



### Engaging Interdisciplinary Faculty into Water Research for Successful REU Site and RET Site Programs

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INSTITUTE FOR CRITICAL TECHNOLOGY AND APPLIED SCIENCE VIRGINIA TECH. Tuesday, October 22, 2019 (1:30 – 2:45 p.m.)

EEC/NSF Grantees Conference, Arlington, VA.



#### Program



- Our REU and RET Site programs (25 min.)
  - Our REU Story Vinod
  - Our REU Scholar Erin
  - Our RET Story Vinod/Jeremy
- Group work Interdisciplinary Teams for REU and RET site Programs: Challenges & Opportunities – (20 min.)
- Break (5 min.)
- Program Evaluation
  - REU Site and RET Site Assessment work Vinod & Jeremy (15 min.)
- **Q&A** (10 min.)







#### **Our REU Story**

- In 2004, a colleague of mine from Virginia Water Resources Research Center (located on VT campus) and I started brainstorming an idea to put together an NSF/REU Site on interdisciplinary water science and engineering.
- Water research happens in various colleges (Engineering, Science, Agri. & Life Sc., Natural Resources & Environment, Architecture & Urban Studies) at VT
- We contacted various colleagues and submitted an REU Site proposal in Aug. 2004.







# REU Site (2007-2019): Collaboration of Faculty across Five Colleges at Virginia Tech

 Faculty and Graduate Student Mentors from COS, COE, CNRE, CALS, and CAUS.

COS – College of Science COE = College of Engineering CNRE = College of Natural Resources and Environment CALS = College of Agricultural and Life Sciences CAUS = College of Architecture and Urban Studies

 Theme: Interdisciplinary Water Science and Engineering







#### **NSF-REU Scholars**





























- 115 REU Scholars; 78 women, 37 men; 21% URM students
- Mentorship team: 25+ faculty and 80+ graduate students from 5 different colleges at VT





#### **Geographic Diversity of REU Scholars**



Location of REU Scholars' Schools: 2007-2019







#### **Current REU Site Program: Academic Departments**

Academic departments of host faculty/grad. students:

- Biological Sciences
- Civil and Environmental Engineering
- School of Plant and Environment Sciences
- Engineering Education
- Forest Resources and Environmental Conservation
- Geosciences

International Partner: Indian Institute of Technology, Madras (IITM), India

REU Site Host institution: Institute for Critical Technology and Applied Science (ICTAS)

Host lab: Learning Enhanced Watershed Assessment System (LEWAS) lab







#### **REU Site Implementation Details**



Professional Development Activities: Seminars, Field Trips, Presentations





#### Professional Development Activities: 10-week plan; Summer 2019



May 31	Summer Experience, Expectations, and Deliverables, 9 am- 11 am	Library Research Skills, 1:30-3:00 pm Amanda MacDonald
June 7	Strengths Finder Workshop, 9-11 am Michelle Crotto	Communicating Science Workshop, 1:30-3:30 pm Dr. Carrie Kroehler
June 14	5 min Presentation, 9-11 am	
June 21	Graduate Panel, 9-10:30 am	Writing and Presentation Review, 1:30-3:30 pm
June 28	Dr. Pruden's Presentation 9-11 am	Dr. Edward's Presentation, 1:30-3:30 pm
July 5		
July 12	Entrepreneurship Presentation, 10:30-11:30 am Dr. Matthew Hull	Communication Styles and Intergroup Dialogue, 1:30-3:30 pm Dr. Christian Matheis
July 19	10 min Presentation, 9-11:30 am	Hydroelectric Dam, 1:00-4:30 pm
July 26	Water Treatment, 8:30-11:30 am	Ethics Discussion, 1:30-4:30 pm Yousef Jalali
August 1	Summer Research Symposium 9 am-4 pm	
August 2	Concluding Ceremony	•









































#### **Publications**



#### **Total Number of publications: 58**

\*Indirect contribution of the REU fellows

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#### **Recent Publications**

