APPROACHES FOR USING YOUTH EDUCATION TO INCREASING STORMWATER AWARENESS
COREY DENENBERG DEHNER & PAUL MATHISEN

WORCESTER POLYTECHNIC INSTITUTE’S
MASSACHUSETTS WATER RESOURCE OUTREACH CENTER
WROC PARTNERS

Students

Municipalities

Central Massachusetts Regional Stormwater Coalition

MassDEP

Commonwealth of Massachusetts Department of Environmental Protection

Massachusetts Statewide Stormwater Coalition

Municipality

WROC

MADEP/Partners
ISSUES - MS4’S

(1) Public Education

(2) Public Involvement and Participation

(3) Illicit Discharge Detection and Elimination (IDDE)

(4) Construction Site Runoff Control

(5) Post-Construction Runoff Control

(6) Pollution Prevention and Good Housekeeping
### Emphasis in STE Standards

<table>
<thead>
<tr>
<th>Emphasis in STE Standards</th>
<th>Implication for Curriculum and Instruction</th>
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</thead>
<tbody>
<tr>
<td><strong>Relevance:</strong> Organized around core explanatory ideas that explain the world around us</td>
<td>The goal of teaching focuses on students analyzing and explaining phenomena and experience</td>
</tr>
<tr>
<td><strong>Rigor:</strong> Central role for science and engineering practices with concepts</td>
<td>Inquiry- and design-based learning involves regular engagement with practices to build, use, and apply knowledge</td>
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<tr>
<td><strong>Coherence:</strong> Ideas and practices build over time and among disciplines</td>
<td>Teaching involves building a coherent storyline over time and among disciplines</td>
</tr>
</tbody>
</table>

*Table 2: STE Standards and Implications. (Massachusetts Department of Elementary and Secondary Education, 2016)*
GOALS

- Develop some effective approaches to advance stormwater and watershed education for our youth
- Address requirements for public education in MS4 permits,
- Promote a greater awareness of stormwater and watershed issues
- Provide active, project-based educational opportunities for WPI students
OUTLINE

• GOAL
• BACKGROUND – WROC
• CASE STUDIES
  • 1. PUBLIC AWARENESS THROUGH YOUTH WATERSHED EDUCATION
     (PROJECT WITH SHREWSBURY AND HOLDEN, MA)
  • 2. STORMWATER EDUCATION AND ENVIRONMENTAL STEWARDSHIP
     (PROJECT WITH FITCHBURG, MA)
• SUMMARY
**BACKGROUND:**
**NONPOINT EDUCATION FOR MUNICIPAL OFFICIALS (NEMO)**

**Goal**
Assist local land use boards & commissions in accommodating growth while protecting natural resources

- **CT** (1990s)
- **MN** (1992)
- **RI** (1993)
- **NH** (1998)
- **MA** (2015)
• WPI’S PROJECT-BASED APPROACH:
  • Project based curriculum
  • 7 week term

• JUNIOR YEAR DEGREE REQUIRED IQP
  • Interdisciplinary teams
  • 3-4 students
  • Tackling real-world issue at intersection of science and society
  • Majority completed at a project center (25+ around the world)
  • Preparation Term & Project Term (14 weeks total)
<table>
<thead>
<tr>
<th>For Students</th>
<th>For Municipalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Govt Exposure/Training &amp; NPO partnerships</td>
<td>• Unbiased Assistance</td>
</tr>
<tr>
<td>• Education on:</td>
<td>• ~1800 Work Hours/Project</td>
</tr>
<tr>
<td>• State &amp; Local Politics</td>
<td>• Oppty to Educate Students on Land-use Issues</td>
</tr>
<tr>
<td>• Federal, State &amp; Local Env. Laws</td>
<td>• Collaboration with Watershed Associations &amp; Other Towns</td>
</tr>
<tr>
<td>• Interrelationship Between Branches of Government</td>
<td>• Collaboration with Agency Officials</td>
</tr>
<tr>
<td>• Land Use Planning field work</td>
<td></td>
</tr>
</tbody>
</table>
WROC PARTNERS

Municipality

WROC

MADEP/Partners

MassDEP

Central Massachusetts Regional Stormwater Coalition

Massachusetts Statewide Stormwater Coalition

Students

Municipalities
WROC - PAST PROJECTS
<table>
<thead>
<tr>
<th>Towns</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2017) Charlton, MA</td>
<td>Drinking Water Contamination Educational Campaign</td>
</tr>
<tr>
<td>(2015) Chelsea, MA</td>
<td>Flood Risk Adaptation Assessment</td>
</tr>
<tr>
<td>(2014) Millbury, Holden and Southbridge, MA</td>
<td>General Cost of Compliance with 2014 MS4 Permit</td>
</tr>
</tbody>
</table>
GOAL
Assist 30 Central MA towns in compliance with 2016 Municipal Separate Storm Sewer System (MS4) permit & educate residents on stormwater and its management.

