Final Abstract

Final Report Approved on November 2, 2026

M.L. 2024 Project Abstract

For the Period Ending June 30, 2026

Project Title: Water Quality and Robots: Experientially Educating Minnesotan Youth

Project Manager: Nikolaos Papanikolopoulos

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Website: https://cse.umn.edu/

Funding Source:

Fiscal Year:

Legal Citation: M.L. 2024, Chp. 83, Sec. 2, Subd. 05s

Appropriation Amount: $353,000

Amount Spent: $342,986

Amount Remaining: $10,014

Sound bite of Project Outcomes and Results

This project empowered over 100 Minnesota middle school students to build and deploy affordable underwater robots for lake monitoring. Students collected more than 10,000 validated water quality measurements, demonstrating how hands-on robotics education can advance environmental stewardship, strengthen STEM engagement, and support community-based freshwater monitoring.

Summary of Project and Outcomes

The University of Minnesota, in collaboration with High Tech Kids, developed and implemented an innovative educational program combining underwater robotics, environmental science, and citizen science to engage Minnesota middle school students in monitoring local freshwater ecosystems.

The project developed the "Jar Jar" Remotely Operated Vehicle (ROV), an affordable, reusable underwater robot with a modular sensor system that measures four key water quality parameters: temperature, pH, dissolved oxygen, and turbidity. The program also developed educational curricula, instructional videos, assembly manuals, and field deployment protocols to help students and educators build, operate, and use these systems for scientific investigations.

During the pilot implementation, 26 teams registered, with 14 teams involving over 100 students participating in the initial evaluation. Students assembled underwater robots, learned fundamental engineering and environmental science concepts, and deployed their systems in Minnesota lakes to collect water quality measurements.

The participating teams generated more than 30,000 raw sensor measurements, of which approximately 10,600 were retained following quality control. These measurements provide localized information about freshwater conditions and demonstrate the feasibility of student-led environmental monitoring.

Educator evaluations indicated strong student engagement in robot construction and field data collection, along with reported learning gains in water quality science, citizen science, teamwork, and engineering. The project also identified opportunities to improve electronics assembly, sensor reliability, and data processing to make future implementations more accessible.

Overall, the project demonstrated a cost-effective, scalable approach to integrating STEM education with environmental monitoring while providing Minnesota youth with meaningful opportunities to participate in scientific research and freshwater stewardship.

Project Results Use and Dissemination

The project disseminated results and educational resources through the University of Minnesota's Water Quality and Robots website, which provides publicly accessible curricula, instructional videos, assembly manuals, and deployment guidelines. The project shared validated water quality measurements through an interactive online map, allowing users to explore student-collected lake data. Participating teams presented their findings at a state fair event, promoting community awareness of freshwater monitoring. The project also documented methods, technical developments, educational outcomes, and lessons learned in a research manuscript, supporting future applications of affordable robotics in environmental education and citizen science.

Environment and Natural Resources Trust Fund

M.L. 2024 Approved Final Report

General Information

Date: November 3, 2026

ID Number: 2024-250

Staff Lead: Lisa Bigaouette

Project Title: Water Quality and Robots: Experientially Educating Minnesotan Youth

Project Budget: $353,000

Project Manager Information

Name: Nikolaos Papanikolopoulos

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Project Reporting

Final Report Approved: November 2, 2026

Reporting Status: Project Completed & Additional Update Approved

Date of Last Action: November 2, 2026

Project Completion: June 30, 2026

Legal Information

Legal Citation: M.L. 2024, Chp. 83, Sec. 2, Subd. 05s

Appropriation Language: $353,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to provide opportunities for middle school youth to develop skills for measuring water quality using robotic water-quality sensing kits and communicating results through group study and hands-on projects.

Appropriation End Date: June 30, 2027

Narrative

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

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

While water quality is central to the health of Minnesotan watersheds and the general population, there is a general lack of education on the subject and an absence of inexpensive, accessible tools for water quality sensing. The ubiquity of water bodies across the state, however, and the availability of inexpensive water quality sensors, have created a significant opportunity to expand water quality awareness and to develop monitoring tools accessible to local communities.

