



# Environment and Natural Resources Trust Fund

## 2021 Request for Proposal

### General Information

**Proposal ID:** 2021-335

**Proposal Title:** Water Quality and Robots: Experientially Educating Minnesotan Youth

### Project Manager Information

**Name:** Nikolaos Papanikolopoulos

**Organization:** U of MN - College of Science and Engineering

**Office Telephone:** (612) 625-0163

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### Project Basic Information

**Project Summary:** We propose educational activities for middle school youth on water quality in Minnesota. Through group study and hands-on projects, youth will gain skills for measuring water quality and communicating results.

**Funds Requested:** \$344,000

**Proposed Project Completion:** 2023-06-30

**LCCMR Funding Category:** Environmental Education (C)

### Project Location

**What is the best scale for describing where your work will take place?**

Statewide

**What is the best scale to describe the area impacted by your work?**

Statewide

**When will the work impact occur?**

During the Project and In the Future

## Narrative

### **Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.**

Even though water quality is central to the health of Minnesotan watersheds as well as the general population, there is often a general lack of awareness on the subject and an absence of inexpensive, highly-available tools for distributed water quality sensing. However, the ubiquity of water bodies across the state and the availability of inexpensive water quality sensors has created a significant opportunity to spread water quality awareness and develop monitoring tools accessible to local communities. The 4-H Youth Development Organization reached approximately 65,000 youth in 2019, over 3,500 of which expressed interest in water or wetlands, and over 3,600 expressed interest in robotics. This shows a significant pool of interest at the cross-section between water quality and sensing.

We see a unique opportunity for Minnesota's youth to engage in issues related to water quality while investigating innovative options to measure water quality. By combining the education network of 4-H with the water quality sensing expertise at UMN, we envision the creation of learning communities that allow students across the state to study water quality sensing. The study will be complemented with hands-on activities involving visits to local water bodies and observation of water quality.

### **What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.**

We propose a solution in the form of a multi-faceted learning experience for youth of diverse backgrounds and demographics, centered around water quality issues pertinent to Minnesota. Virtual communication technology will be leveraged to create learning communities, together with the network and expertise of 4-H youth education, to facilitate student-student collaboration and expert-student coaching and mentoring on water quality sensing topics. Students will apply the ideas learned by assembling innovative low-cost robotic systems and using them to measure the water quality of local watersheds. The application of learning activities to the real world will be accomplished by making the measurement data available to local water quality stakeholders. Field experts at the Minnesota Robotics Institute at the University of Minnesota will use On-Campus Immersion experiences for youth to further demonstrate the value of underwater robotics and sensing in addressing authentic water quality issues.

As a prerequisite to this opportunity for youth, we also propose the development of an inexpensive robotic water quality sensing kit. Feedback gathered from the students' use of the kit will inform improvements, with the end objective of designing a kit to empower individual citizens to collect high-value water quality data using inexpensive, readily available, and easily-assembled parts.

### **What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?**

By engaging youth in authentic water quality issues through this proposed program, we aim to equip 150 young people as citizen scientists with the skills for (i) building innovative, accessible water quality sensing equipment, (ii) measuring water quality indicators, and (iii) sharing water quality knowledge and data effectively with stakeholder audiences. A by-product of these outcomes is a field-tested design of a low-cost water quality monitoring kit that citizens can build and use. These outcomes promote the democratization of environmental data collection and lower barriers to entry, enabling the concerned citizen to actively study and care for Minnesota's watersheds.

## Activities and Milestones

### Activity 1: Develop and Plan Educational Hands-on Programs

**Activity Budget:** \$84,626

**Activity Description:**

We will work with youth educator partners across the state to design the program experience and identify key topics and themes in water quality. A central part of the program design will be the connection to the current major water quality challenges. As part of this design process, we will identify a minimum of 30 viable sampling locations at watersheds distributed throughout the state; these sites will be target locations visited during hands-on activities. Program themes will be integrated into several topic-specific learning tracks. To prepare the hands-on part of the program, we will design the water quality sensing kit including sensing hardware selection and software assembly. Feedback from youth educator partners will be employed to balance system sophistication and usability. Supporting documentation on kit assembly will be written as well. We will assemble a bank of kits and develop kit distribution methods to account for team location and technology access. The sensor kit will include sensors that measure among other parameters water temperature, turbidity, and pH. These parameters will be linked to basic concepts of mathematics, physics, and chemistry. Local experience coordinators will be trained on water quality content and sensor kit assembly fundamentals through a series of workshops.