RESULTS
Developed Educational Toolkits for Schools & Community Events
<table>
<thead>
<tr>
<th>Towns</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrewsbury, MA and Holden, MA</td>
<td>5th Grade Watershed Curriculum</td>
</tr>
<tr>
<td>Fitchburg, MA</td>
<td>Stormwater &amp; Environmental Education Curriculum</td>
</tr>
</tbody>
</table>
GOAL
Create a new 5th grade Watershed Curriculum, a curriculum encompassing the water cycle, stormwater runoff and the watershed, for the towns of Shrewsbury and Holden that met the new Massachusetts Next Generation Science Standards and complies with the first minimum control measure in the MS4 Permit.
PUBLIC AWARENESS THROUGH YOUTH WATERSHED EDUCATION

APPROACH

Objective 1: Understand current watershed curriculum, awareness, and teaching methods in Shrewsbury and Holden

- Content Analysis
- Semi-Structured Interviews
- Passive Observation
- Surveys

Objective 2: Gained knowledge of current stormwater education and awareness practices

- Content Analysis
- Semi-Structured Interviews

Objective 3: Use data collected to create a watershed curriculum for Shrewsbury and Holden

- Code Information

Objective 4: Pilot, evaluate, refine curriculum

- Pilot
- Evaluate
- Refine

Objective 5: Develop and present final recommendations

- Present Final Recommendations
PUBLIC AWARENESS THROUGH YOUTH WATERSHED EDUCATION

FINDINGS

• Finding resources for teaching about stormwater runoff.
• Need for curricula that are easy to use with clear objectives.
• A teacher’s confidence in a subject is important.
• Lack of a specific standard addressing stormwater in the Massachusetts state framework.
• To comply with the first minimum stormwater control measure, materials must improve awareness and public outreach regarding stormwater runoff.
• Students must be engaged for effective learning.
• Need measurable outcomes to assess effectiveness.
PUBLIC AWARENESS THROUGH YOUTH WATERSHED EDUCATION

RECOMMENDATIONS

• 1: PRE-LESSON AND POST-LESSON SURVEYS GAUGE EFFECTIVENESS

• 2: PARTNER WITH THE MA DEPARTMENT OF ELEMENTARY & SECONDARY EDUCATION AND INCORPORATE QUESTIONS REGARDING STORMWATER IN THE MA STE STANDARDS.

• 3: PROVIDE TEACHERS WITH A CENTRALIZED DATABASE OF RESOURCES & CREATE WORKSHOPS
PUBLIC AWARENESS THROUGH YOUTH WATERSHED EDUCATION

ACKNOWLEDGEMENTS

• OUR ADVISOR PROFESSOR COREY DEHNER FOR ADVISING US THROUGHOUT THE DURATION OF THIS PROJECT.

• OUR SPONSORS ANDREA BRIGGS, MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION, AND KERRY REED, CENTRAL MASSACHUSETTS REGIONAL STORMWATER COALITION

• OUR PRIMARY TEACHER CONTACTS SARAH MATTHEWS AND TIM SWEETEN, FOR GUIDANCE AND SUPPORT DURING THE CREATION OF THE WATERSHED CURRICULUM.

• SHERWOOD MIDDLE SCHOOL SCIENCE DEPARTMENT, FOR ALLOWING US THE OPPORTUNITY TO PILOT THE WATERSHED CURRICULUM.

• NICOLE SCOLA FOR SPARING TIME TO HELP US UNDERSTAND HOW TO DEVELOP A CURRICULUM AND THE MASSACHUSETTS SCIENCE TECHNOLOGY AND ENGINEERING CURRICULUM FRAMEWORK.

• NEWTON TEDDER, BRAD STONE, AND ISABEL MCCAULEY FOR ALLOWING US TO INTERVIEW THEM AND PROVIDING US WITH IMPORTANT INSIGHT ON THE MS4 PERMIT.

• ERIN ANDERSON, STEPHANIE COVINO, MEGAN GRAHAM, WENDY KALWARCZYK, JILL O’CONNOR, LAURA RYAN, ELAINE SANTELMANN, PAUL STARRETT, MEG TABACKSO, AND MARK WARREN FOR SHARING IMPORTANT INFORMATION ABOUT EDUCATION, STORMWATER CURRICULA AND THE CREATION OF EDUCATIONAL MATERIALS.