We see an opportunity for Minnesota's youth to engage with water quality challenges while investigating innovative ways to measure water quality. Increasingly, young Minnesotans are paying attention to issues of pollution and climate, while educational networks serving youth are well-established statewide. The 4-H program at the University of Minnesota (UMN), for instance, reaches tens of thousands of youth annually, while High Tech Kids, a STEM-focused nonprofit, reaches over 5,000. What is needed is an engaging program delivered through these networks that equips youth to steward Minnesota's water bodies. By combining the networks of our partners in youth outreach with UMN's expertise in water quality sensing and robotics, we are confident that we can help the next generation learn to better understand and care for our natural resources.

What is your proposed solution to the problem or opportunity discussed above? Introduce us to the work you are seeking funding to do. You will be asked to expand on this proposed solution in Activities & Milestones.

We propose a multi-faceted learning experience for the youth of diverse backgrounds and demographics centered around water quality issues pertinent to Minnesota. We will leverage virtual communication technology and our partners' network and expertise in youth education to create learning communities that will facilitate student-to-student collaboration and expert-to-student coaching and mentoring on water quality sensing topics. Students will apply the ideas they learn 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 UMN's Minnesota Robotics Institute (MnRI) will use on-campus immersion experiences to further demonstrate to youth the value of underwater robotics and sensing in addressing challenging water quality issues.

As a prerequisite to creating this opportunity for youth, we propose developing an inexpensive robotic water quality sensing kit. Feedback gathered from the student's use of the kits will inform improvements. The goal is to design a kit that empowers 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 the barriers to entry, enabling the concerned citizen to study and care for Minnesota's watersheds actively.

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

Activities and Milestones

Activity 1: Develop and Plan Educational Hands-on Programs

Activity Budget: $159,583

Activity Description:
We will work with statewide youth educator partners (High Tech Kids/ UMN Extension) to design a free summer program with experience in critical topics and themes connected to current significant water quality challenges. During the design process, we will identify at least 30 viable sampling locations at watersheds statewide as target locations to be visited during hands-on activities. We will then integrate program themes into several topic-specific learning tracks. To prepare for the hands-on part of the program, we will design the water quality sensing kit, select sensor hardware, and create software. We will employ feedback from our youth educator partners to balance system sophistication and usability, write supporting documentation on kit assembly, assemble a bank of kits, and develop kit distribution methods that account for team location and access to technology. The kit will include sensors that measure water temperature, turbidity, and pH, among other parameters, and these parameters will be linked to basic concepts of mathematics, physics, and chemistry. We will train local experience coordinators (teachers/chaperones) in a 3-day workshop on water quality content and the essentials of assembling the sensor kits. Background checks for minor safety will be conducted for all parties involved in youth education.

Activity Milestones:

Description	Approximate Completion Date
Build partnerships, promote program design meetings, identify 30 local data collection sites.	September 30, 2024
Design program structure, identify key topics and learning tracks.	October 31, 2024
Design and validate sensor kit, develop distribution options, procure and assemble kit components.	January 31, 2025

Activity 2: Create Learning Communities

Activity Budget: $105,147

Activity Description:
We will identify and train local experience coordinators (Teachers/Chaperones) through contacts at High Tech Kids and UMN Extension, who will monitor the interactions between students and domain experts (faculty and staff). Their role is critical since they will manage students' learning needs and the technology immersion requirements. The 3-day training workshop will provide materials and resources explaining how to direct the learning communities on water quality and robotic sensing topics. We will also create learning tracks that break down issues and encourage student-to-student knowledge sharing and collaboration.

Robotics is a powerful tool for experiential learning, but there are several obstacles: (i) students from underrepresented groups often do not have easy access to robotics resources; (ii) designing robotic experiments for science-based water quality topics is complex; and (iii) system affordability and accessibility to all students has not always been a priority. Our learning communities will have the flexibility of online content delivery and mailing kits, allowing groups to be reconfigured into subgroups that will execute the different tasks. The requested resources will overcome these obstacles by providing students with access, directions, and hardware to complete the design and implementation of robotics experiments.