**Activity Milestones:**

Description	Completion Date
Build partnerships, promote program design meetings, identify 30 local data collection sites.	2021-09-30
Design program structure, identify key topics, and learning tracks.	2021-10-31
Design and validate sensor kit, develop distribution options, procure and assemble kit components.	2022-01-31
Promote and perform training sessions for local Coordinators.	2022-03-31

### Activity 2: Create Learning Communities

**Activity Budget:** \$71,652

**Activity Description:**

We will identify and train Learning Community Facilitators for directing the interactions between students and domain experts (faculty and staff). Their role is critical since they need to translate the students' needs for learning with the actual sensors and system constraints. They also need to have a good in-depth understanding of the student backgrounds. The materials and resources we will provide to the Facilitators will instruct them on how to direct the learning communities through the topics relating to water quality and robotic sensing. Furthermore, learning tracks will be provided to breakdown topics and encourage student-to-student sharing of knowledge and collaboration. Robotics is a powerful tool for experiential learning, but there are several constraints associated with its use: (i) students from underrepresented groups often fail to follow; (ii) mapping of robotic experiments to science-based water quality topics is not trivial; and (iii) making the systems affordable and accessible to all students is not always a priority. The Learning Communities will be flexible to transition into online content delivery (given the experience during the 2020 coronavirus pandemic) along with the ability to allow groups to be reconfigured into subgroups that will execute the different tasks in order to maintain social distancing.

**Activity Milestones:**

Description	Completion Date
Identify, train learning community Facilitators for the five 4-H regions; deliver materials and resources.	2021-12-31

Provide learning tracks to students throughout the five 4-H regions.	2022-04-30
Provide virtual correspondence between learning track groups and domain experts.	2022-06-30
Facilitate cross-track sharing of studies.	2022-09-30

### Activity 3: Program Implementation and Evaluation

**Activity Budget:** \$187,722

**Activity Description:**

We will schedule and carry out water quality education programs for a target participation number of 150 students carrying out sampling experiments at 30 sites across the state. We will transfer education materials and send the sensor kits to team coordinators. Minnesota Robotics Institute (MnRI) robotics and sensing experts will coach the sensory system design and assembly via a flexible combination of face-to-face and virtual communication according to team location. Prior to site visits, training will be administered regarding all DNR-compliance safety procedures and standardized methods of data collection. MnRI will provide on-campus interaction with domain experts with the opportunity for using students' sensor kit designs onboard a research laboratory underwater robot. Water quality data collected over the course of the program will be aggregated and processed, to be made available for documenting water quality. An important component of the whole effort is the evaluation of the methods used. Online surveys of students and the other stakeholders will be conducted to provide feedback on the concepts or sensors that excite the student population or the ones that fail. A revised set of activities and sensors will be created and be shared under open-source guidelines with the broader community.

**Activity Milestones:**

Description	Completion Date
Supply sensor kit, provide build session coaching, training for watershed visit protocols.	2022-06-30
Provide on-campus immersion, AUV interaction, and on-site data collection.	2022-08-31
Aggregate and process measurement data, re-publish to teachers and stakeholders for environmental education.	2022-09-30
Collect post-experience feedback from students and coordinators.	2023-02-28
Final on-site data collection.	2023-06-30

## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Prof. David Mulla	Department of Soil, Water, and Climate, UMN	Prof. David Mulla is a world-renown scientist in water quality issues and precision agriculture. Since January 2004 he has been the Director of the Precision Agriculture Center at the Univ. of Minnesota. He will oversee the project efforts in water quality by selecting the parameters/sensors used by the students.	Yes
Prof. Junaed Sattar	Department of Computer Science and Engineering, UMN	He is the founding director of the Interactive Robotics and Vision Laboratory at UMN. He specializes in autonomous underwater robotics, including design, construction, and field deployment. His robotics underwater student camps gather hundreds of students every year. He will be coordinating the underwater robotics aspects of the project.	Yes
Margo A. Bowerman	University of Minnesota Extension Center for Youth Development	She is the Co-Chair of the Minnesota State 4-H STEM Team. She will provide oversight for the project in the Northwest MN region, and knowledge and connections related to water quality and invasive species. Finally, she will provide expertise in creating STEM learning experiences for youth.	Yes
Patrick Jirik	University of Minnesota Extension Center for Youth Development	Patrick Jirik is a Regional Extension Educator and Extension Professor. He serves on the statewide 4-H STEM team and the statewide 4-H Volunteer Systems team. He is involved in educational program development and delivery and is located in the Rochester area. He will coordinate the project activities in Rochester.	Yes
Michael Compton	University of Minnesota Extension Center for Youth Development	He serves as the state STEM Director for the University of Minnesota 4-H Center for Youth Development. Michael's role focuses on statewide STEM program development including the design and delivery of educational programs and curricula, partnership, and fund development. He will supervise the project activities in Worthington.	Yes
Brian Mc Neill	University of Minnesota Extension Center for Youth Development Morris	Brian Mc Neill will supervise the project activities in the Morris area. He has specialties with STEM and Supervision. He has been involved with the 4-H Aquatic Robotics program in Minnesota and trains teams to educate the public on Aquatic Invasive Species.	Yes
Travis Henderson	Minnesota Robotics Institute	He is a Research Engineer at UMN's Minnesota Robotics Institute. His experience combines work on designing and building robots for environmental monitoring with outreach to youth through designing and leading STEM education efforts. He will have the same roles in this project.	Yes

