

**Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)**

Project Title:

ENRTF ID: 117-C

Digital Watershed Simulator for K-12 Education and Outreach

Category: C. Environmental Education

Total Project Budget: \$ 314,489

Proposed Project Time Period for the Funding Requested: 2 years, July 2018 to June 2020

Summary:

We will use a cutting-edge visualization platform to turn water resource education into intuitive, hands-on, informal, and play-based learning experience for K-12 students and communities in Minnesota.

Name: Zengqiang Liu

Sponsoring Organization: St. Cloud State University

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St. Cloud MN 56301

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Web Address _____

Location

Region: Central, Metro, Northeast

County Name: Benton, Hennepin, Ramsey, Sherburne, St. Louis, Stearns

City / Township:

Alternate Text for Visual:

Schematic of the digital watershed simulator. Various watershed images built on the simulator. A regular sand box image and the same sandbox image with the simulator turned on. A child playing on the simulator demonstrating the 3D features.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____ %



Environment and Natural Resources Trust Fund (ENRTF)

2018 Main Proposal

Project Title: Digital watershed simulator for K-12 education and outreach

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I. PROJECT STATEMENT

In order to educate the public on water resource concepts and regulations especially regarding floodplains, we need an intuitive tool that can engage the broadest audience possible when such concepts and regulations are discussed in classrooms or communities, regardless the age or technical level of the audience. Imagine an educator captivates her students in classroom or a presenter engages his audience in an outreach event with such a tool that turns complicated concepts and issues of water resources into intuitive play of sand blended seamlessly with the cutting-edge technology of augmented reality. We propose to design such a tool that we call a digital watershed simulator. With this simulator, we will create play- and inquiry-based water resource education for K-12 and outreach. Learners use their hands and imaginations to generate rivers, lakes, mountains, and land with sand. The computer detects the sand landscape in real time and overlays color coded elevation, contour lines, and simulated water flow on the sand with a digital projector. Simulating an event becomes playing with sand and watching the sand turn into terrains and water flow across the terrains. Attached graphics depict a schematic, sample educational content, and how easy it is to engage even the youngest audience.

The simulator is based on the [ARSandbox](#) research project created at the University of California. We envision a water resource education and outreach program for entire Minnesota. This requires a much more refined design and out-of-the-box user experience not achieved by ARSandbox. We thus propose to dramatically improve the design. We will then build 20 simulators, create educational content, provide K-12 teachers training seminars and let them take the simulators to their schools to provide water resource education to 60,000 students state-wide. We will train interns and run an outreach program during summers at county fairs and the State Fair, museums, and community centers. We will collect feedbacks and continuously improve our project.

Our project goals are to greatly enrich water resource education at K-12 schools and outreach and improve public interest in water resource issues. In order to achieve our goals, we propose three activities.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Improve design for portability, ease of construction, calibration, and use **Budget: \$88,431**

Our first prototype's wooden frame is heavy, bulky thus non-portable, and required considerable time to construct and calibrate. We propose to redesign the frame using high-precision light-weight extruded aluminum modular beams and create a precision machining-free assembly process that our tour guides and K-12 teachers can follow with minimal tools and efforts. This will make possible for K-12 teachers training, simulator deployment at schools, and outreach activities. The redesigned simulator will not need recalibration after each transportation and requires considerably less time to build. This makes our project easily scalable to a large number of deployed simulators to potentially cover the whole state.

We will also redesign the user interface to eliminate the need for a user or demonstrator to interact with a sophisticated computer system. We will design a curtain system for the simulator to work in brightly lit rooms.

Outcome	Completion Date
1. The new prototype is significantly easier to build than current prototypes.	Sep. 1, 2018
2. The new prototype can be disassembled for transportation in a car.	Sep. 1, 2018
3. The new prototype needs no calibration after reassembly.	Sep. 1, 2018
4. The user interface is intuitive without having to use keyboard or mouse.	Oct. 30, 2018
5. A curtain system is designed for the simulator to function in brightly lit room	Jan. 15, 2019

Activity 2 Build 20 units. Create educational content, train K-12 teachers, do outreach **Budget: \$197,560**

In order to improve public interest in environmental science and water resources, we will use the simulator to create a series of video projects to explain watershed, river, buffer, zone, floodplain etc. We will also provide teaching materials based on the simulator for K-12 teachers so they can enrich their existing curricula.