Activity Milestones:

Description	Approximate Completion Date

Identify local experience coordinators through educational partners.	December 31, 2024
Provide program information, resources, materials, and learning tracks to students throughout the state.	April 30, 2025
Host a 3-Day Training Workshop for 35 local Coordinators (Teachers and Chaperones).	May 31, 2025
Provide virtual correspondence between learning track groups and domain experts.	June 30, 2025
Facilitate cross-track sharing of studies.	September 30, 2025

Activity 3: Program Implementation and Evaluation

Activity Budget: $88,270

Activity Description:
We will carry out the free summer water quality education programs for the target participation of 150 students to conduct sampling experiments at 30 sites across the state. We will send education materials and sensor kits to local experience coordinators. MnRI robotics and sensing experts will provide coaching on sensory system design and assembly via a flexible combination of face-to-face and virtual communication, according to team location. Before site visits, training will be administered regarding all Minnesota Department of Natural Resources compliance safety procedures and standardized data collection methods.

MnRI will provide the top 5 team students with on-campus opportunities to interact with domain experts and to use the students' sensor kit designs onboard a research laboratory underwater robot. Water quality data collected throughout the program will be aggregated, processed, and made available for documenting water quality. The educational partners will monitor, evaluate, and work with MnRI to improve the methods used. Online surveys of students and other stakeholders will be conducted to provide feedback on the concepts or sensors that excite the students and on the ones that fail. A revised set of activities and sensors will be created and shared with the broader community.

Activity Milestones:

Description	Approximate Completion Date
Supply sensor kit to all participants and local coordinators	June 30, 2025
Host on-campus immersion session for the top 5 teams, AUV interaction, and on-site data collection	August 31, 2025
Aggregate and process measurement data, re-publish to teachers and stakeholders for environmental education.	September 30, 2025
Collect post-experience feedback from students and local coordinators	February 28, 2026
Analyze the post-experience feedback and publish the results	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Prof. David Mulla	Department of Soil, Water, and Climate, UMN	David is a world-renowned scientist in water quality issues and precision agriculture. Since January 2004, he has been the Director of the Precision Agriculture Center at UMN. He will oversee the project efforts in water quality by selecting the parameters and sensors used by the students.	Yes
Prof. Junaed Sattar	Department of Computer Science and Engineering, UMN	Junaed is an associate professor of Computer Science and Engineering and the founding director of UMN's Interactive Robotics and Vision Laboratory. He specializes in all aspects of autonomous underwater robotics. His underwater robotics student camps gather hundreds of students annually. He will coordinate the underwater robotics aspects of the project.	Yes
Margo A. Bowerman	UMN Extension Center for Youth Development	Margo is the Co-Chair of the Minnesota State 4-H STEM Team, and oversees STEM programming in the northwest region of MN. She has expertise in creating high quality, scaffolded learning experiences for youth from kindergarten to one year past high school. She will review the education activity design.	Yes
Cheryl Moeller	High Tech Kids	Cheryl has worked for nearly 20 years in informal STEM education. She is the Executive Director at High Tech Kids, a Minnesota nonprofit offering K-12 STEM programs in robotics to over 5,000 Minnesota students each year. High Tech Kids will coordinate students and volunteers to participate in the proposed.	Yes
Travis Henderson	Minnesota Robotics Institute, Department of Computer Science & Engineering, University of Minnesota (UMN)	Travis is a research engineer and STEM outreach program coordinator at MnRI. His experience combines work on designing and building robots for environmental monitoring with outreach to youth through developing and leading STEM education efforts. He will have the same roles in this project.	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.
Tasks in activity 3 of the proposal focus on producing and publishing a corpus of data; these data are the water quality metrics gathered by students through hands-on experiments with water quality sensing kits. These are the steps we will perform to disseminate the data:
1. We will validate the credibility of the data against existing datasets, such as the Minnesota Pollution Control Agency (MPCA), the Minnesota Lake Browser, etc.