18

- Basu, D., Lohani, V. K., & Muffo, J. A. (2018). Analysis of undergraduate research experiences in an interdisciplinary water science and engineering program. *International journal of engineering education*, *34*(1), 155-170.
- Jalali, Y., & Matheis, C., & Lohani, V. K. (2019, June), Ethics Instruction and the Role of Liberatory Praxis and Theory Paper presented at 2019 ASEE Annual Conference & Exposition, Tampa, Florida. <u>https://peer.asee.org/32758</u>
- Schulte, M.L., McLaughlin, D.L., Wurster, F.C., Varner, J.M., Stewart, R.D., Aust, W.M., Jones, C.N., and Gile, B. (2019). Short- and Long-Term Hydrologic Controls on Smouldering Fire in Wetland Soils, International Journal of Wildland Fire, 28, 3, 177-186.
- Qin, M., White, C., Zou, S., and He, Z. (2018). Passive Separation of Recovered Ammonia from Catholyte for Reduced Energy Consumption in Microbial Electrolysis Cells. Chemical Engineering Journal, 334, 2303–2307. DOI: 10.1016/j.cej.2017.11.190





#### **Other Research Contributions**

Media attentions

Examples:

- Fighting For Flint; Virginia Tech Magazine (Spring 2016)
- Water Experts to Convene Again, *Arizona Daily Sun* (Jan. 22, 2013).
- Awards and fellowships Examples:
  - In 2016, a first place award in the Technology and Engineering Category in the NSF/AAAS Emerging Researchers National Conference in STEM
  - In 2015, Woody Everett Award from Computers in Education Division of the American Society for Engineering Education
- **115 research papers** in the 12 REU Site proceedings: http://www.lewas.ictas.vt.edu/nsf-reu-site/reu-accomplishments
- Presentations at VT Symposium (2012 -19): <a href="https://research.undergraduate.vt.edu/our-services/sur.html">https://research.undergraduate.vt.edu/our-services/sur.html</a>









#### **REU Site: Key Lessons Learned**

- 1) Research projects for REU fellows and their roles should be clearly defined.
- 2) Professional activities should include a variety, e.g., seminars by research faculty members in academia as well as professionals from industries to help REU fellows think about their career options.
- 3) Multiple opportunities for oral presentations is very helpful.
- 4) Graduate students should challenge REU fellows to develop independent research skills.







#### **REU Site: Lessons Learned (Cont.)**

- 5) Activities that promote social interaction and professional bonding among scholars are as critical as the research activities.
- 6) Coordinators with university-level undergraduate research office is always helpful.
- 7) External assessment experts play an important role in site evaluation.
- 8) Documentation of research papers in the form of a research proceeding provides a source for ownership and pride to REU fellows.

Basu, D., Lohani, V. K., and Muffo, J., 2018. "Research Experiences for Undergraduates on Interdisciplinary Water Sciences and Engineering: Accomplishments in Nine Years," <u>International Journal of Engineering Education</u>, 34(1), pp. 155-170.



#### Program



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## NSF REU Site - Interdisciplinary Water Science and Engineering



# From REU to Ph.D.

Erin Milligan

Former REU and current Ph.D. Student in Department of Civil and Environmental Engineering, Virginia Tech



### Investigation of Microbial Contaminants in Drinking Water Systems in Rural Puerto Rico after Hurricane Maria

Objective: Characterize the spatial and temporal occurrence of microbial contaminants in six Puerto Rican drinking water systems six months after Hurricane Maria.

Personal Objective: Optimize and validate polymerase chain reaction (PCR) assays for seven pathogens.







treatment: n (1-6); house number sampled





## Timeline of an Environmental Microbiology Project

- Literature Review
- Experimental Design
- Environmental Sampling
- Filtering
- DNA Extraction
- Solid-phase Extraction
- Assay Validation
- Sample Analysis
- Sequencing
- Publishing









### REU Site: A Comprehensive Research Experience

Deliverables:

- Paper
- Poster, Presented at VT Summer Research Symposium
- Presentations
  - 5, 10, 15-min.
  - Peer feedback









