage with social challenges.

In addition to the teacher involvement during implementation, fifteen (15) teacher partners were directly involved in the design process of the version two kit. Undergraduate student classes worked closely with teacher-partners to design and test prototype versions of the kit and curriculum. Stakeholder involvement adds value to the design of the programming, providing concrete insight into the needs and constraints of existing STEM classrooms. Co-development creates agency for these important stakeholders, and establishes genuine connectedness between K-12 educators and UMD. In this way GOAL is not just a UMD project, but a community product.

GOAL Kit Version Two: The PropCart (V2) is the current kit being implemented in schools. This version has students building a small wheeled cart powered by a rubber band driven propeller. The challenge is to determine the most efficient way to deliver a total payload across a set distance with the least amount of energy used (measured via units of rubber band twists). The challenge theme is intended to reiterate resource efficiency, and illustrate the role of STEM in environmental sustainability. Challenge curriculum and details are provided [1]. There is an array of parameters for the student teams to explore, and the kit was strategically designed so that there is not a convergence of solutions. Teams have been successful with a variety of approaches and modifications. Culminating events are organized with classes or small groups collaborating to build a "competition" PropCart for the on-site challenge. Individual exploration and observations are combined to create the challenge PropCart and delivery plan. The intention is to demonstrate value from individual independent exploration, while still allowing for feasible event logistics that keep all individuals invested and engaged.

GOAL Chronology, Successes/Challenges and Lessons Learned:

The following discussion outlines a detailed chronology of the GOAL program and the evolution of community engagement. Challenges and lessons learned are presented throughout.

Spring 2020-Summer 2020 [2]: The GOAL program was initiated in spring 2020. The beginning of the COVID pandemic brought an abrupt shift to online education, which instantly opened a void in K-12 hands-on STEM engagement. The pandemic also brought about a complete shutdown of traditional outreach avenues. This meant a major disruption in the STEM pathways that disproportionately affected historically underrepresented and first-generation students.

GOAL was conceived as a wide-reaching, scalable opportunity to maintain successful pathways for underrepresented groups to become engaged and pursue STEM.

Version one of GOAL was a cardboard built rubber band dragster. The design was based off of an off-the-shelf kit, and GOAL worked with the manufacturer to provide a kit to specification. A curriculum was developed around data collection and graphing, and this information fed design challenges to achieve a target distance as well as the furthest distance. The componentry was tested to ensure that limiting phenomenon (ex. “wheelie-ing”, or traction limits) was observable across a variety of possible surfaces eliminating simplistic “more-is-better” approaches.

School systems were the most obvious partners for distribution, and GOAL reached out to county administrators in the state. Despite the cold-call, the need for hands-on learning created a real desire to explore partnerships. Discussions were brief and chaotic as both UMD and local school systems were scrambling to roll-out online instruction. Because funding, designing, and procurement were happening simultaneously, alignment and commitment was difficult to ensure. Interestingly, additional challenges came from other external school system partners who were protective of their positioning in providing learning hardware. Tying the curriculum to specific NGSS learning outcomes provided strong attractiveness for school administrators.

Prince George’s County Public Schools (PGCPS) was the first school system to partner with GOAL and was a high priority partner. In addition to being the geographical home county of UMD, PGCPS demographics represents one of the highest minority populations in the state. Despite the proximity, students from this county have been historically underrepresented at the University. PGCPS identified a need for programming within an existing summer bridge program directed at preparing rising 9th graders entering four of their technology high school programs. The GOAL kits offering hands-on activities were a welcome capstone activity for an otherwise fully virtual summer program.

In the summer of 2020, 750 kits were distributed to PGCPS. UMD met virtually with teachers prior to rollout to discuss the kit and curriculum activities. The implementation was primarily organized by the school system and UMD was called upon for highly attended virtual student information sessions to discuss the kit and to provide introductory information about engineering and college opportunities. PGCPS also organized the culminating competition which was run online. There were some issues with synchronization, and the competition challenge was loosely tied to the curriculum of the kits. PGCPS also introduced a decoration and video production aspect to the challenge, incorporating art and communication, turning the activity into a full STE-Arts-M experience. UMD attended the Saturday event which was highly attended by students in the bridge program. During the early meetings, the PGCPS teachers adamantly emphasized the power of a team-based competition in motivating the students, and the event thoroughly confirmed this aspect with an extraordinary amount of online participation and excitement surrounding the competition. This was counter to UMD concerns that competition could create a barrier toward engagement - an example of how stakeholder feedback is so critical toward impactful implementation.