2. We will make adjustments based on this validation step,

3. We will create a web-based portal to share the data with the public, with the help of the University of Minnesota's College of Science & Engineering Information Technology staff. In the meantime, we will make sure this portal satisfies the data management requirements/protocols of the University and the state. Access to the portal will be open to the public, without a need for a password or credentials. Our group has significant experience with the dissemination of data to the public (for example, our work in the dissemination to the public of truck stop parking availability data throughout the state of Minnesota and other states).

The funding from the Environment and Natural Resources Trust Fund will be acknowledged through the use of the trust

fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENTRF Acknowledgment Guidelines.

For the long-term implementation, we will make the plans, and bills of materials available to the educational community under open-source guidelines (from Activity 3, and for five years after, the public will be able the access them at a Minnesota Robotics Institute outreach website with no fees through simple authentication protocols).

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 work be funded?

We are determined to ensure that the effects of this effort extend far beyond the funding window. 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. To encourage statewide democratization of environmental data collection, plans and bills of materials will be made available to the educational community under open-source guidelines.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount	$ Amount Spent	$ Amount Remaining
Personnel										
Nikos Papanikolopoulos- Principal Investigator/Project Manager		Management of the Project and related activities			36.8%	0.04		$38,542	-	-
Junaed Sattar- Co-Investigator- Robotics Lead		Coordinate the robotics activities.			36.8%	0.08		$64,482	-	-
David Mulla- Co-Investigator - Water Quality Leader		Coordinate the water quality activities.			36.8%	0.04		$21,239	-	-
Travis Henderson- Project Coordinator		Assist with robotic hardware design/prototyping; coordinate activity development.			36.8%	0.16		$15,321	-	-
Mike Bazakos- Consulting for Activities		Consult for activity development.			36.8%	0.04		$29,337	-	-
One Graduate Research Assistant at 25% from CS&E		Assist with water quality sensing kit design.			24.1%	0.3		$39,394	-	-
Three Graduate Research Assistant at 25% from CFANS		Assist with water quality parameter selection & data processing.			24.1%	0.18		$6,331	-	-
Saad Bedros- Coordinator for Activities		Coordinate the robotics activities.			36.8%	0.04		$24,224	-	-
CFANS Research Staff		Assist with water quality parameter selection & data processing.			36.6%	0.5		$59,338	-	-
							Sub Total	**$298,208**	**$298,208**	**-**
Contracts and Services										
High Tech Kids	Subaward	Fund the cost of High Tech Kids' Youth Coordination responsibilities in this proposed work.				0.3		$15,295	$7,433	$7,862

							Sub Total	**$15,295**	**$7,433**	**$7,862**
Equipment, Tools, and Supplies										
	Tools and Supplies	The kit includes sensors for temperature, pH, turbidity, and dissolved oxygen. Additional costs include a compute board, electronics protector case, power source, and various consumables necessary for assembly.	Robot kits for 150 students. These will be used by the participating students for data collection.					$38,000	$36,995	$1,005
							Sub Total	**$38,000**	**$36,995**	**$1,005**
Capital Equipment										
							Sub Total	**-**	**-**	**-**
Acquisitions and Stewardship										
							Sub Total	**-**	**-**	**-**
Travel In Minnesota										
	Miles/ Meals/ Lodging	Travel costs associated with milestones in Activity 3: First, 3-day Workshop training - 35 local experience coordinators (2 days will be online training and 1 day will be an in-person building session). Second, we will have - 5 volunteers and 20 youth participants from the top 5 teams for a one day in-person immersion experience at UMN-TC. Allocations (per person-day): Miles: $50 Meals: $50 Lodging: $100	Funds for youth participants and adult volunteers to travel the the UMN Twin Cities campus for two separate events	X				$1,497	$350	$1,147
							Sub Total	**$1,497**	**$350**	**$1,147**
Travel Outside Minnesota										
							Sub Total	**-**	**-**	**-**
Printing and Publication										