### REU Site: Professional Development Activities

- Workshops: Engineering Ethics, Leadership, Strengths Finding, Entrepreneurship
- Field trips: Water & WWTP, Sedimentation Sites, VT Center for Sustainable Nanotechnology
- Lectures from VT Faculty
- Graduate Student Panel











### REU Site: Food, Fun, Lifelong Friends

- Hiking the Appalachian Trail
- Animal Shelter Volunteering
- Home-style Southern Cuisine
- Tubing on the New River
- Swimming under Waterfalls
- Farmer's Market
- Movie Nights









### Personal Trajectory

- Attended Ohio University from 2015-2019
- Participated in 2018 REU
- Received offers from three graduate schools
- Graduated with B.S. in Civil Engineering
- Pursuing Ph.D. in Civil and Environmental Engineering at Virginia Tech
- Received 2019 NSF GRFP







### Acknowledgements

- Dr. Vinod Lohani
- Dr. Amy Pruden
- Dr. Marc Edwards
- Dr. Emily Garner
- Ishi Keenum
- ICTAS Facilities







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#### NSF/RET Water E<sup>3</sup>G (Engineering, Ecology, Environment, Geosciences) (2017 - 2020)

Twenty-five teachers have participated to date

• Participants have been responsible for teaching over 100 students in the three years of the program.

Program Structure 10-week vs. 6-week Professional Development (PD)



Teacher's home institutions in rural Appalachia.

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gSuite for interdisciplinary collaboration

Poster as a major deliverable

Master Teacher Program







Our **Goal** is to provide teachers (grades 9-12 & community college) with interdisciplinary water research experiences that integrate perspectives from engineering, ecology, environmental science, and geosciences.



#### NSF/RET Water E<sup>3</sup>G Interdisciplinary Team

#### **Academic Departments**

- Civil and Environmental Engineering ٠
- **Engineering Education** ٠
- Geosciences ٠
- **Biological Sciences**
- Crop and Soil Environmental Sciences ٠

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- Forest Resources and Env. Conservation ٠
- RET Site Host institution: Institute for Critical ٠ Technology and Applied Science (ICTAS)
- Virginia Western Community College, Roanoke



Dr. Xia (CSES)







Dr. Pruden (CEE)



Dr. Edwards





Dr. Schreiber (Geosciences)

Dr. Dymond (CEE)

(Biology)

Dr. Brown (Biology)

Dr. He

(CEE)

Dr. Clark (VWCC Collaborator)





Dr. Hotchkiss (Biology)



Dr. McLaughlin (FREC)



Dr. Muffo (Assessment Expert)



(Curriculum Design

Expert)



#### NSF/RET Water E<sup>3</sup>G Schedule and Professional Development



- The six-week program takes place in the middle of summer. The chevrons at right show the 6-week breakdown in red, with the weekly breakdown in blue.
- Fridays are reserved for professional development and field trips. The teachers earn CEUs through the process, and are thrilled to earn money while doing so.

Mornings	A			
Workshop: Google suite for collaboration	Teacher host			
Research summary presentation	Learning act			
Dr. Edwards' (of Flint, MI renown) presentation	Learning act			
Workshop: Creating effective group work	Little River			
Workshop: Scholarship of teaching and learning	Water treatn			
NSF PIRE workshop with Dr. Pruden	Helmet lab			
Mountain Lake geomorpholog	gy and karst ti			
VT symposium and poster presentations				









### NSF/RET Water E<sup>3</sup>G Master Teachers (MTs)

Some of the most successful Teachers recruited for the Master Teacher Program

MT Responsibilities

- Provide substantial curricular materials
- Help account for previous Teacher dev. status
- Assist other teachers with content development
- Continuation of previous research

**Professional Development** 

- Virginia Western Community College (VWCC) PD day
- New building (\$37M price tag) with (\$300k water flume)
- Build learning community
- MT initiative to help launch PD for local teachers
- Teachers can use facilities, hardware and tools
- Panel session by MTs at 2019 VAST Conference (Nov. 2019)

Deliverables are reviewed 3x

AND APPLIED SCIENCE

- First by MTs for general requirements meeting
- Second by the facilitating lab (LEWAS)
- Third by the hosting lab for technical proficiency