Fall 2020-Spring 2021: A second neighboring school system, Montgomery County Public Schools (MCPS), became a partner during the 2020-2021 school year. A similar cold-call to

system administrators initiated the collaboration. The school system identified middle schools where they observed significant drops in STEM interest among historically underrepresented groups. The selection of implementation sites (schools) was left to the discretion of the school system, as access to the aggregate demographics and student information required a litany of additional approval. Access to demographic data from participants is still a challenge, and the GOAL team relies on independent survey analytics. A delivery of 750 kits was provided in the fall and the school system distributed these to teachers at the target schools.

The majority of the UMD communications occurred with the system administrators, and teacher meetings were organized prior to first semester implementation. Struggles with online instruction dominated the time and efforts for both MCPS and UMD, and direct teacher interaction was limited. Details about the implementation within the classroom during the semester were widely unknown. Between semesters, the UMD team was able to meet with two teachers to discuss implementation approaches and gather feedback. There were also a large number of unused or unclaimed kits from the fall delivery, but implementing teachers eagerly collected these for a second round of implementation during the second semester. With this relatively hands-off implementation, the included kit curriculum was welcomed as it provided teachers with clear guidelines and extended learning activities during execution.

Summer 2021: With the success of the GOAL kits in summer bridge programming in 2020, PGCPS was eager to continue with the GOAL kits for summer 2021 (~750 participants). The second implementation was less rushed, and UMD was able to closely work with the teachers in planning the culminating event. Loosening pandemic restrictions allowed for a hybrid event where a small number of top performers met in-person with the event streamed to the rest of the students online. The event took place at one of the participating schools and the participants were bussed in by the school system. The challenge was designed to work without the need for synchronization and was directly tied to the curriculum of the kit. The art and video production aspect was celebrated with multiple awards categories. The event boasted a strong turnout and a substantial survey response count.

Fall 2021: The rushed design and implementation of V1 allowed for several opportunities for further optimization. Starting in fall 2021, an undergraduate course was integrated into redesign of the GOAL programming to come up with a V2. An existing service learning course was repurposed to explore this effort. The value of stakeholder perspective was clear, and the redesign effort included collaboration with multiple teacher partners. These teacher partners were provided V1 kits as a baseline implementation which introduced GOAL to a third local school district. [2] provides a detailed look at the fall 2021 implementation. MCPS postponed fall V1 implementation due to production delays and a restructuring toward more controlled kit distribution.

Spring 2022: MCPS implemented 750 V1 kits through specifically identified teacher partners. MCPS again determined distribution, but more closely tracked teacher implementers. UMD met with teachers prior to implementation and continued contact through the semester.

A second undergraduate course, Entrepreneurial Design Realization, joined the effort to further develop V2. This course specifically focuses on bringing environmentally and socially

responsible projects out into the public domain. Teacher and participant feedback was incorporated into the selection of the PropCart kit. Initial testing was carried out through a public, campus-wide event where hundreds of K-12 kids constructed a PropCart and ran an abbreviated version of the challenge. Finally, 60 students from an MCPS implementing school were invited to campus to participate in a PropCart kit challenge to further test the curriculum. This culminating event was timed to coincide with the Mechanical Engineering capstone presentation day to provide additional connection and exposure to UMD engineering education. This first on-campus event explored possibilities and logistics for future events. A student service learning project team volunteered to facilitate the event. The integration of the UMD students provided tremendous opportunity for undergraduate impact, providing agency and opportunity to real-world utilization of engineering skills toward conscientious do-ing. Kit manufacturing transitioned fully in-house through the campus' maker-space fabrication facilities, and kit cost was reduced from $10 to $4 per kit.

