

Creative Approaches to Promote Interdisciplinary Research: Experience from REU and RET Sites

Dr. Vinod K. Lohani, Professor, Dept. of Engineering Education

Director, Education and Global Initiative, Institute for Critical Technology and Applied Science (ICTAS)

Jeremy Smith, PhD Student, Dept. of Engineering Education

Debarati Basu, PhD Candidate, Dept. of Engineering Education, Virginia Tech

Eileen Cahill, REU Scholar



LEWAS - Learning Enhanced Watershed Assessment System

NSF EEC Grantees Conference, Arlington, Virginia

10/30/2017

Workshop Overview

Introduction (30 min)

Overview of our REU Site program

Active participation 1 (verbal) (7 min)

Brief discussion of REU Site impacts

Active participation 2 (written) (8 min)

Evaluation and Findings (20 min)

REU Site evaluation

REU fellows' research contribution

Lessons learned from REU Site

RET evaluation

Research to Practice (10 min)

Undergraduate Experiences

Graduate Student Experiences

Closing Thoughts

NSF/REU Site on Interdisciplinary Water Science and Engineering: Virginia Tech

- **Started in 2007**
- **Implementation of the 4th Cycle in progress**



REU Fellows:

- 95 REU Scholars
- 62 women, 33 men
- 18% underrepresented

Mentorship Team:

- 22 faculty
- 80+ graduate students
- 5 colleges at VT

REU Site Goals

- 1) To expand undergraduate students' participation in **interdisciplinary water research** projects
- 2) To encourage undergraduate students to pursue **graduate education**
- 3) To develop a diverse, internationally competitive and **globally engaged scientific and engineering workforce**
- 4) To develop undergraduates into **independent researchers**, rather than dependent learners.



REU Site Faculty Mentors



Dr. Dietrich
(CEE)



Dr. Xia
(CSES)



Dr. Lohani
(EngE)



Dr. Widdowson
(CEE)



Dr. Pruden
(CEE)



Dr. Carey
(Biology)



Dr. Vikesland
(CEE)



Dr. He
(CEE)



Dr. Muffo
(Assessment
Expert)



Dr. Younos
(NGO)



Dr. Hagedorn
(CSES)



Dr. Scott
(BSE)



Prof. Kennedy
(ID)



Prof. Sharma
(I.D)



Dr. McLaughlin
(FREC)



Dr. Dymond
(CEE)



Dr. Edwards
(CEE)



Dr. Irish
(CEE)



Dr. Benfield
(Biology)



Dr. Hester
(CEE)



Dr. Little
(CEE)

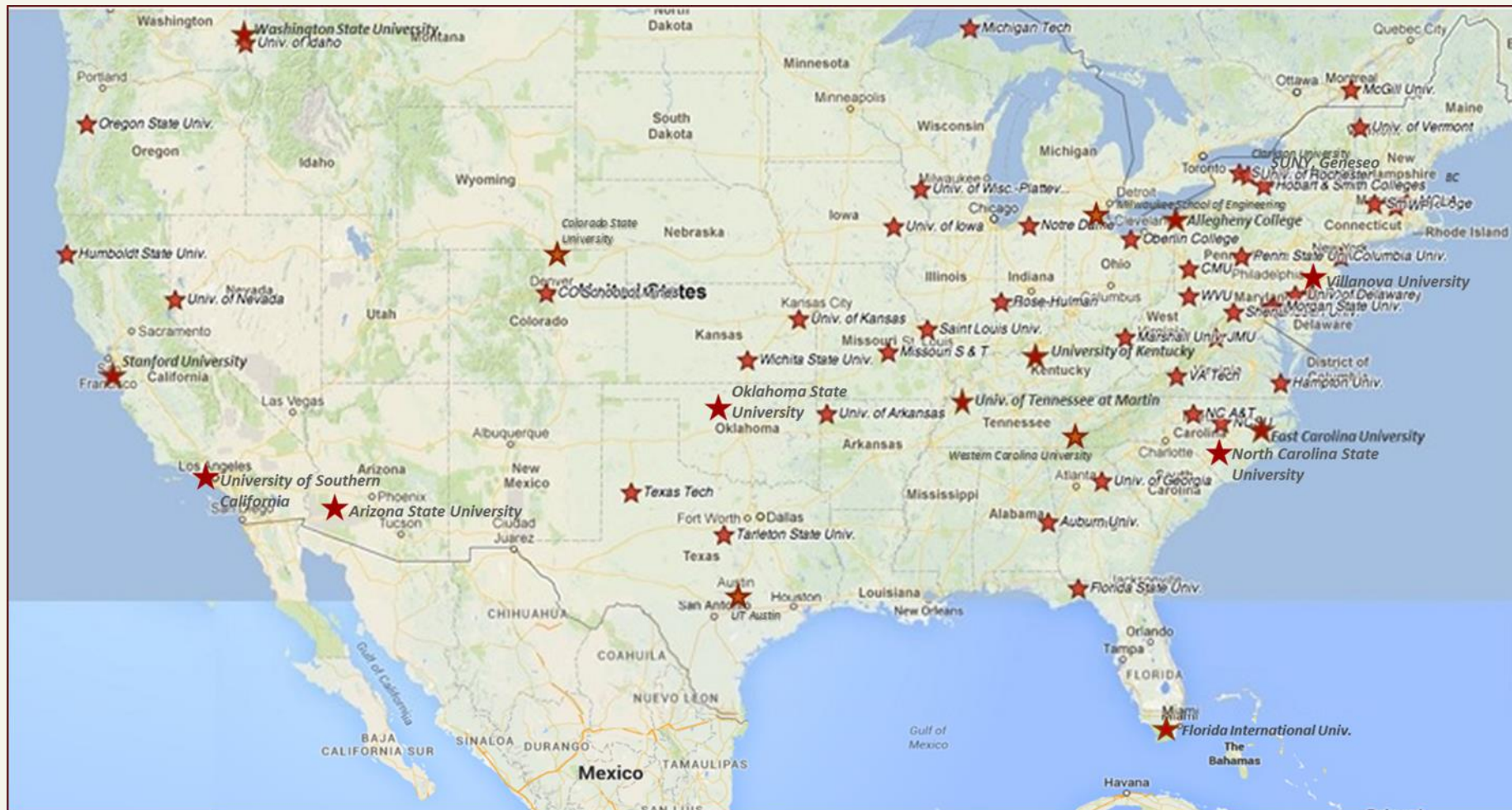


Dr. Weiss
(Geosciences)



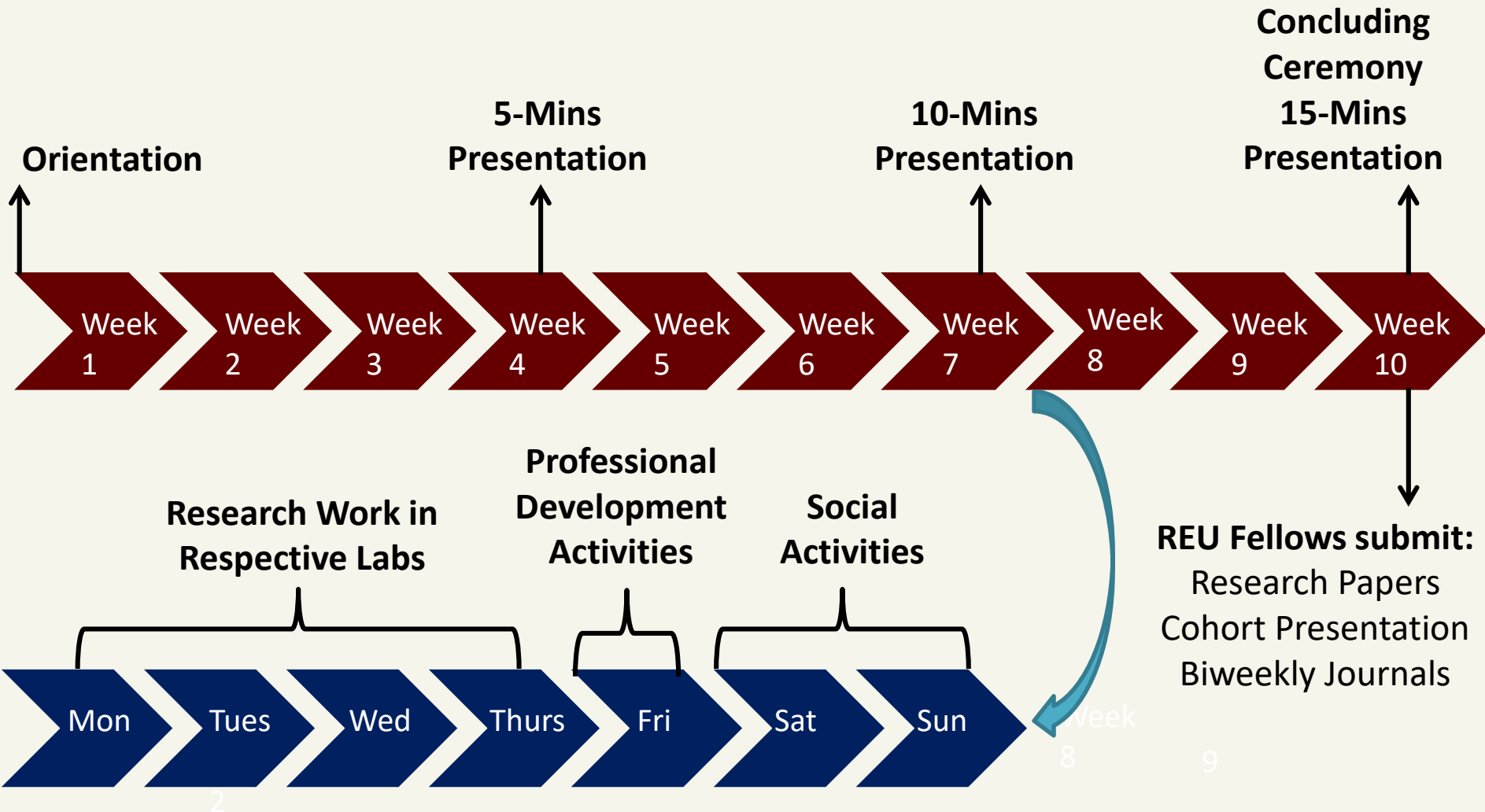
Dr. Schreiber
(Geosciences)