Here is a video created by Saint Cloud State University students using a simulator:

<https://www.youtube.com/watch?v=mqiiAEZaU-E>



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We plan to give two K-12 teacher training seminars each semester with a total of eight seminars. After each seminar, the teachers will take the simulators to their schools to engage students in their schools with the content from the seminar and collect survey data. We will collect the simulators after two months and refurbish them for the next training seminar. During the summers, we will take our simulators to county fairs, the State Fair, museums, and community centers for public outreach, in separate teams.

Outcome	Completion Date
1. The first build of 10 simulators	Oct. 15, 2018
2. The first iteration of teaching content and video creation and tour guide training	Oct. 15, 2018
3. The second build of 10 simulators, K-12 teachers training sessions 1 and 2	Jan. 15, 2019
4. The second iteration of teaching content and video creation and tour guide training	Jan. 15, 2019
5. Public outreach at County and State Fairs, museums, and community centers, K-12 teachers training sessions 3 and 4	Sep. 15, 2019
6. The third iteration of teaching content and video creation and tour guide training	Oct. 30, 2019
7. K-12 teachers training sessions 5 and 6	Jan. 15 2020
8. K-12 teachers training sessions 7 and 8	Jun. 30, 2020
9. Public outreach at County and State Fairs, museums, and community centers	Jun. 30, 2020

Activity 3: Evaluate the effectiveness of our program, provide remote technical support **Budget: \$28,498**

We will develop surveys and collect results from K-12 schools to assess learning outcomes. Using feedbacks, we will improve the simulator design and our educational content. We will also develop remote technical support procedure to support the K-12 teachers that have received their simulators for the 2-month loan.

Outcome	Completion Date
1. Development of remote maintenance	Oct. 15, 2018
2. Collect and analyze survey data from first semester of simulator deployments	Jan. 15, 2019
3. Collect and analyze survey data from second semester of simulator deployments	Jun. 1, 2019
4. Collect and analyze survey data from third semester of simulator deployments	Jan. 15, 2020
5. Collect and analyze survey data from fourth semester of simulator deployments	Jun. 1, 2020

III. PROJECT STRATEGY

A. Project Team/Partners

Dr. Liu and Dr. Cheng are Associate Professors at Saint Cloud State University. Dr. Liu is an expert in scientific instrumentation and an educator. He provides technical and educational expertise in task 1 and 3 and leadership to the project. Dr. Cheng is an expert in water resources and environmental science and engineering, especially watershed science and floodplain management. He is also an educator. He will provide content expertise in task 2. One graduate student will coordinate the project to offload work of Dr. Liu and Dr. Cheng, especially during semesters when they teach full time while the other (hired on demand) will assist technical designs. Four undergraduate interns will build and maintain simulators, assist educational materials production and K-12 teacher seminars. They will attend outreach activities as presenters and provide remote technical support. One undergraduate intern is tasked to work on software improvement and another is hired on demand.

B. Project Impact and Long-Term Strategy

We are re-imagining water resource education with an intuitive and play-based tool. With out-of-the-box simplicity and educational content that we are developing, we believe that this project will truly transform water resource education and outreach in Minnesota and ensure that public opinions will always be based on education and always in favor of environmental protection. We plan to make the project sustainable beyond the funding period by building, selling, renting and servicing simulators to continue to fund our activities.

C. Timeline Requirements

This project requires two years in order to improve the simulator from a concept to a solid product, generate and revise educational content, train K-12 teachers and interns to provide education and outreach outcomes, all the while building working relationships with partners such as schools, museums, fairs, and community centers.