							Sub Total	**-**	**-**	**-**
Other Expenses										
							Sub Total	**-**	**-**	**-**
							Grand Total	**$353,000**	**$342,986**	**$10,014**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel In Minnesota	Miles/Meals/Lodging	Travel costs associated with milestones in Activity 3: First, 3-day Workshop training - 35 local experience coordinators (2 days will be online training and 1 day will be an in-person building session). Second, we will have - 5 volunteers and 20 youth participants from the top 5 teams for a one day in-person immersion experience at UMN-TC. Allocations (per person-day): Miles: $50 Meals: $50 Lodging: $100	The travel cost is generally ineligible but is necessary for the project to (1) train the local experience coordinators and (2) provide travel for students and coordinators to attend the on-campus immersion experience.

Non ENRTF Funds

Category	Specific Source	Use	Status	$ Amount	$ Amount Spent	$ Amount Remaining
State						
			State Sub Total	**-**	**-**	**-**
Non-State						
			Non State Sub Total	**-**	**-**	**-**
			Funds Total	**-**	**-**	**-**

Attachments

Required Attachments

Visual Component

File: 9494020c-e82.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....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
Budget Justification	482f1bce-7f1.pdf
Approval to Submit Proposal- 1101631 Papanikolopoulos LCCMR	495bd7ba-173.pdf
ECL Letter of Support	7005a3d3-25f.pdf
Northarvest Support Letter	773666cb-436.pdf
4-H State STEM Team Support Letter	e4d78e69-dcf.pdf
Manuals for Building the Robot	65e85137-87e.pdf
Manual for the Environmental Components	f1eadcd3-933.pdf
Final Report	3266479e-1c1.pdf
Final Publish Paper	a5766439-074.pdf
Website	4a60a99a-cb7.pdf

Media Links

Title	Link
Water Quality and Robots: Experientially Educating Minnesota Youth	https://waterandrobots.umn.edu/

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

The only change made is the addition of a plan for disseminating the water quality data gathered through this project's activities.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you understand that travel expenses are only approved if they follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I understand the UMN Policy on travel applies.

Does your project have potential for royalties, copyrights, patents, sale of products and assets, or revenue generation?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

Does your project include original, hypothesis-driven research?

No

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing $10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

Yes

Do you certify that background checks are performed for background check crimes, as defined in Minnesota Statutes, section 299C.61, Subd. 2, on all employees, contractors, and volunteers who have or may have access to a child to whom children's services are provided by your organization?

Yes

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A

Work Plan Amendments

Amendment ID	Request Type	Changes made on the following pages	Justification For Amendment Request (word limit 75)	Date Submitted	Approved	Date of LCCMR Action
1	Amendment Request	• Budget • Other • Budget - Personnel • Budget - Professional / Technical Contracts • Budget - Capital, Equipment, Tools, and Supplies • Budget - Travel and Conferences • Attachments	Additional salary expenses were necessary because we involved more personnel than anticipated to complete the grant activities successfully. Additional staff and team members provided mentoring, coordination, technical assistance, and support to participating youth and teams. At the same time, travel expenses were lower than budgeted because most teams used online communication to build and develop their robots, reducing the need for statewide travel. We therefore request permission reallocate the remaining travel funds. See additional update	October 5, 2026	Yes	October 23, 2026

Additional Status Update Reporting

Additional Status Update September 16, 2026

Date Submitted: September 22, 2026

Date Approved: October 23, 2026

Overall Update
Additional personnel expenses were necessary to ensure the successful implementation and completion of grant activities. As the project progressed, we determined that we needed additional staff and team involvement to provide participating youth and teams with mentoring, coordination, technical assistance, and ongoing support. This additional capacity helped maintain program quality and ensured teams received the guidance needed to complete their activities successfully. Travel expenses were lower than originally budgeted because teams effectively used online communication and virtual collaboration to coordinate, plan, troubleshoot, and develop their robots. This significantly reduced the need for statewide travel without affecting participation or program outcomes. Equipment, Tools, and Supplies expenses were also lower than anticipated. During prototype development and testing, the project team identified more efficient methods for building and assembling the robot kits. These improvements reduced equipment and material costs while still providing teams with the resources necessary to achieve the grant objectives. We respectfully request approval to reallocate $10,086 from Travel and $25,248 from Equipment, Tools, and Supplies, totaling $35,334, to Personnel. This reallocation reflects actual project needs and expenditures while maintaining the original scope, objectives, and intended outcomes of the grant-funded program and supporting its success.