# Graduate Student Mentor Experiences and Lessons Learned REU & RET

#### **Gantt Charts**

- Project Management
- Efficient use of short timelines improves agency
- Virtual planning and thought experimenting
  - Exports to .csv
  - Overhead-free
- Microsoft Project/Asana/OpenProject
- Freeplane/coggle/MindMeister for concept mapping (.mm)

											PH	ASE	ONE											PI	IASE	тwo	1				
WBS NUMBER	TASK TITLE	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE		W	EEK 1	1		١	WEEK	(2			WE	EK 3									<b>K 5</b>				EK 6	
						м	т	w	R	FM	Т	w	R	F	м	т	w	RI	= M	Т	w	R	F	мт	w	R	F	M	тν	V R	F
1	Planning study and initial literatu	ire reviews																													
1.1	Establishing use case/study focus	5/21/18	6/3/18	12	100%																										
1.1.1	Reading literature	5/22/18	6/3/18	11	100%																										
1.3	Making notes/Summarizing on literature	6/3/18	6/5/18	2	95%																										
2	Project Definition and Planning																														
2.1	Identifying VR Technology to implement on	5/25/18	6/7/18	4	100%																										
2.2	Review/Place order	5/23/18	6/9/18	3	0%																										
2.3	Outlining experiemtal procedure	5/30/18	6/10/18	0	90%																										





REU Plan	10 wks
Titration	
4 W1: Introductory week, JS&DH out	2 days
Investigation of Automatical Automatica	1 day
After Lunch Kelly meeting w/ Lohani &	1 day
Familiarize with the Lab	2 days
Get set up in McBryde	1 hr
View the website, iDisplay site	0.38 days
Methods and Equipment	1 hr
Case Studies	1 hr
Education and Outreach	1 hr
Itt Review (VR, VE, Visualization)	1 wk
Places to look: ACM, IEEE, Frontiers	



# Graduate Student Mentors' Experiences and Lessons Learned REU & RET

#### **Curricular Similarities**

**Engineering Design Methods** 

- Concept maps to organize thoughts and reduce perceived abstraction
- KJ Technique for group brainstorming
- House of Quality for project requirement alignment with technical specifications

Relationships ++: Strong Positive + : Medium Positive											
- : Medium Negative	Function Requirements										
Strong rositive	Р	rogramming	B	Mechanical							
Technical Requirements	Trigger	Run/End	Notify	Take Sample	Transfer to container	Multiple Sampling	Preserve				
Programmable Interface	++	++	++								











#### Think, Pair, Share: 20 min.

Please get together w/ your neighbor and discuss for 10 min.:

- (a) Your key motivation to attend this workshop
- (b) Your prior REU and/or RET Site or similar experiences
- (c) Challenges in developing an interdisciplinary team
- (d) Opportunities on your campus (Collaborations, Infrastructure, etc.)

We'll seek feedback from you (10 min.)





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#### Purpose:

- a) To determine if the program has achieved its goals (summative assessment)
- b) To gain feedback about the program components while it is in progress, so that it can be improved (formative assessment)







#### **Assessment : REU Expert Evaluation (Focus Group)**



#### What did you like about the program that you just completed?

- Interaction with graduate students and faculty.
- Exposure to things in academia such as papers, presentations, literature reviews, etc.
- Independent research with some guidance
- Good balance between research work and the social activities and the professional development and the Friday meetings with each other.
- Expansion of view of what you can do with water.
- Know better the employment opportunities regarding water within academia but not outside of academia.







#### **Sample Questions**

- How has the REU Program at Virginia Tech influenced your thoughts about your academic plans?
- How has the REU Program at Virginia Tech influenced your thoughts about your career plans?
- Which aspects of the REU Program had the most positive impact on you and why?