Geographic Diversity of the REU Site Fellows



★ Denotes location of REU Fellows' Schools until 2017

REU Site Implementation Details



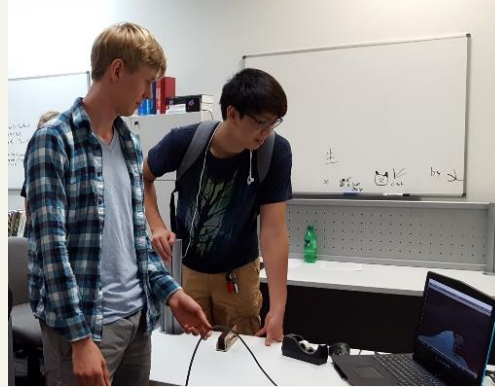
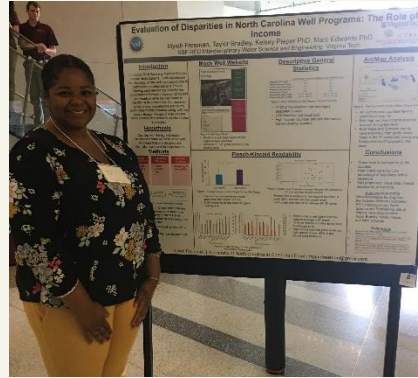
Professional Development Activities: Seminars, Field Trips, Presentations

Two New Features for the 4th Cycle: 2017-2020

- 1) An international component, which is being implemented in collaboration with a prestigious engineering institution in India (i.e., the Indian Institute of Technology, Madras), with faculty mentors from both countries (US and India)
- 2) Collaboration of some REU fellows with high school teachers recruited in an RET Site



Research Activities of the REU Fellows



Professional Development: Seminars



Professional Development: Field Trips



Social Networking Opportunities



Active Participation 1

(verbal feedback, 7 mins)

Share your thoughts regarding the possible impacts of an REU Site that has been operational for 10+ years...

Impact of the REU Site Program at Three Levels

Department & College

- Development/enhancement of an interdisciplinary laboratory: the **Learning-Enhanced Watershed Assessment System (LEWAS)**
- Use of LEWAS-based instruction in various engineering courses (Freshman Engineering, Civil Engineering, etc.)
- Research infrastructure for graduate and undergraduate students

University

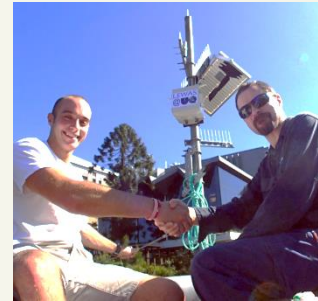
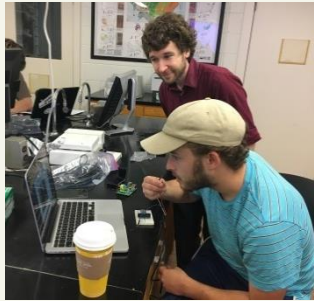
- LEWAS use at other VT Colleges (Ex., Science, Agriculture, etc.)
- Inspired interdisciplinary undergraduate research program (Institute for Critical Technology and Applied Science (ICTAS) REU Grants Program)

Regional & Global

- LEWAS utilization outside of Virginia Tech
- Community colleges, KLE Tech (India), Univ. of Queensland (Australia)
- Implementation of NSF RET Site Program on interdisciplinary water science
- Miscellaneous (Ex., C2Gen Course)

Department / College Level Impact

Enhancement of an Interdisciplinary LEWAS Lab

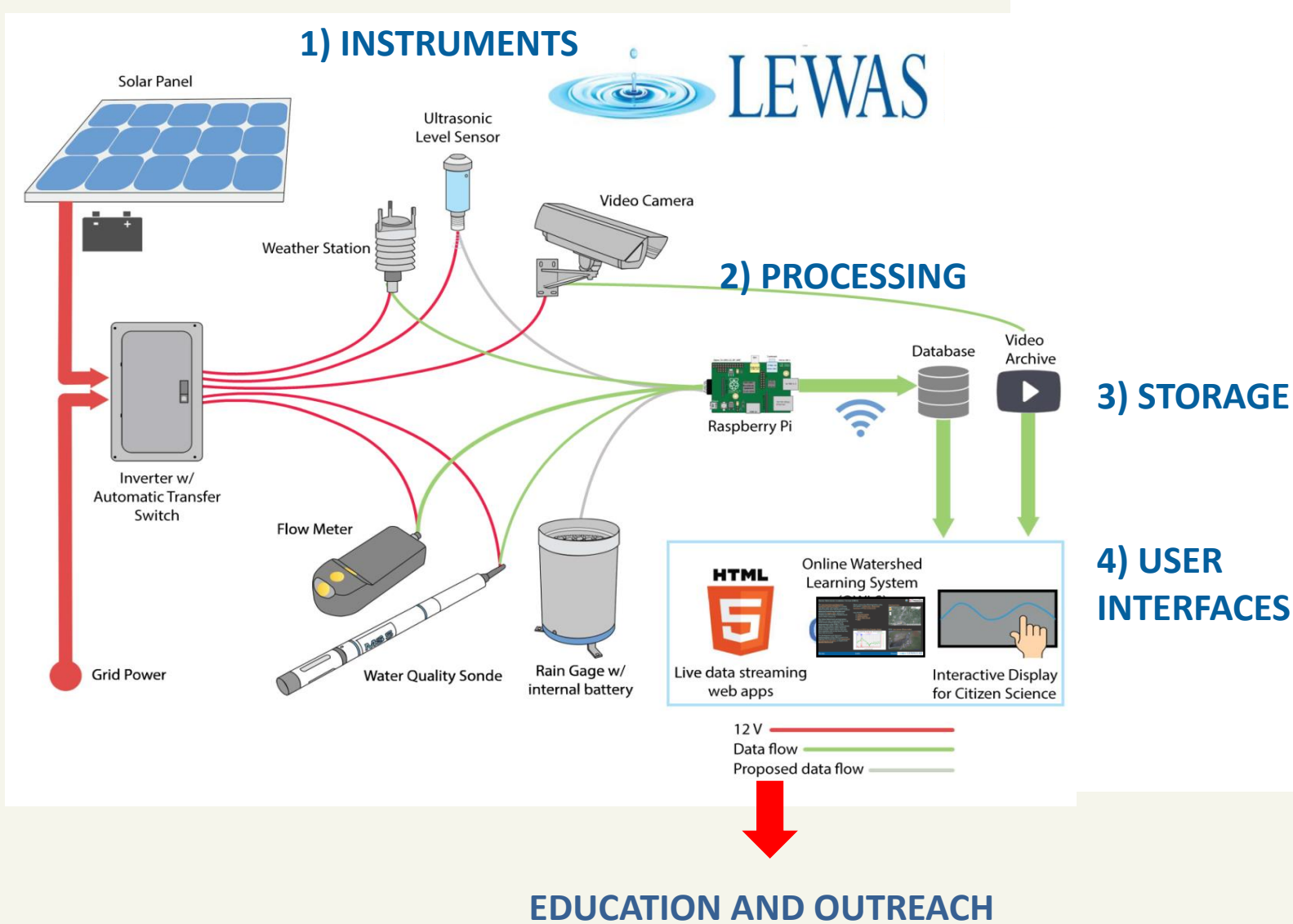


LEWAS Lab Team Members' Backgrounds:

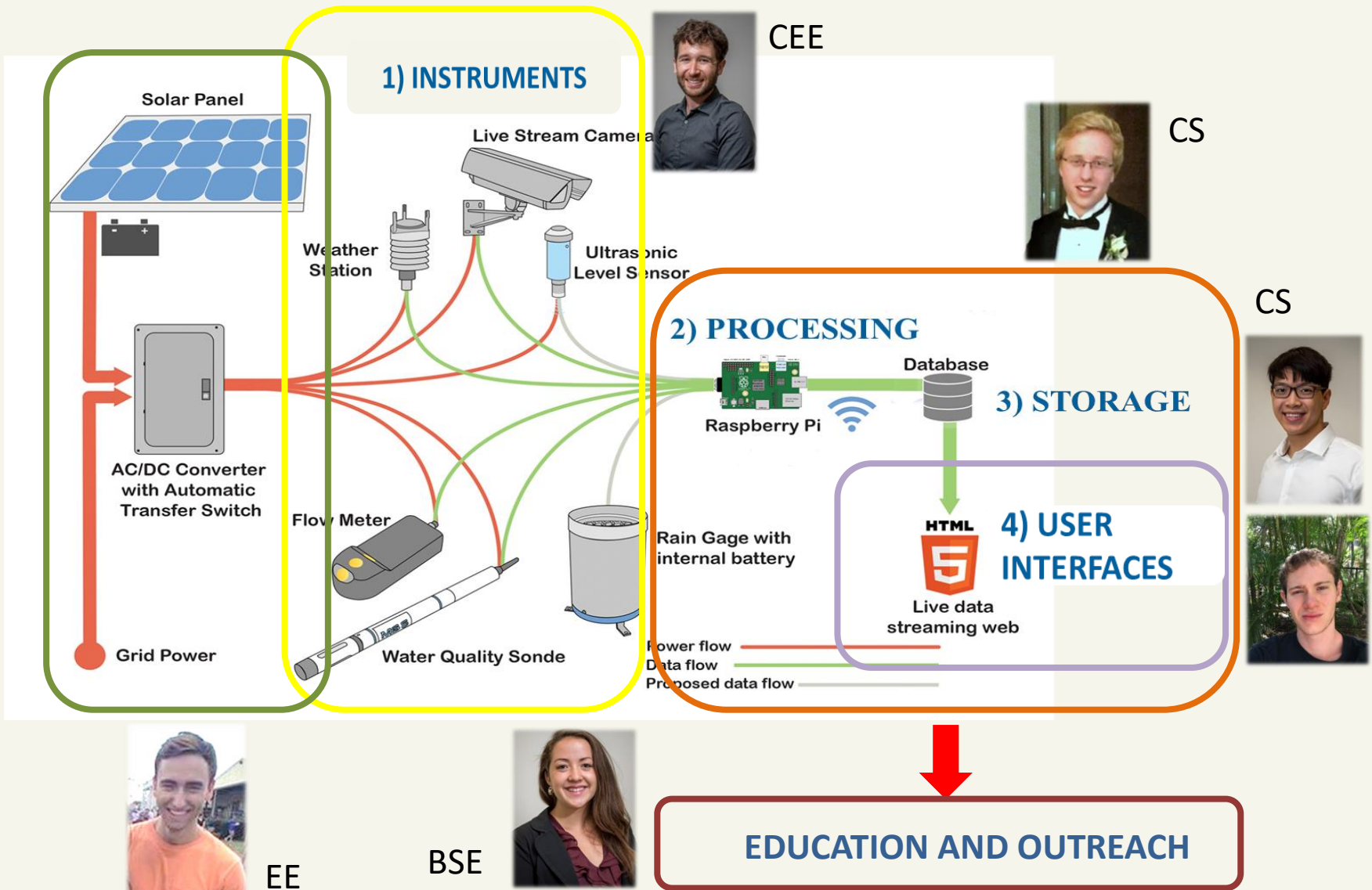
- Civil & Environmental Engineering
- Electrical Engineering
- Engineering Education
- Mechanical Engineering
- Biological Systems Engineering
- Computer Science
- Business Analytics
- Chemical Engineering
- Industrial Systems Engineering



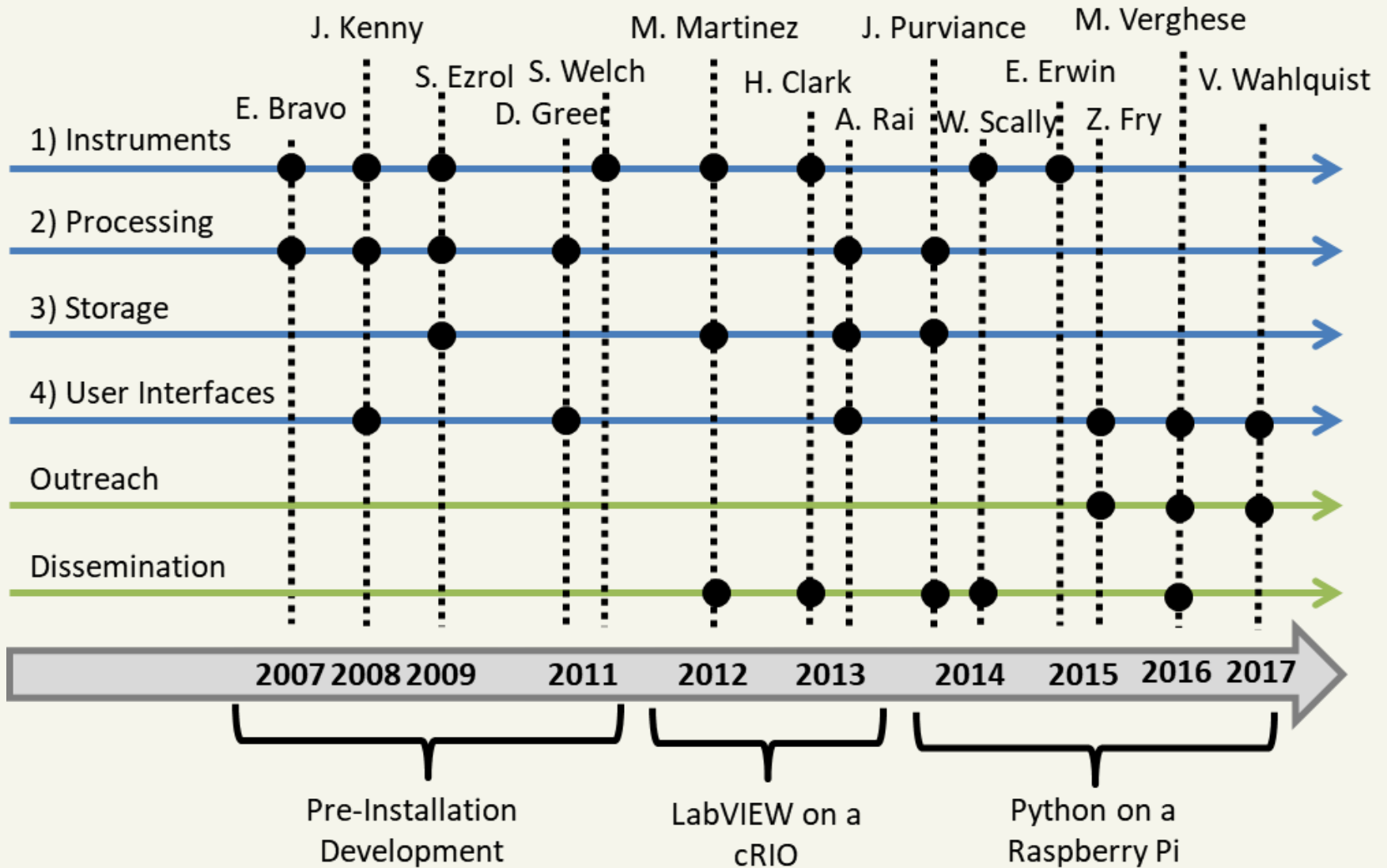
Interdisciplinary System



Current Undergraduate Students' Contributions



Contributions to LEWAS lab: 14 REU fellows



LEWAS within Our Department/College this Semester

Department: Engineering Education , Civil Engineering

Courses at various academic levels:

- *Foundations of Engineering (ENGE 1215, ENGE 1414)*
- *Intro to Environmental Engineering (CEE 3104)*
- *Hydrology (CEE 4304)*

**Two PhD Dissertations
Completed
Three Dissertations
Ongoing**

Total Number of Students Engaged: 340 (400 by the end of semester)

Purpose: Environmental Monitoring and Analysis with Real Time Data



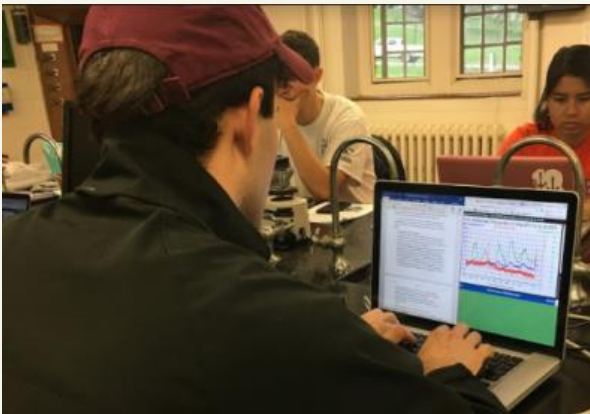
University Level Impact

LEWAS/OWLS Instructional Use at Virginia Tech

Virginia Tech, Blacksburg, VA, USA

College of Engineering

- ENGE 1024: Engineering Exploration (F09-S14)
- ENGE 1215: Foundations of Engineering (F16, F17)
- ENGE 1216: Foundations of Engineering (S15)
- ENGE 1114: Exploration Engg. Design (F17)
- CS 3114: Data Structures and Algorithms (F15)
- CEE 2814: CEE Measurements (F15)
- CEE 2804: Intro to Civil Engg (F17)
- CEE 3314: Water Resources Engineering (S13, S15)
- CEE 4304: Hydrology (F12, S14, S15, S16, F16, F17)
- CEE 5734: Urban Hydrology (S15)
- BSE 3324: Small Watershed Hydrology (F16)



College of Science

- GEOS 1124: Resources and the Environment (F13)
- GEOS 4804: Groundwater Hydrology (F13, F16)

College of Agriculture and Life Sciences

- CSES/ENSC 4314: Water Quality (S15, S16)
- ENSC 4414: Envir. Monitoring and Analysis (S16, S17)

College of Architecture and Urban Studies

- IDS 2016: Industrial Design Lab II (S16)

College of Liberal Arts and Human Sciences

- AHRM 4604: Housing: Energy & Environment (S16)

College of Natural Resources and Environment

Principles of Watershed Hydrology (FREC 3104)(S16, S17)

Research Infrastructure for other Departments

- One (1) Doctoral work in Civil and Environmental Engineering
- Six (6) Masters in Civil and Environmental Engineering
- One (1) Masters in Crop and Soil Environmental Sciences



LEWAS Data Use Throughout the University

“I cannot express enough how much LEWAS has assisted with expedient notification and review.”