Summer 2022: After successful testing and manufacturing, the PropCart kit (V2) was rolled out for the 2022 summer bridge program with PGCPS. UMD was eager to explore an on-campus culminating event, but scheduling challenges, group size, and date confirmation created major logistical hurdles. Ultimately, a 650 participant in-person culminating event was held at one of the participating schools. UMD was given full control to plan and execute the design challenge which included a "challenge curveball" (a change in the design challenge track) for the finalists. The event was successful with a high student and teacher energy throughout the day. UMD was also able to provide an engineering information session that included alumni speakers with diverse educational pathways and admissions information. The student service learning team assisted with facilitation. The in-person event created an unprecedented access to a high priority audience along with stronger access to teacher connections which are vital for subsequent development. Media releases are still being sought, and participant survey responses were lower than prior years.

Fall 2022: MCPS took delivery of 750 PropCart kits. The school distribution was again selected by the school system. Teacher meetings and support was provided to introduce the new version of the GOAL kits. Two middle schools were also selected (100 participants) for the fall on-campus culminating event which coincided with mechanical engineering capstone presentations. Information sessions were presented using the college's engineering student ambassadors. Bus logistics from two schools, timing for the capstone presentations, and constraints with transportation and school hours limited overall programming. There were challenges in survey participation, and the demographic of the culminating event participants was not as representative of the general population as desired (for example, less than 50% of the students self-reported identifying as female). All 750 kits were implemented during the fall semester prompting a delivery of an additional 750 kits for the spring.

Conclusions and Future Directions:

The ability to connect with school systems during the pandemic offered unique opportunities to partner and integrate the GOAL programming into the public school system curriculum. The school system integration provides a consistent platform for the GOAL programming which ensures longevity of the program and its ability to reach intended audiences. Post launch, there has been interest from other school systems to utilize GOAL, but logistics of implementation

(e.g., disconnection between administrators and in-classroom implementers) creates a lot of inertia toward getting relationships started. This factor has kept collaborations from expanding to the scale of PGCPS or MCPS. While the COVID pandemic created a lot of chaos, it also provided a unique opportunity where action was necessary. An additional aspect that quickly attracted school system interest was the connection of the activity content to utilized curriculum standards such as NGSS.

The inclusion of the stakeholders in co-developing the GOAL content is invaluable. Continuous incorporation of teacher and participant feedback will be a hallmark of the program design in perpetuity. Understanding the differences between the needs of the teachers and administrators is also critical, meeting both are necessary for program implementation. The diversity of the different in-class implementations means that the kits need to be flexible enough to allow for independent exploration (single student or single class) while providing opportunities for broader large scale implementations (multiple classes from multiple schools).

Some challenges always exist as internal logistics, teacher contacts, demographic information, and media releases are all difficult to navigate across distinct organizations. The planning of large culminating events requires significant lead time and funding which further complicates communication and delays. Better control over kit distribution is another area of future cooperation.

Future plans include creating an online, open-access resource library that K-12 educators and other educational partners can use to replicate the kits and associated curriculum for use with their students. This expansion also includes developing a community of practice for implementers to share ideas and add-on curriculum. This resource would help balance the preservation of open-ended exploration while also providing opportunities for structured activities should implementers prefer more scaffolding.

Although the focus of this paper is on the community engagement aspect of the project, assessment is another major part of the GOAL program and is a prime area for future development. A post activity IRB approved survey is currently shared with participating teachers and students to capture data that includes gender, race, first generation college student status, grade level, exposure to engineering, increased interest in engineering, potential challenges to pursuing higher education, and overall program experience. Details on the assessment efforts can be found in [3]. Results have been positive, for example 2021/2022 results show: 87%/58% historically underrepresented minorities, and 75%/77% responded that the activity made them interested in learning more about engineering. Future work ties toward strengthening the assessment to better capture the true impact of the programming on moving the needle toward future STEM educational pursuits. GOAL is exploring partnering with UMD's College of Education for these newer efforts. Assessments are expected to expand to include event-specific surveys and interviews, teacher surveys, and assessments on undergraduate student impact. GOAL is also working with the school systems to more accurately gather demographic representation of the students participating in the activity (not just those completing the assessment survey). As the program scales, capturing data becomes increasingly challenging.

References:

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