## Long-Term Implementation and Funding

**Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?**

To see that the effects of this effort extend far beyond the funding window, the following will be done. The data collected from watersheds across the state will be processed and made available to environmental educators and researchers in relevant institutions for the purposes of developing data-informed educational materials and strengthening watershed scientific models. In addition, the feedback gathered from the program evaluations will be used to improve the sensor kit hardware, software, and system documentation. Plans and bills of materials will be made

available to the educational community under open-source guidelines to encourage statewide democratization of environmental data collection.

## Project Manager and Organization Qualifications

**Project Manager Name:** Nikolaos Papanikolopoulos

**Job Title:** Minnesota Robotics Institute Director, McKnight Presidential Endowed Professor of CS

### **Provide description of the project manager's qualifications to manage the proposed project.**

Nikolaos P. Papanikolopoulos, an IEEE Fellow, received a Diploma degree in electrical and computer engineering from the National Technical University of Athens, in Greece, in 1987, an M.S.E.E. in electrical engineering from Carnegie Mellon University, in 1988, and a Ph.D. in electrical and computer engineering from Carnegie Mellon University, in 1992. Currently, Papanikolopoulos is the McKnight Presidential Endowed Professor in Computer Science, a Distinguished McKnight University Professor in the Department of Computer Science at the University of Minnesota, and Director of the Minnesota Robotics Institute. His research interests include robotics, computer vision, sensors for transportation applications, and control. He has authored or coauthored more than 350 journal and conference papers in the above areas, including more than 80 refereed journal papers. His work has been funded by NSF, NIH, DHS, DARPA, MnDOT, Wisc DOT, Kansas DOT, FHWA, Honeywell, Minnesota Corn Growers, 3M, Johnson Controls, and Sentera. He has advised more than 30 Ph.D. students and holds eight patents. He has been General and Program Chair for the two largest international robotics conferences (IEEE International Conference on Robotics and Automation and IEEE/RSJ International Conference on Intelligent Robots and Systems). He has received the IEEE Robotics and Automation Distinguished Service and George Saridis awards. He founded along with his students ReconRobotics Inc. that has deployed more than 6,000 robots worldwide. His service to the University of Minnesota ranges from working with a donor to secure a \$10M donation for the robotics effort to chairing the MnDRIVE Robotics, Sensors, and Advanced Manufacturing planning committee for organizing MnRI and the MS in Robotics program. He has also organized and supported robotics summer camps for middle-schoolers from underrepresented groups for the last 14 years. More than 1,000 students have participated in these events.

**Organization:** U of MN - College of Science and Engineering

### **Organization Description:**

The project will be managed by the Minnesota Robotics Institute (a unit of the College of Science and Engineering, University of Minnesota). The Minnesota Robotics Institute (MnRI) is an outcome of the University of Minnesota's Discovery, Research, and Innovation Economy (MnDRIVE) initiative that brings together interdisciplinary researchers to solve grand challenges and increase Minnesota's position as a worldwide leader in robotics research and education. MnRI is housed in the world-class Gemini-Huntley Research Laboratory, made possible by a generous gift from Jim & Sharon Weinel and Fred & Siri Oss. The laboratory has 20,000-square-foot, state-of-the-art robotics research space and includes nine flexible robotics labs and various workspaces for faculty and graduate students—including a two-story drone lab and labs that provides research space for research on underwater robots. MnRI is offering a number of outreach programs that range from robotics summer camps to support of high school robotics teams throughout the state. MnRI has also started an MS program in Robotics. The project will be done in collaboration with the College of Food, Agricultural and Natural Resource Sciences (CFANS) and the University of Minnesota Extension.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
Project Manager		Management of the project and related activities.			36.5%	0.1		\$33,805
Water Quality Faculty Leader		Coordination and supervision of the water quality activities.			36.5%	0.1		\$25,988
Robotics Faculty Leader		Coordination and supervision of the robotic activities.			36.5%	0.1		\$16,889
4 UMN Extension Staff Members		Recruit students and assist in the planned activities at the various sites.			36.5%	0.4		\$40,269
Robotics Hardware Engineer		Help with the robotic kits and hardware.			31.8%	0.32		\$30,755
Youth Coordinator		Coordinate the student recruitment and evaluation of the program.			31.8%	0.32		\$23,656
Industry Liaison		Contact industry to provide supplies and mentorship to participating students.			36.5%	0.16		\$25,159
CFANS Graduate Assistant		Assist the students with water quality issues.			50%	0.25		\$20,535
CS&E Graduate Assistant		Assist the students with the robotic kits.			50%	0.25		\$21,111
							<b>Sub Total</b>	<b>\$238,167</b>
<b>Contracts and Services</b>								
							<b>Sub Total</b>	<b>-</b>
<b>Equipment, Tools, and Supplies</b>								