- Professional Engineer Plan Review/Inspector

“LEWAS has certainly helped us here in SID track illicit discharges ... still flummoxed by the exceedances we are seeing.”

- Professional Engineer Stormwater Compliance Manager

“... the university plans to add about 3 million square feet of new development in the next 30 years ... the existing floodplains might change over the course of three decades ... make sure *VT doesn't make any (rash) decisions* with respect to building placement.”

- Delegate to the Graduate Student Assembly, Student in Geosciences

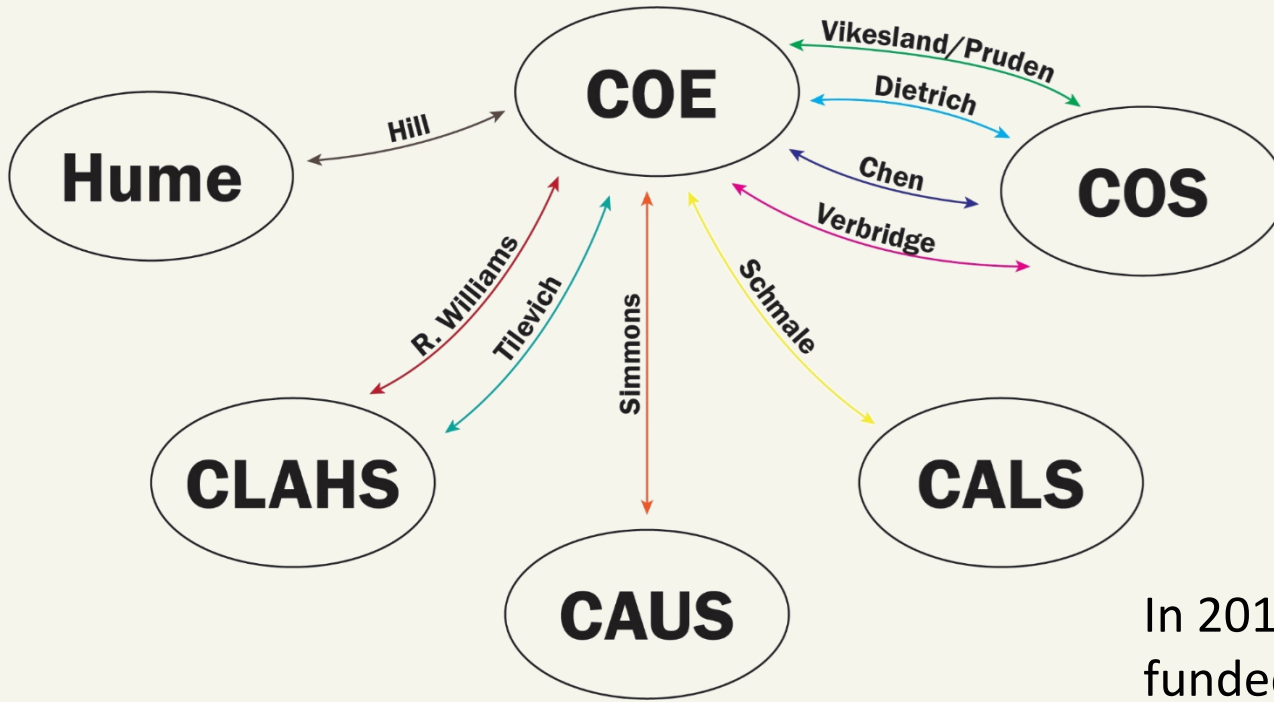
ICTAS REU Grants: Objectives

- To provide seed funding to faculty teams to engage undergraduates from, preferably underrepresented groups, in interdisciplinary research during the academic year.
- To increase VT's proposals to NSF's REU Site program and IRES program.



ICTAS REU Poster Session
April 21, 2017

ICTAS REU 2016 Award Recipients



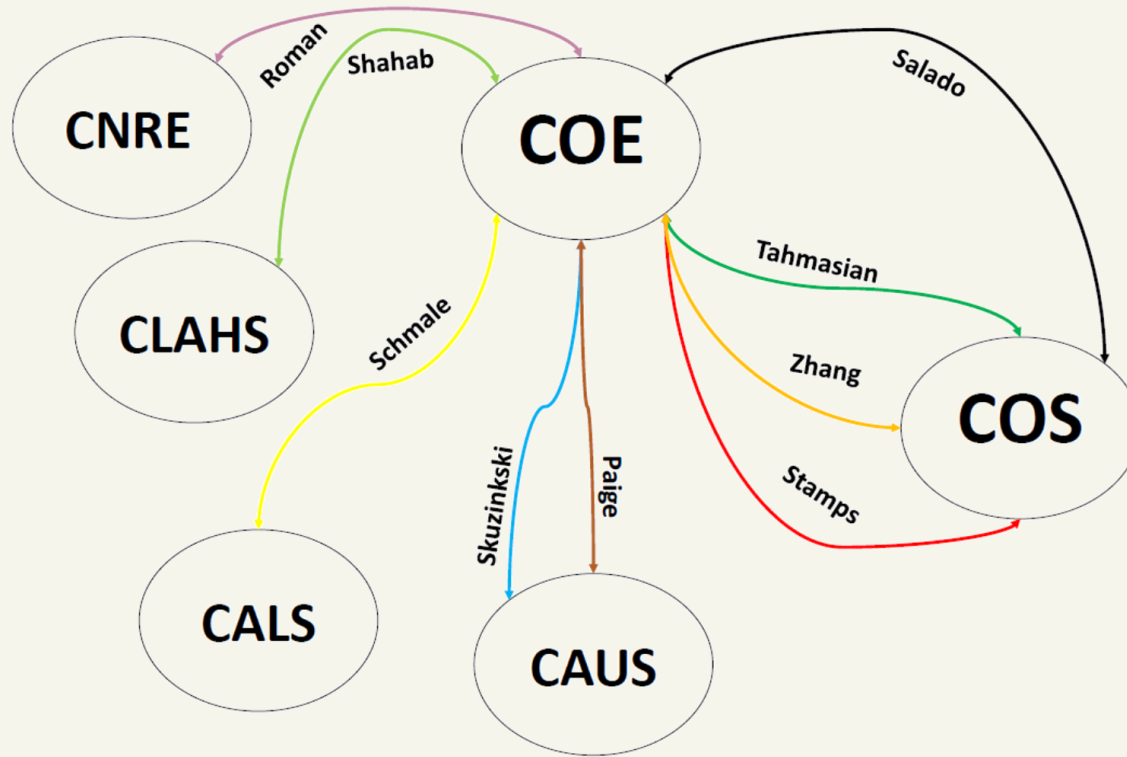
Nanotechnology and Antibiotic Resistance
Efficient Radio Spectrum
Big Data and Nanoscale Imaging
Host-Pathogen Interactions
Transforming Bio and Engineering with Education
Health and Intelligent Infrastructure
Computational Music
Autonomy at Scale
Space Communications

COE: College of Engineering
CNRE: College of Natural Resources and Environment
CLAHS: College of Liberal Arts and Human Sciences
CALS: College of agriculture and Life Science
CAUS: College of Architecture and Urban studies
COS: College of Sciences

In 2016, awarded 9 faculty and funded each at \$10,000

- 24 ICTAS REU scholars including 15 from underrepresented groups were engaged in undergraduate research
- 34 faculty members across 5 colleges and Hume Center collaborated

ICTAS REU 2017 Award Recipients



Bioinformatics and Statistics

Data Analysis and Encoding for Geosciences

Resilient Communities

Robotics and transportation

Digital Gaming and Education

Cell Sorting and Dance

Environment and Nucleation

Biosurface Engineering

Case Study Learning

COE: College of Engineering

CNRE: College of Natural Resources and Environment

CLAHS: College of Liberal Arts and Human Sciences

CALS: College of agriculture and Life Science

CAUS: College of Architecture and Urban studies

COS: College of Sciences

In 2017, awarded 9 faculty and funded each at \$10,000

- 30 ICTAS REU scholars including 22 from underrepresented groups are engaged in undergraduate research
- 28 faculty members across 6 colleges