#### **Sample Comments**

- "The REU Program at Virginia Tech provided me with the invaluable opportunity to publish my first academic peer-reviewed paper. This experience has made me realize that I enjoy writing and sharing my scientific findings with others. I plan to earn my Master's Degree (possibly in Earth Sciences) in the future, and I feel that my publication (made possible via the Virginia Tech REU program) will improve my application's competitiveness."
- "I went into the wastewater and water field. My interest in wastewater processing was piqued by the REU."
- "Conducting a small research study where I was the main one responsible was very beneficial to get a taste of the entire process before committing several years to a larger project."
- "I had never taken on such an independent role in a research project before the REU program. Learning how to devise a specific research question, collect data using unfamiliar equipments and techniques, analyze the collected data, and present my findings to colleagues through a variety of media was a new, positive experience for me."





#### Assessment Summary (2017-2019)



#### Number of questions in questionnaire

Year	Pre-test	Post-test
2017	19	22
2018	19	21
2019	19	22

\*16 Likert scale questions, cultural intelligence scale, and open-ended questions.

#### Number of focus group questions

Year	
2017	11
2018	11
2019	13

#### Sample assessment question for each evaluation goal

	_
Evaluation Goals	Sample Assessment Questions
Promoting graduate studies	I am considering attending graduate school as one of my career options after I graduate. (entry & exit survey)
	How many of you are motivated to go to graduate school now? – did the NSF REU influence your motivation? (focus group)
Fostering communication skills	I know how to communicate my research findings orally and by documenting it in a research paper. (entry & exit survey)
	How do you think that your communication skills improved as a result of this program? [Probing questions – Verbal? Written? Cohort Presentation? Other?] (focus group)
Improving research skills	I know everything that I need to know to conduct research in the library. (entry & exit survey)
Developing independent researchers	I am confident that I understand how to conduct scientific research independently (entry & exit survey)
Improving understanding of ethics and professional responsibility	I have a good understanding of the role of ethics in scientific investigations. (entry & exit survey)
Likert Scale for entry and exit surveys' closed ende	d questions:

1 = Strongly Disagree; 2 = Disagree; 3 = Neutral/No Opinion; 4 = Agree; 5 = Strongly Agree







#### **Assessment Summary Report**



Analysis of REU assessment data- 16 Likert Scale questions

**2017 2018 2019** 

The differences between the average of the entry and exit survey scores (5 point Likert scale data) over past 3 years (2017-19).

The most positive changes have been demonstrated in response to the following statements over three years:

I am confident that I understand how to conduct scientific research independently (+3.7) I know everything that I need to know to conduct research in the library (+3) I am aware of the many ways in which scientists from different fields interact with each other in conducting research in water sciences (+2.9)







#### **Assessment Summary Report - Dr. Muffo Comments**

- It seemed to be a positive experience overall all three years.
- It was an intense exploratory experience for the students. They got to try out being graduate students for ten weeks without having to be enrolled as graduate students. During that time they also got to interact with those who were experiencing being graduate students and were mentored by them as well as by research project principal investigators (PIs).
- As a result of the experience, a majority decided to continue on to graduate school, but a distinct and sometimes substantial minority decided to pursue other interests.
- Many reported improvements in: oral and written communication skills; better understanding of the roles of graduate students and faculty in research; conducting research in the library; ability to conduct research independently; and awareness of the ways in which scientists in different fields interact with each other.
- In terms of decreases, there was no clear pattern over the three-year period. In 2017 and 2019 there was a decrease of students intending to go to graduate school, but that was not the case in 2018, when there was an actual increase. Likewise there were decreases in those needing help from others in conducting scientific research in 2017 and 2019 but not in 2018, when there was little change...





#### Alumni Survey- 2019



#### Implementation

- 13-16 items questionnaire
- Implemented in March 2019
- 29 responses

Number of participants





#### **REU alumni's education/career status**



Undergraduate students' decision on highest level of education





#### **Assessment : NSF/RET Site Goals**

#### **Purposes:**

a) To determine if the program has achieved its goals (summative)

b) To gain feedback about the program components while it is in progress, so that it can be improved (formative assessment)







#### Assessment : RET Program Results : Focus Group



- We got to do things we would not normally get to do, like setting up the experiment and going out into the field. These are normally outside of the parameters of what we get to do in our usual jobs. That was enjoyable.
- Somebody is paying us for professional development for a change, like other professions, rather than us having to pay for our professional development. It's nice to be treated like a professional...
- It was surprising how many people outside of the program who were tremendously helpful as well. There were many networking opportunities that led to others who are now helping us work with the schools. ... We found people at (Virginia) Tech willing and even eager to help us. We can see bringing our students back to visit some of the labs from Friday site visits.
- I did like the field trips. It is not always easy to get *access* to those places.
- Tour somebody else's labs... allow more time for collaboration with other teachers... for science.