	Tools and Supplies	Robotic kits and sensors for 150 students.	These will be used by the participating students for data collection.					\$61,021
							<b>Sub Total</b>	<b>\$61,021</b>
<b>Capital Expenditures</b>								
							<b>Sub Total</b>	-
<b>Acquisitions and Stewardship</b>								
							<b>Sub Total</b>	-
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	Funds for faculty leaders to travel to sites from their location: 10 trips per year x 300 miles round trip x \$0.575 miles = \$1,725 Funds for Extension Co-Is to travel to St. Paul from their location: Margo Bowerman - 2 trips per year x 660 miles round trip x \$0.575 miles = \$759 Michael Compton - 2 trips per year x 400 miles round trip x \$0.575 miles = \$460 Patrick Jirik - 2 trips per year x 168 miles round trip x \$0.575 miles = \$193 Brian McNeill - 2 trips per year x 304 miles round trip x \$0.575 miles = \$350 Funds for Extension Co-Is to travel to sites from their location: Margo Bowerman - 2 trips per year x 200 miles round trip x \$0.575 miles = \$230 Michael Compton - 2 trips per year x 200 miles round trip x \$0.575 miles = \$230 Brian McNeill - 1 trip per year x 138 miles round trip x \$0.575 miles = \$79. Funds for transporting youth each year via bus rental - 3 buses = \$6,000.	Travel costs of all participants to sites and the UMN to complete the different milestones.					\$40,600
							<b>Sub Total</b>	<b>\$40,600</b>
<b>Travel Outside Minnesota</b>								
							<b>Sub Total</b>	-



<b>Printing and Publication</b>								
							<b>Sub Total</b>	-
<b>Other Expenses</b>								
		CS&E Network and Computer Services	CS&E Network and Computer Services - Networking and computer charges are expenses charged to sponsored and non-sponsored accounts to support the portion of networking and computer infrastructure used by sponsored and non-sponsored research projects. In a formula found to be Circular A21 compliant by the Office of Treasury Accounting and Int/Ext Sales and SPA, research specific computing is separated from general-purpose computing. The networking and computer support charge is based on FTEs and special projects that can be attributed to research-only projects.					\$4,212
							<b>Sub Total</b>	<b>\$4,212</b>
							<b>Grand Total</b>	<b>\$344,000</b>

## Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

## Attachments

### Required Attachments

#### *Visual Component*

File: [3625c822-5c2.pdf](#)

#### *Alternate Text for Visual Component*

The visual highlights the overarching theme of the proposal, the stakeholders, the water quality challenges, and the project objectives.

### Optional Attachments

#### *Support Letter or Other*

Title	File
Bonanza Educational Center Support Letter	<a href="#">76172f9a-43d.pdf</a>
Agricultural Utilization Research Institute Support Letter	<a href="#">2529ec34-204.pdf</a>

## Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

**Does your project have patent, royalties, or revenue potential?**

No

**Does your project include research?**

No

**Does the organization have a fiscal agent for this project?**

Yes, Sponsored Projects Administration

# WATER QUALITY AND ROBOTS: EXPERIENTIALLY EDUCATING MINNESOTAN YOUTH



Educational  
Program

Engaging  
**150**  
Students

Sampling  
**30**  
Sites

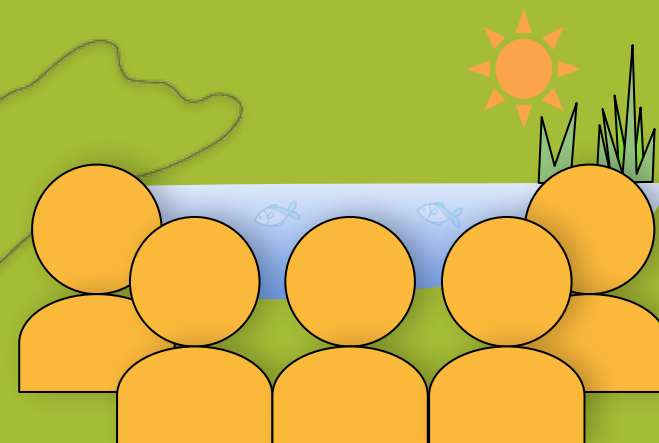
WATER QUALITY  
CHALLENGES

INTRA-STATE  
COLLABORATION

INNOVATIVE  
SENSING

CITIZEN  
SCIENCE

Program features



Improving  
water quality  
monitoring  
through  
youth  
education &  
engagement