Regional and Global Level Impact

LEWAS: K-12 Education and Outreach

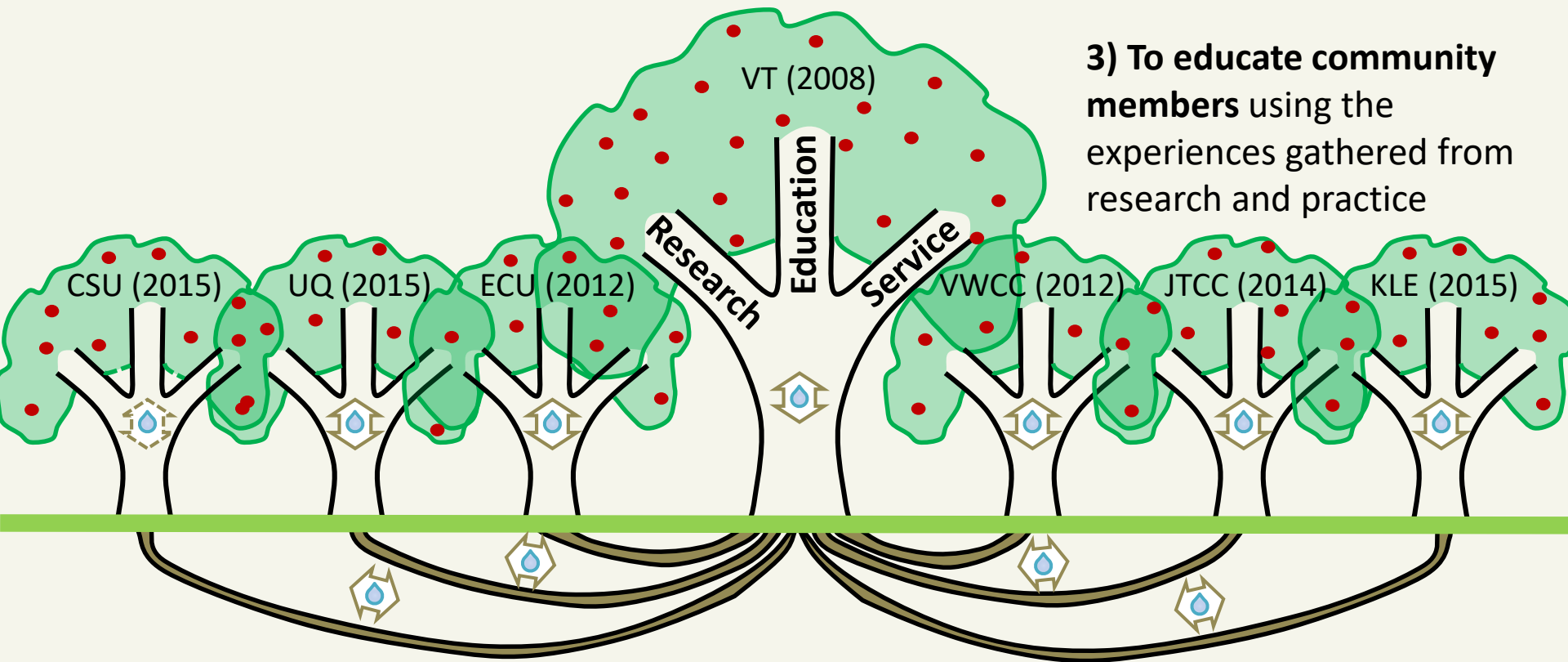


Collaboration for an IUSE/NSF Proposal



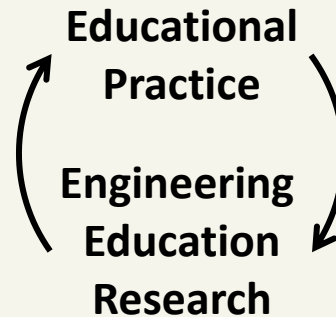
HBCU Summit, October 15-16 2017: Colleagues and students from North Carolina A & T visiting the outdoor field site

LEWAS Lab use Globally



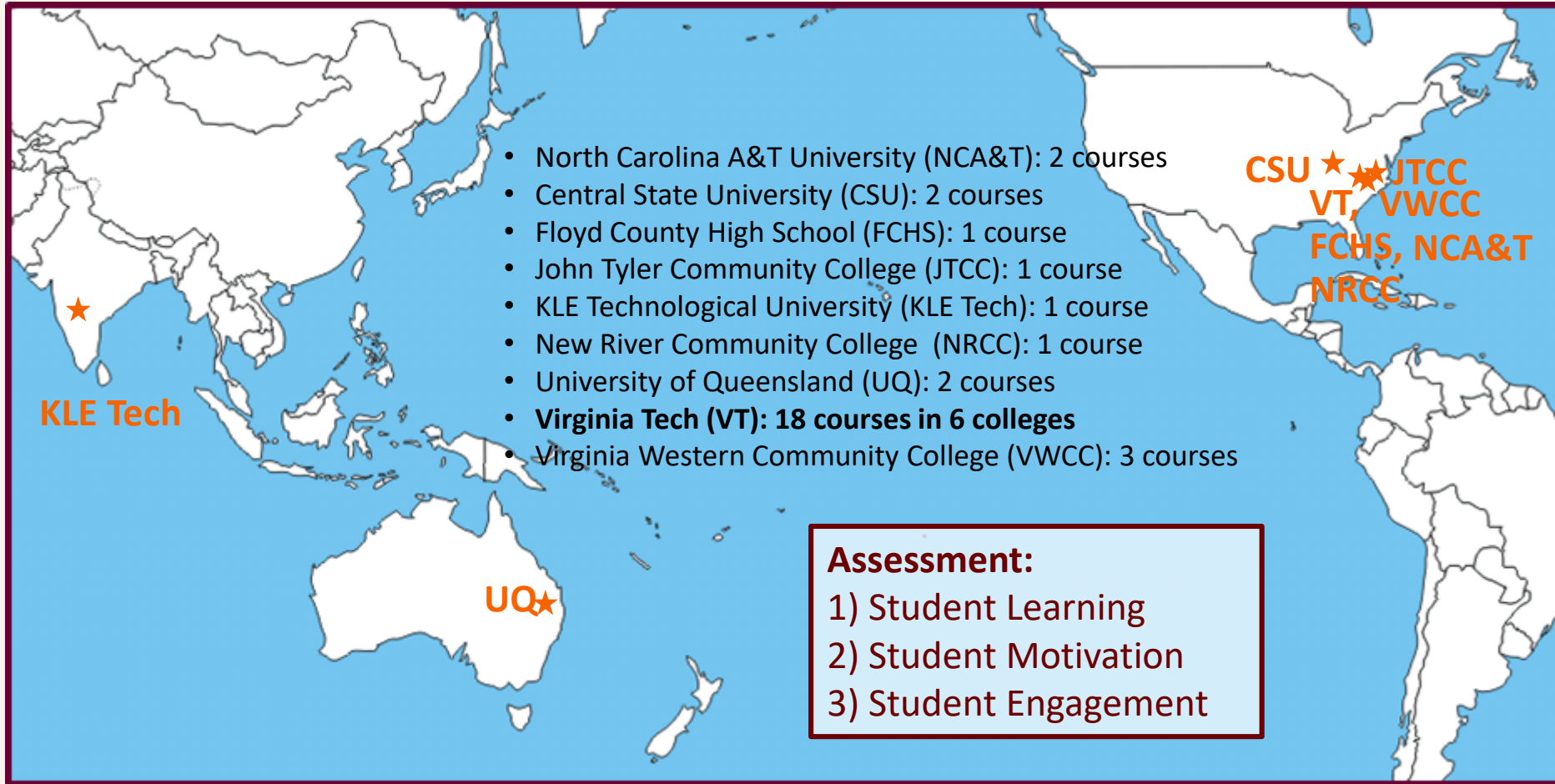
3) To educate community members using the experiences gathered from research and practice

1) To engage in **interdisciplinary research** with cutting-edge technology for advancing environmental monitoring education



2) To bring this **research into practice** by educating both engineers and non-engineers with hands-on authentic problems