#### Assessment: RET Program

#### Implemented new instruments geared toward Teachers

#### **Concerns-Based Adoption Model (CBAM)**

- Two instruments: Survey & Interviews
- Developed in the 1970s

#### **Creative Achievement Questionnaire (CAQ)**

- Measures individual achievements and recognitions in nine artistic and scientific
  - domains: 1. Visual arts 6. Music
    - 2. Writing 7. Invention
    - 3. Humor 8. Science
    - 4. Dance 9. Culinary
    - 5. Drama





1: Hadley Wickham et. al., <u>https://www.r-project.org/logo/</u>, accessed 6/10/2018

LEARNING ENHANCED WATERSHED ASSESSMENT SYSTEM



#### **Assessment : RET Program Results : CBAM**

#### **CBAM Stages of Concern Questionnaire**

- Adapted to Qualtrics
- Pre- and Post-

CBAM Levels of Use structured interviews performed to follow up on teaching module implementations

- Other notables
  - Increased confidence to perform research
  - The most creatively achieved teacher had an outstanding number of implementations (3)



Level	Level of Use	Description
0	Nonuse	Little to no action
Ι	Orientation	Information gathering
II	Preparation	Preparation for first use
III	Mechanical Use	Use w/o reflection
IVA	Routine	Reliable use with few changes
IVB	Refinement	Continual adaption & improvement
V	Integration	Collaboration w/ others to improve
VI	Renewal	Large improvement & reevaluation

More results can be found in: Smith, J. D., & Lohani, V. K. (2019, June), *An Interdisciplinary RET Program: Assessment with Concerns-Based Adoption Model (RTP)* Paper presented at 2019 ASEE Annual Conference & Exposition , Tampa, Florida. https://peer.asee.org/32075





#### NSF RET Ecosystem Model (with Dr. Laura J. Bottomley)

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Based on ecology luminary Odum's "Energese" language nvestigators National Science • Public Funding, \$ (Faculty) Foundation Money and energy flow in opposite directions 0 NSF/RET Ecosystem Proposal Grant is Generation Percent Percent Nonwhite Urban University Site Scientific Represente Research 0.067 National Science Investigators -0.531 +0.670 Minority Foundation (Faculty) +0.264 Public Funding ÷ White Nonwhit Education Income Predomina Learning Populatio Professional Module +0.386 Development Developmer Nonwhite Income Learning K12 Teachers Module Production Consumption Energy Sink Compnent Interaction Source Subsystem Subsystem



Students

K12 Student

Learning



LEARNING ENHANCED WATERSHED ASSESSMENT SYSTEM



Collaborative Research: An Interdisciplinary Approach to Prepare Undergraduates for Data Science Using Real-World Data from High Frequency Monitoring Systems: Oct. '19 - Sept. '23; \$2M; IUSE/NSF

Faculty Team: Ten faculty including 4 REU/RET Site faculty from VT

**Goal**: To develop and implement an interdisciplinary collaborative approach to enable undergraduate students to develop Data Science expertise through various STEM+C disciplines including engineering, computer science, environmental science and biology.

**Partners**: Virginia Tech (lead), NCA&T State University, Vanderbilt University

Courses: VT: Hydrology, Ecology, Environmental Monitoring NCA&T: Hydrology, Engineering Statistics, Ecological Engineering Vanderbilt: Data Science Methods for Smart City Applications, Reliable Distributed Systems

#### High Frequency Data Sources:

Learning Enhanced Watershed Assessment System (LEWAS) Lab, Virginia Tech SMART City Lab, Nashville, Vanderbilt Univ.







### Thanks for your attention!

**Questions?** 