2018 Detailed Project Budget

Project Title: Digital watershed simulator for K-12 education and outreach

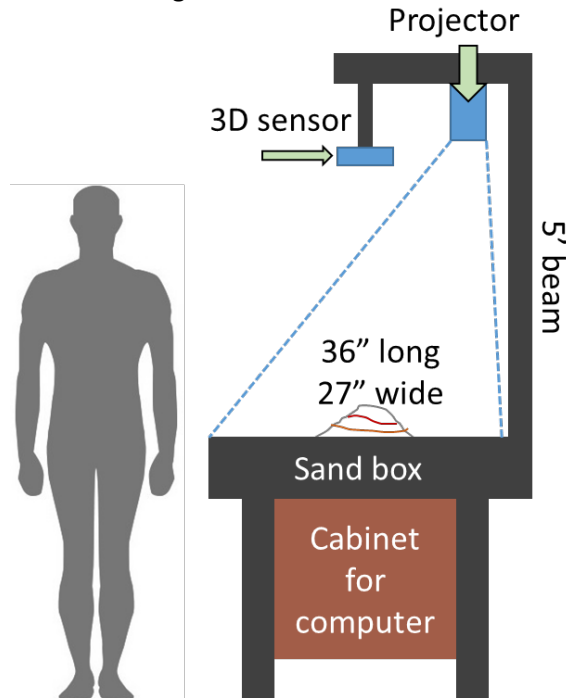
IV. TOTAL ENRTF REQUEST BUDGET 2 years

BUDGET ITEM	AMOUNT
Personnel:	\$ -
Zengqiang Liu, Project manager, developer, educator (63% FTE during summers, 5% FTE during semesters, 71% salary, 29% benefits, 2 years)	\$ 61,072
Jeffrey Cheng, Associate project manager, developer, educator (56% FTE during summers, 4% FTE during semesters, 75% salary, 25% benefits, 2 years)	\$ 57,298
1 Graduate assistant program coordinator (data analysis, scheduling, purchasing, outreach, communication etc.), 50% FTE academic year (61% salary, 39% benefits-tuition remission), 20hr/wk, 28wk/yr, \$9,251/yr salary, \$5,899/yr tuition remission, 100% FTE summer (93% salary, 7% benefits), 40hr/wk, 12wk/yr, \$25/hr, 2 yrs	\$ 56,219
1 Graduate student design engineer 25% FTE (100% salary) 10hr/wk, 28wk/yr, \$25/hr, 2 yrs	\$ 14,000
6 Undergraduate interns (building, testing, and repairing units, software development, training K-12 teachers and giving presentations at fairs and community centers, data gathering) \$15/hr, ~3hr/wk, 45wk/yr, 2yrs	\$ 24,900
Professional/Technical/Service Contracts: None	\$ -
Equipment/Tools/Supplies: We request for exception to purchase computers and audiovisual equipment. Each simulator requires a computer and a projector as its main components. We will also need extra computers during development and some spare parts for repairs.	\$ -
Task 1: redesigning prototype materials such as PCs, sensors, projectors, hand tools	\$ 12,000
Task 2: 20 units production (\$3000 each: PC, projector, sensor, and structural materials)	\$ 60,000
Task 3: spare parts and materials for maintenance of the 20 units	\$ 12,000
Acquisition (Fee Title or Permanent Easements): None	\$ -
Travel:	\$ -
Mileage (~35,000 miles \$0.52/mile), lodging, and meals for travel to and from K-12 teacher training seminars, outreach presentations, and collecting units back from K-12 schools	\$ 17,000
Additional Budget Items: None	\$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND \$ REQUEST =	\$ 314,489

V. OTHER FUNDS

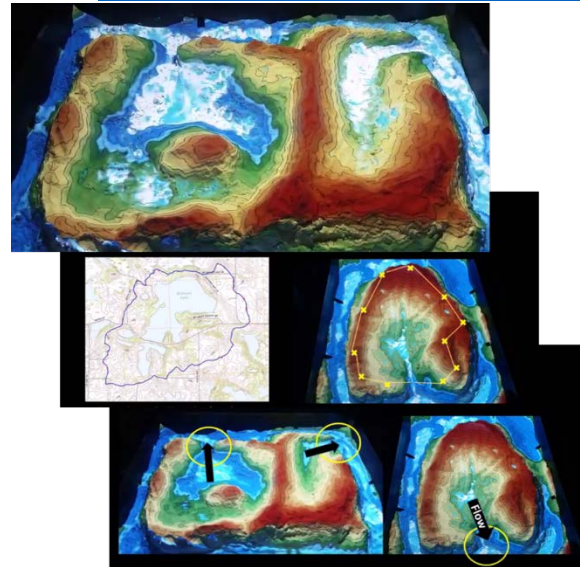
SOURCE OF FUNDS	AMOUNT	Status
Other Non-State \$ To Be Applied To Project During Project Period: N/A	\$ -	
Other State \$ To Be Applied To Project During Project Period: N/A	\$ -	
In-kind Services To Be Applied To Project During Project Period: Indirect costs are provided in-kind at SCSU's negotiated rate of 12%.	\$ 37,739	<i>Secured</i>
Past and Current ENRTF Appropriation: N/A	\$ -	
Other Funding History: N/A	\$ -	

Schematic: Digital watershed simulator.