LEWAS/OWLS Use in Instruction, Globally

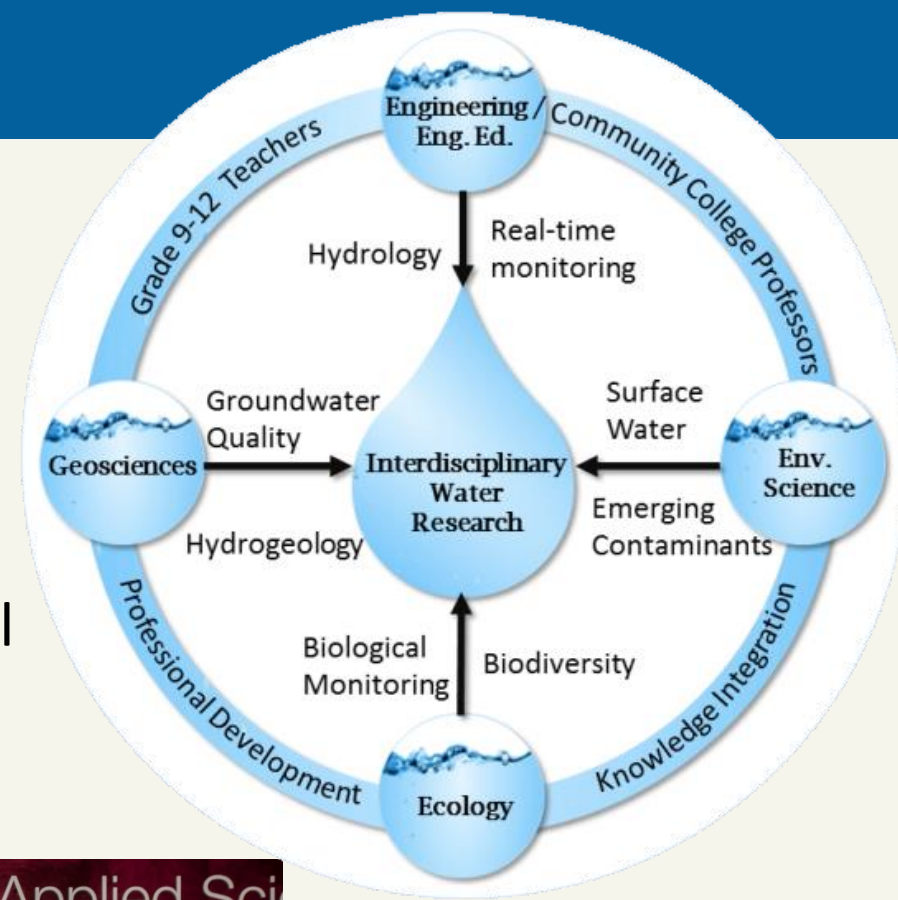


Adapted from http://d-maps.com/carte.php?num_car=3502&lang=en

**NSF/RET Site
on
Interdisciplinary Water E³G
(Engineering, Ecology, Environment, Geosciences)
(2016-19)**

RET Water E³G Goal

To provide teachers (*grades 9-12 & community college*) with an interdisciplinary water research experience that integrates water research perspectives from engineering, ecology, environmental science, and geosciences.



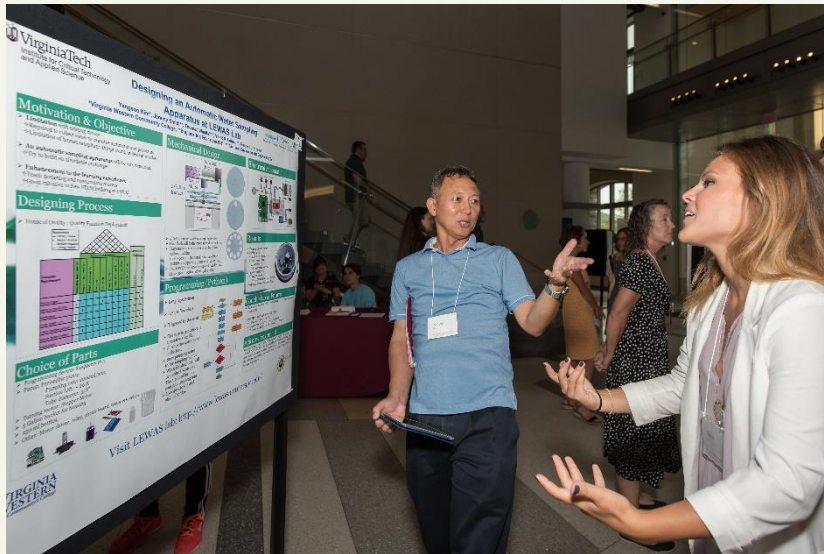
RET Water E³G Objectives

1. Develop and implement a six-week research experience program for RET site participants involving ***hands-on learning experiences*** in E³G areas.
2. Develop and implement a ***professional development program*** for teachers.
3. Guide participants in *development* and *implementing* STEM-based interdisciplinary water research ***learning modules***.
4. Establish a ***community of teachers*** mentored in interdisciplinary water research for support, collaboration, and dissemination of Site activities to a larger group of teachers.

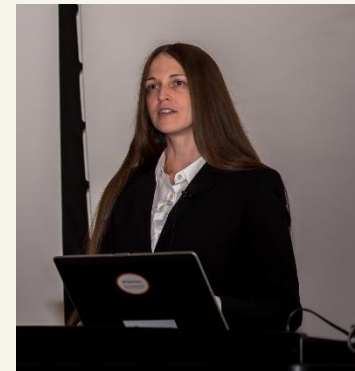
Research Component



Teachers performed in-lab water-related researches in one of the laboratories on the Virginia Tech campus.

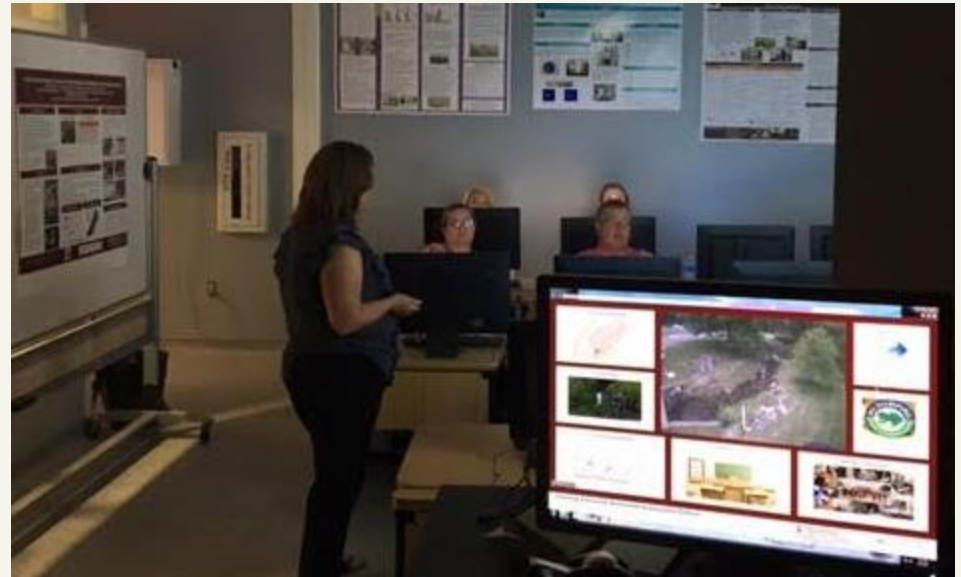


Teachers presented their research at poster session and in talks at the summer culmination.



Learning Module Development Component

Teachers collaborated and were guided by professional instructional designers to develop learning modules based on their lab research



Active Participation 2

(written feedback, 8 mins)

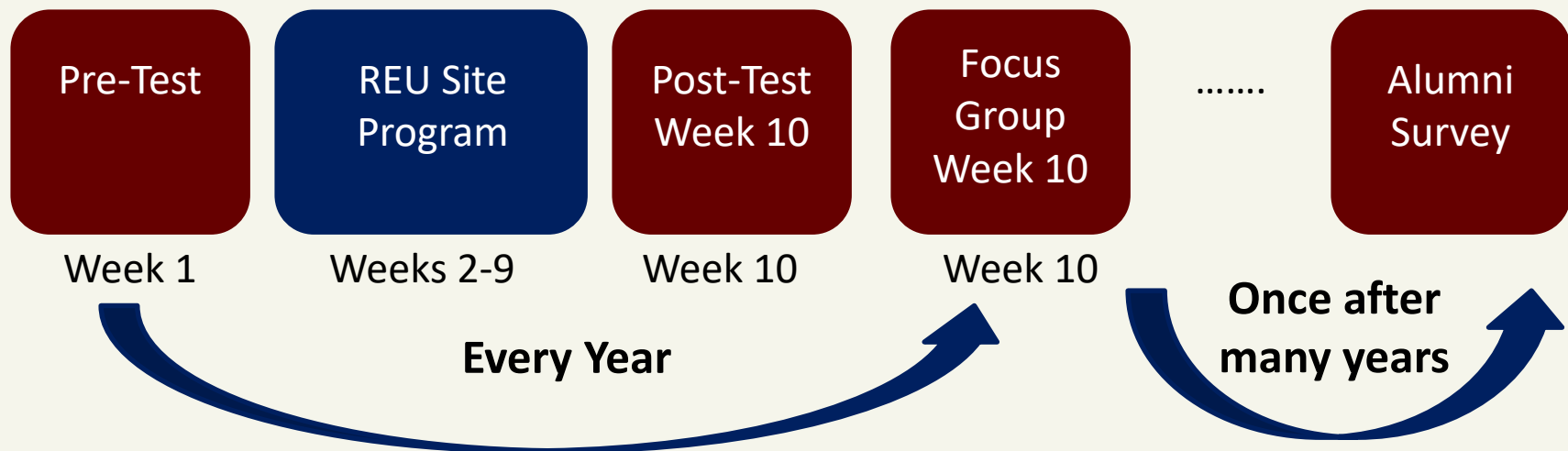
Any time we implement one of these experiences, assessment is important to measure success of these programs...

What questions might you ask REU/RET participants to assess these programs?

Assessment of the NSF/REU Site Goals

Purpose:

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



Conducted by :

External assessment expert Dr. Muffo



Water REU Site Goals

- 1) To expand undergraduate students' participation in **interdisciplinary water research** projects
 - 2) To encourage undergraduate students to pursue **graduate education**
 - 3) To develop a diverse, internationally competitive and **globally engaged scientific and engineering workforce**
 - 4) To develop undergraduates into **independent researchers**, rather than dependent learners.
- **19 questions of the pre and post-tests are mapped to these four goals**

Assessment Results for Goal 4

Goal 4: To develop undergraduates into independent researchers, rather than dependent learners

Survey Questions	n	Results (p-values, if significant)	Quantitative Measures
I am confident that I understand how to conduct scientific research independently.	18	Significant increase $p < .01$	Increase from mean entry to exit survey scores: 0.22; Wilcoxon Signed Rank test
I know everything that I need to know to conduct research in the library.	79	Significant increase $p < .0001$	Paired left-tailed t-test
I know how to communicate my research findings orally and by documenting it in a research paper.	18	Significant increase $p < .01$	Increase from mean entry to exit survey scores: 0.67; Wilcoxon Signed Rank test

Assessment with Focus Group (an example)

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.