Activity 1
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 2
During the summer, parts for the robotic kits were sourced and fabricated for distribution to the teams. Kits were distributed to the teams, and a website was created to share the data they collected. At the end of the program, teams presented their findings at the Minnesota State Fair.
(This activity marked as complete as of this status update)

Activity 3
Activity 3 successfully provided free summer water quality education programming to youth across Minnesota. A total of 150 students participated through 30 teams, surveying 30 lake sites statewide, with some teams surveying additional sites as time allowed. Teams were supported by two parent/adult leaders from their counties, and Zoom sessions with project staff and researchers were held as needed to provide technical assistance, troubleshooting, and guidance. The project built 34 water quality sensor kits and distributed 32 to the 30 participating teams. Due to their larger number of participants, two teams received two sensor kits each to ensure students had adequate access to the equipment. One additional kit was retained by the project team as a testbed for troubleshooting and continued program development, and one was provided to a young student through MnRI's outreach program. Teams prepared posters and brochures presenting findings from their surveyed lake sites. Top teams presented their work at the 2025 Minnesota State Fair. Because of natural disasters, six teams completed their activities after the State Fair and later met with project researchers via Zoom to present their findings. The team also collected feedback and used it to improve kits, materials located on the website.
(This activity marked as complete as of this status update)

Dissemination
https://waterandrobots.umn.edu/ to see the updates and outcomes so far for the grant. The publication is Mukherjee,

R. et al. (2026). Leveraging Cost-effective Robotics for K-12 STEM Education through Water Quality Monitoring Tasks. In Proceedings of the IEEE International Conference on Robotics and Automation (ICRA 2026). IEEE.

Status Update Reporting

Final Status Update August 14, 2026

Date Submitted: September 22, 2026

Date Approved: October 23, 2026

Overall Update
The water and robots program run by the University of Minnesota consisted of: the design and development of underwater robotic kits and water quality monitoring pods, creation of instructional materials to build and operate the robotic kits, two teaching workshops to educate instructors on the training materials, field deployment by 28 student teams culminating in a state fair competition, and an ICRA publication along with open-sourcing the relevant materials for the benefit of the broader scientific community. The survey conducted at the end of the program's pilot run uncovered multiple friction points affecting the program. The team resolved many of these issues during the program through ongoing support for broken parts, deployment concerns, and questions about data preservation protocols. These issues led to targeted fixes to the robotic kit design and revisions to the instructional materials to eliminate friction points.

Activity 1
In 2025, the robotic kit was prototyped and tested at facilities at the University of Minnesota. Subsequently, student participants were notified of the program, and training sessions were coordinated with educators.
(This activity marked as complete as of this status update)

Activity 2
During the summer, parts for the robotic kits were sourced and fabricated for distribution to the teams. Kits were distributed to the teams, and a website was created to share the data they collected. At the end of the program, teams presented their findings at the Minnesota State Fair.
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Activity 3 successfully provided free summer water quality education programming to youth across Minnesota. A total of 150 students participated through 30 teams, surveying 30 lake sites statewide, with some teams surveying additional sites as time allowed. Teams were supported by two parent/adult leaders from their counties, and Zoom sessions with project staff and researchers were held as needed to provide technical assistance, troubleshooting, and guidance. The project built 34 water quality sensor kits and distributed 32 to the 30 participating teams. Due to their larger number of participants, two teams received two sensor kits each to ensure students had adequate access to the equipment. One additional kit was retained by the project team as a testbed for troubleshooting and continued program development, and one was provided to a young student through MnRI's outreach program. Teams prepared posters and brochures presenting findings from their surveyed lake sites. Top teams presented their work at the 2025 Minnesota State Fair. Because of natural disasters, six teams completed their activities after the State Fair and later met with project researchers via Zoom to present their findings. The team also collected feedback and used it to improve kits, materials located on the website.
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Status Update Reporting