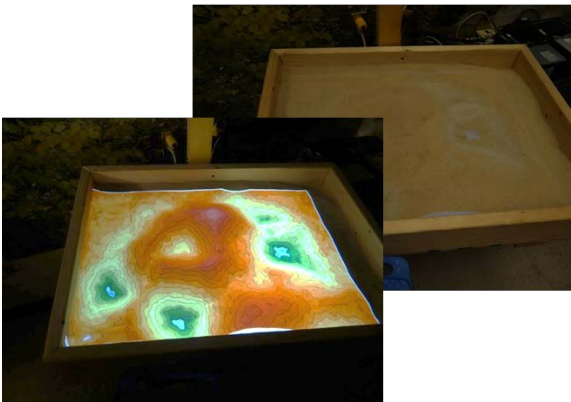
Images: Various watersheds built on a simulator.

Credit: [Jessie McDonald, Saint Cloud State Univ.](#)



Images: A regular sand box and the same sand box with the simulator turned on.

A regular sand box



The same sand box with the simulator

Image: A preschool child (4-yr) was playing on the simulator. While he was creating a landscape with sand, the simulator was measuring the landscape with a 3D sensor and overlaying real-time color-coded elevation and contour lines on the sand with a digital projector. Water can be introduced by a hand gesture. Realistic water flow is simulated by the computer.





Environment and Natural Resources Trust Fund (ENRTF)

2018 Qualifications

Project Title: Digital watershed simulator for K-12 education and outreach

Project manager: Zengqiang "John" Liu, Ph. D. Experimental Physics

Qualifications:

Dr. Liu is an Associate Professor at Saint Cloud State University. He is an expert in scientific instrumentation. Besides experimental physics, he is also experienced with electrical, mechanical, optical, and software engineering, public education and outreach. He also has interest and experience in environmental and agricultural data collection and system integration. He has designed and built numerous devices for scientific research, teaching, public demonstration, and outreach. Some of his devices, such as the Open-Source Physics Laboratory Data Logger, have received national recognitions from the American Association of Physics Teachers. Since the improvement of the simulator is highly technical and requires working knowledge from several disciplines, he will provide the technical expertise and overall leadership to the project. He will be heading the effort of task 1 and 3 and assisting Dr. Cheng with task 2.

Associate project manager: Jeffrey Cheng, Ph. D. Hydrology, P. E. (water resources engineering)

Qualifications:

Dr. Cheng is an Associate Professor at Saint Cloud State University. He is an expert in water resources and environmental science and engineering, especially watershed science and floodplain management. He is also an educator. He has worked with Minnesota DNR and MPCA on numerous hydrological research projects. He will be heading the effort of task 2 and assisting Dr. Liu with tasks 1 and 3.

Project responsibilities:

The project manager will be responsible for the overall management of the project to ensure its outcomes are achieved as planned and adjust priorities and workflow as needed. He will be responsible for writing progress reports and the final report. He will also be responsible for hiring student interns, approving purchases, and providing technical expertise in task 1, i.e. improving the design of the simulator, which is highly technical. He will also lead the effort in task 3 with technical support and evaluation. He will support the associate project manager who will lead the effort in task 2 to create content and provide training. Since both the manager and associate manager teach full time during semesters, a program coordinator is needed to offload daily tasks such as record keeping, student intern training, seminar, and event scheduling, purchasing, coordinating simulator build and repairs, and basic data analysis.

Organization description:

The Saint Cloud State University is a regionally renowned university at the heart of Central Minnesota. It offers over 200 programs including B.S. degrees in Hydrology, Earth science, Environmental Science, and a number of teaching B.S. degrees in science education including Earth Science Education. Dr. Liu and Dr. Cheng have both been in the front line of educating future science educators of Minnesota.