Alumni Survey Implementation and Results

Implementation:

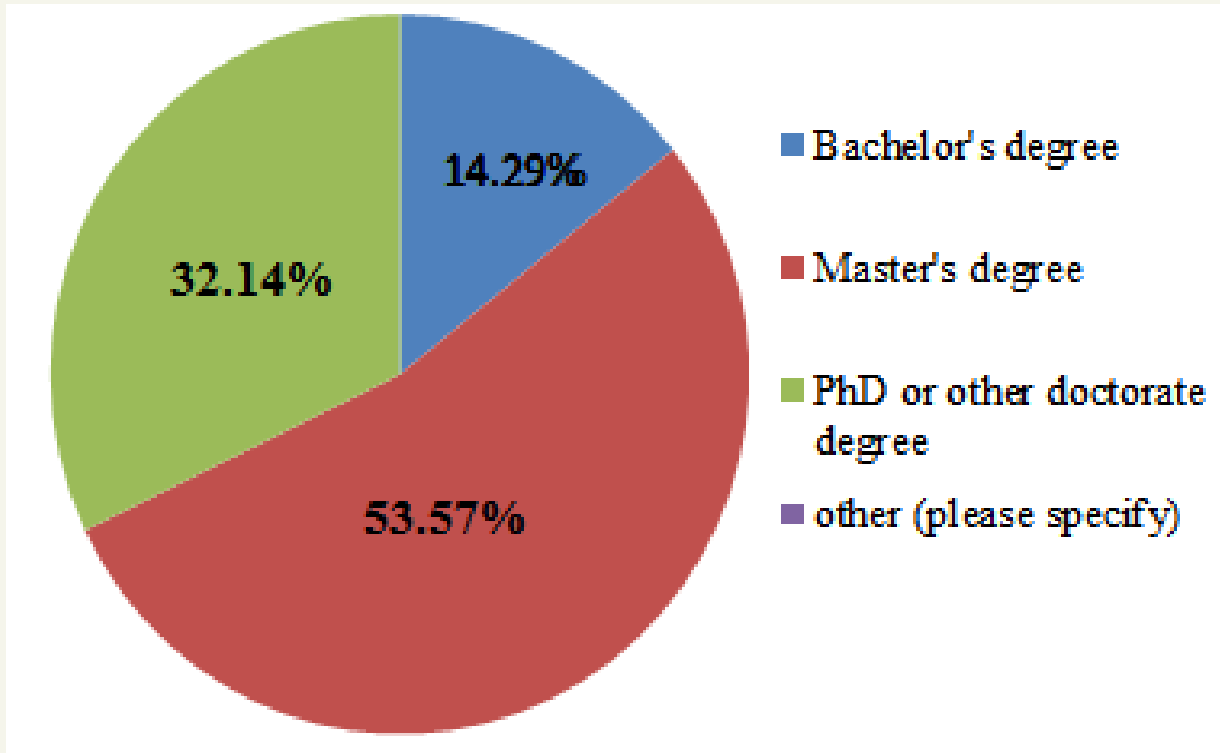
- 24 - item online anonymous survey
- Implemented in May 2016
- 28 respondents out of 76

Results:

- **82%** of alumni agreed that the REU Site had made **positive impact on their academic plans**
- **85%** of the alumni positively replied when asked about the influence of the REU Site on their **decision to pursue/not pursue graduate school**

Alumni Survey Results

Highest level of education planned by the REU alumni (n = 28)



Example quote of an REU Alumni:

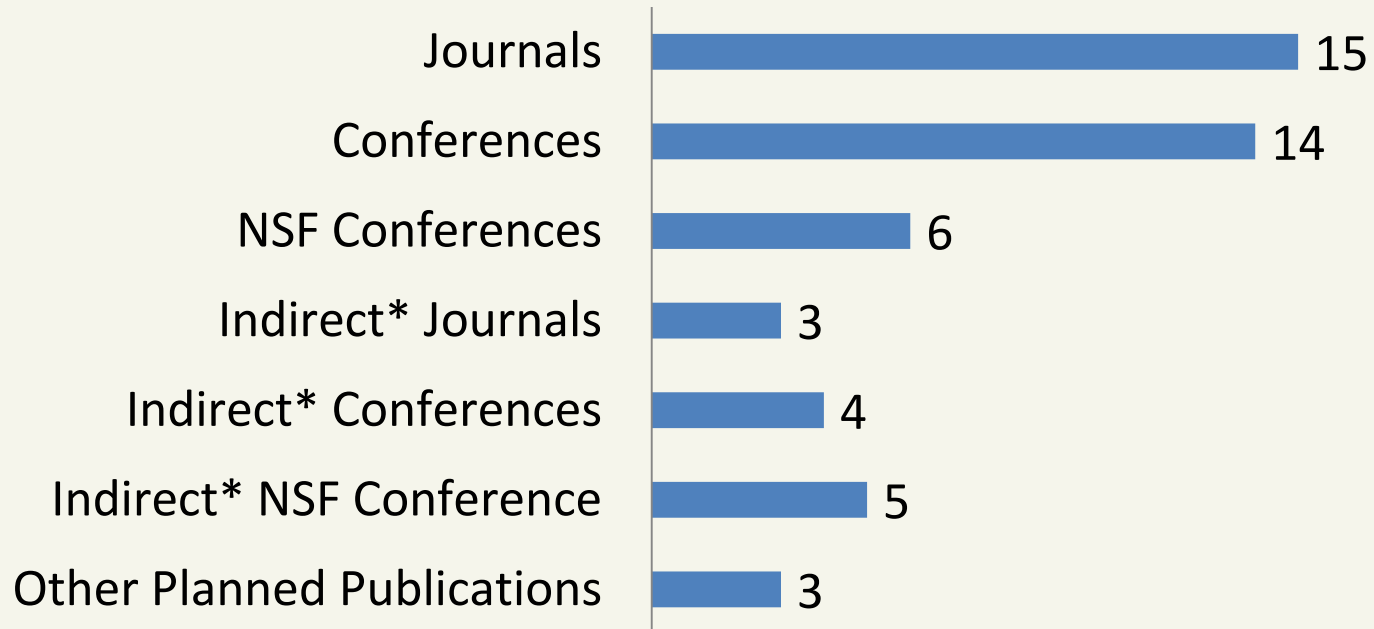
"...I had already decided to pursue a master's degree, but after my REU, I've started considering a doctorate degree as well."

Detailed findings presented in:

Basu, D., Lohani, V. K., & Muffo, J. Research Experiences for Undergraduate in Interdisciplinary Water Sciences and Engineering: Accomplishments in Nine Years, *International Journal of Engineering Education* (Accepted, 2017).

Research Contribution of the REU fellows

Numbers of Publications



Total Number of publications: 50

*Indirect contribution of the REU fellows

Other Research Contributions

- **Mass Media Mentions**

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
- **95 research papers** in the 10 REU Site proceedings:
<http://www.lewas.centers.vt.edu/index.php/lewas-nsf-reu/past-proceedings>
 - **Presentations at VT Symposium (2012 -17):**
<http://research.undergraduate.vt.edu/present-publish/SymposiaVT.htm>

Water REU Site Lessons Learned

- 1) Research projects for REU fellows and their roles should be clearly defined.
- 2) Prior communication with REU fellows help.
- 3) Structured schedule of the professional development activities are recommended for good cohort experience.
- 4) 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.
- 5) Multiple opportunities for oral presentations is very helpful.
- 6) Graduate students should challenge REU fellows to develop independent research skills.

Water REU Site Lessons Learned (Cont.)