Status Update June 1, 2026

Date Submitted: September 22, 2026

Date Approved: October 23, 2026

Overall Update
We have made significant progress toward our milestones. The robot is built, the teams are forming, and outreach training was completed as of May 31, 2025. We are fine-tuning the program based on training feedback and will begin activities with each group. Updates to the project can be found at waterandrobots.umn.edu. The website has also been added to the hyperlink in Tab 7.

Activity 1
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Dissemination
The materials were disseminated via a website (waterandrobots.umn.edu), and its URL was added to the hyperlinks in tab 7. In-person training was completed on May 31, 2025, where youth coaches and mentors had the opportunity to build and review the training materials with the researchers. The project kits were also picked up or shipped on this day to various teams across the state. The housing for the sensor pod has been increased from 2" to 3" in diameter, and the internal electronics plate has surface-mounted, fixed components for added robustness.

Status Update Reporting

Status Update December 1, 2025

Date Submitted: December 1, 2025

Date Approved: February 17, 2026

Overall Update
Currently, the team is working on implementing the suggested additions based on the data collected and the teams that participated over the summer. The final edition is set to be released between March and April for the next batch of youth participation for the summer of 2026.

Activity 1
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 2
This activity was previously marked complete.
(This activity marked as complete as of this status update)

Activity 3
The data needed for Activity 3 have been collected, and the team has evaluated them. With that, the team is currently working on making the suggested improvements, so as to jump-start the next round of data collection for spring.
(This activity marked as complete as of this status update)

Dissemination
https://waterandrobots.umn.edu/ to see the updates and outcomes so far for the grant

Additional Status Update Reporting

Additional Status Update June 1, 2025

Date Submitted: August 28, 2025

Date Approved: September 8, 2025

Overall Update
We have made significant progress toward our milestones. The robot is built, the teams are forming, and training for the outreach was completed as of May 31, 2025. We are fine-tuning the program based on the feedback from the training and will begin the activities with each group. Updates to the project can be found at waterandrobots.umn.edu. The website has also been added to the hyperlink in Tab 7.

Activity 1
The initial phase of the project has been completed. Partnerships have been established, program design meetings have been promoted, and 30 local data collection sites have been identified. The program structure has been designed with key topics and learning tracks clearly defined. Additionally, the sensor kit has been designed and validated, with distribution options developed and all components procured and assembled.
(This activity marked as complete as of this status update)

Activity 2
As of May 31, 2025, significant implementation steps have been completed to support statewide engagement. Local experience coordinators were identified in collaboration with educational partners. Program information, resources, materials, and defined learning tracks were successfully distributed to students throughout the state. Virtual correspondence was established between learning track groups and domain experts, enabling ongoing mentorship. Cross-track sharing of studies was encouraged to promote interdisciplinary learning and collaboration. Additionally, a three-day training workshop was conducted for 35 local coordinators, including teachers and chaperones, to ensure effective program delivery. We will conduct two more virtual training sessions in the next month and will answer questions throughout.
(This activity marked as complete as of this status update)

Activity 3
We are now focusing on this activity.

Dissemination
The materials were disseminated via a website (waterandrobots.umn.edu), which was added to the hyperlinks in tab 7. In-person training was completed on May 31, 2025, where youth coaches and mentors had the opportunity to build and review the training materials with the researchers. The kits for the project were also picked up or shipped on this day to the various teams across the state.

Status Update Reporting

Status Update June 1, 2025

Date Submitted: August 28, 2025

Date Approved: September 8, 2025

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Dissemination
waterandrobots.umn.edu