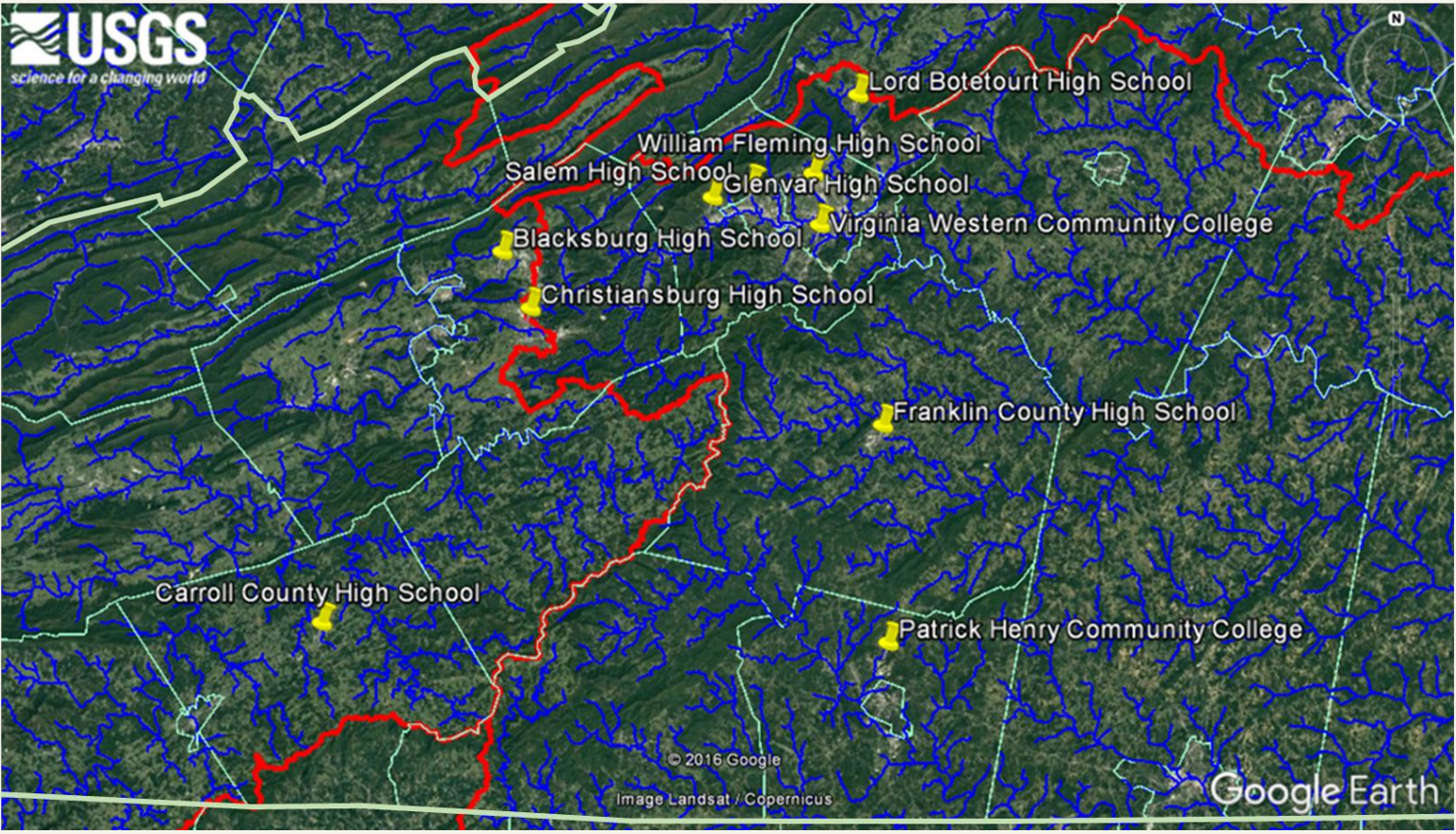
- 7) Activities that promote social interaction and professional bonding among scholars are as critical as the research activities.
- 8) Coordinators with university-level undergraduate research office is always helpful.
- 9) External assessment experts play an important role in site evaluation.
- 10) Documentation of research papers in the form of a research proceeding provides a source for ownership and pride to REU fellows.
- 11) Cohort presentation in the form of YouTube videos may be useful for program recruitment

RET Contributions and Schools

James River
(to Chesapeake Bay)

Roanoke River
(to Atlantic Ocean)

New River
(to Gulf of Mexico)



RET Research: Concern-Based Assessment

Concerns-Based Assessment Model (CBAM)

- Stages of Concern (SoC) survey
*Teachers were found to be **less concerned** with the learning module implementation at the beginning of the six weeks than at the end of the research experience*
- Levels of Use (LoU) interviews performed to follow up on teaching module implementations

Creative Achievement Questionnaire (CAQ)

- Measures participant creative achievement in nine artistic and scientific domains:
- Teachers were not found to be particularly creatively achieved



- | | | | |
|----|-------------|----|-----------|
| 1. | Visual arts | 6. | Music |
| 2. | Writing | 7. | Invention |
| 3. | Humor | 8. | Science |
| 4. | Dance | 9. | Culinary |
| 5. | Drama | | |

Research to Practice

Research to Practice: Undergraduate Experiences

Interdisciplinary Experiences

- Gets exposed to various disciplinary perspectives and expertise
- Shares and gains knowledge beyond their own discipline
- Collaborates with interdisciplinary team to complete ones' own project
- Learn to communicate to an interdisciplinary team

“...engaging in such interdisciplinary tasks, I got the opportunity to grow others’ education by bringing my own unique discipline to the LEWAS lab”



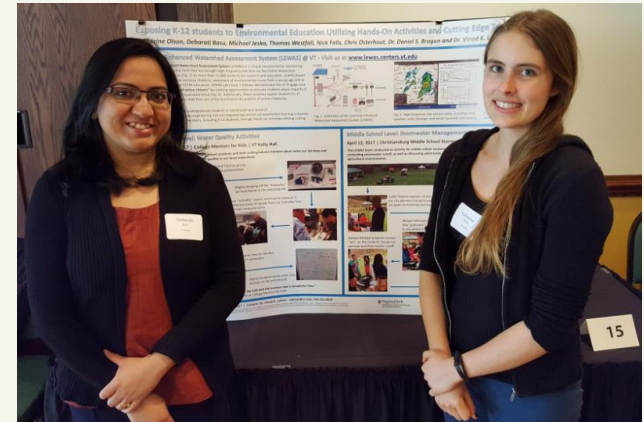
Undergraduates find Links Between Classroom learning and Practical lab Exp.

- Find application of knowledge gained in several courses
- Realize the connection between theoretical concepts and concepts needed to solve in real-world problems
- Gains background knowledge for the future planned courses
- Example related courses:
 - Data Structure and Algorithms
 - Intermediate Software Design
 - Small Watershed Hydrology:
 - Flow analysis, Urban Watershed Effects
 - Statistics: Correlation of parameters
 - Fluid Mechanics: Water behaviour



Undergraduates get Academic and Professional Experiences

- Academic skills:
 - Real-world problem solving
 - Troubleshooting skills
 - Independent learning skills
 - Independent research skills
 - Critical thinking skills
 - Real-world data analysis skills
- Professional Skills:
 - Communication skills
 - Networking skills
 - leadership skills



Impact of Graduate and Faculty Mentoring

- Learn from mentors' experiences and knowledge
- Get courage to handle challenges by exploring unknown technical areas
- Receive guidance for being on track with a problem
- Get confidence and motivation to do certain work
- Receive help in taking academic decisions
- Receive help in taking career decisions



Impact on the Undergraduates' Academic and Career Decisions

- Understand the requirement of certain coursework
- Understand the applicability of the coursework
 - “I see academics as more of a tool than a requirement now”
- Get encouragement to continue as a researcher
- Receive feedback for connecting the points of interest for future endeavor
- Able to take informed decisions for the next step in the career



Research to Practice

Graduate Experiences

Graduate Student Experiences

Designing Research Projects

Mentoring REU and RET Scholars

Designing Assessments

Assessing Individual Contributions

Evaluating Program Structure and Outcomes

Developing valid and reliable Instruments

Facilitating RET Learning Module Developments

Program Management/Coordination from inception to proceeding

NSF Grant Writing

Acknowledgements

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For more information please contact:

Dr. Vinod K. Lohani

vlohani@vt.edu, +1-540-231-0019

LEWAS Homepage: <http://www.lewas.ictas.vt.edu/>

OWLS Homepage: <http://www.lewas.centers.vt.edu/dataviewer/>

LEWAS Video Archive: <http://lewaspedia.enge.vt.edu:8080/videos/stroubles1/>

LEWAS Intro Video: <https://www.youtube.com/watch?v=ROZhLhRoxJc>

LEWAS Twitter Feed: <https://twitter.com/LEWASLab>

KJ Technique: Ideate Research to Practice

Prompt: Our lab has implemented research to practice through REU and RET practices and activities, as well as by implementing research best-practices by graduate Engineering Education students.

How might someone in your position implement Research to Practice in their work?

How do I KJ?

1. Work individually without sharing ideas (yet, silent reflection)
2. Share ideas as a group by placing sticky notes on the walls
3. The most popular ideas are shared out of the group

Debarati's Experiences

For NSF- REU Site (Summer, 2014-2017)

- **Mentored** 2 REU fellows for their undergraduate research project
- **Analyzed** REU Site accomplishments over nine years from 2007-16
- **Re-designed** and assisted in **conducting program evaluation** with an assessment expert, Dr. John Muffo
- **Implemented and analyzed data** of the REU alumni survey
- **Coordinated and managed Site activities** like field trips, seminars, social activities, orientations and concluding ceremonies
- **Edited and compiled Site Proceedings of Research**, Research Opportunities in Interdisciplinary Water Sciences and Engineering (2014, 2015)

For NSF- RET Site (Summer, 2017)

- **Facilitated learning module development** activities for teachers participating in the NSF-RET Site Program

Graduate Student Mentors' Experiences

- Planning and setting timelines for project completion
- Interdisciplinary experience
- Selecting potential research projects
- Giving agency to students to select their project



Planning and setting timelines for project completion

- Giving REU fellows time to understand the project and acclimate to the lab
- Setting sub-goals for the REU fellows
- Developing a timeline
- Keeping track of their progress



Interdisciplinary experience

- Understanding background of REU fellows
- Tailoring project to their strengths
- Applying strengths in a disciplinary area outside their expertise



Selecting potential research projects

- Aligning project to the overall goals of the lab
- Continuing the prior work
- Developing research projects in new areas



Giving agency to students to select their project

- Short timelines make students' agency difficult
- Having two to three project ideas before student arrives help in project selection process
- Communication with REU fellows before the program can facilitate co-development of the project easier



Mentoring an REU vs. and RET: an anecdotal tale