• JAMES MONACO FOR PROVIDING US TECHNICAL ASSISTANCE IN MAKING OUR PROJECT VIDEO.

• WORCESTER POLYTECHNIC INSTITUTE FOR PROVIDING US THE OPPORTUNITY TO COMPLETE OUR PROJECT AT THE MASSACHUSETTS WATER RESOURCE OUT REACH.
PUBLIC AWARENESS THROUGH YOUTH
WATERSHED EDUCATION

DELIVERABLES

2018 5th Grade Watershed Curriculum

This curriculum was designed and created by a social science research team at Worcester Polytechnic Institute based out of the Massachusetts Water Resource Outreach Centre in Worcester, Massachusetts. The team worked in collaboration with the Massachusetts Department of Environmental Protection and the Central Massachusetts Regional Stormwater Coalition. This curriculum was specifically designed to satisfy the needs of the 5th grade science teachers in the towns of Shirley, Sterling, and Holden, Massachusetts.

Chapter: The Water Cycle
Day 1
Grade level: 5

Title of Topic: Evaporation, Condensation and Precipitation
Time Frame: 40-50 min

Desired Outcome from Lesson: Students will be able to explain the process of the water cycle.

Topic of Lesson: The water cycle is the process in which water circulates between the Earth's oceans, atmosphere and land. This cycle includes evaporation, condensation, and precipitation.

Student's Goals of the Day:
Students will be able to identify the differences between precipitation, condensation, and evaporation.

Essential Vocabulary:
- Hydrocycle: All the water on the earth's surface, such as lakes and rivers, and substances that move water from one part of the cycle to another.
- Evaporation: The process of turning water from a liquid to a gas.
- Condensation: The process of turning water from a gas to a liquid.
- Precipitation: Rain, snow, sleet, or hail that falls to the ground.

Extended Vocabulary:
- Runoff: Water from rain, snowmelt, or other sources that flows over the land surface.
- Geosphere: Any of the almost spherical concentric regions of matter that make up the earth and its atmosphere, as the lithosphere and hydrosphere.
- Atmosphere: The envelope of gases surrounding the earth or another planet.
- Biosphere: The region of the earth's surface, atmosphere, and hydrosphere (or analogous parts of other planets) occupied by living organisms.

Stormwater Runoff Awareness Through Youth Watershed Education

Supplementary Materials

This is the Supplementary Material for our Interactive Qualifying Project and was completed through the Worcester Polytechnic Institute Water Resource Outreach Center. This project was completed in collaboration with the Massachusetts Department of Environmental Protection and the Central Massachusetts Stormwater Coalition.

May 2nd, 2018

Family Advisors:
Dr. Corey Benenson Delaney
By: Michelle Hall
Sam Malafante
Victoria Marrone
Connor Salwitz

Appendix A: Data Analysis Tools

Curriculum Analysis Matrix
See Excel Spreadsheet titled "Watershed Curriculum Data Analysis Tools" in WPI Library Database under Electronic Resources through South Waterboro Education.

Interview Collection Matrix
See Excel Spreadsheet titled "Watershed Curriculum Data Analysis Tools" in WPI Library Database under Electronic Resources through South Waterboro Education.

Observation Matrix
See Excel Spreadsheet titled "Watershed Curriculum Data Analysis Tools" in WPI Library Database under Electronic Resources through South Waterboro Education.

Qualitative Data Matrix
See Excel Spreadsheet titled "Watershed Curriculum Data Analysis Tools" in WPI Library Database under Electronic Resources through South Waterboro Education.

Detailed Matrix
See Excel Spreadsheet titled "Watershed Curriculum Data Analysis Tools" in WPI Library Database under Electronic Resources through South Waterboro Education.
<table>
<thead>
<tr>
<th>Day</th>
<th>Chapter</th>
<th>Topic</th>
<th>Unit Goal</th>
<th>MA Standard</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>The Water Cycle</td>
<td>Evaporation, Condensation and Precipitation</td>
<td>1</td>
<td>5-ESS2-1</td>
</tr>
<tr>
<td>2</td>
<td>The Water Cycle</td>
<td>Modeling the Water Cycle</td>
<td>2</td>
<td>5-ESS2-1</td>
</tr>
<tr>
<td>3</td>
<td>Watershed</td>
<td>Pollution’s Effect on Water</td>
<td>2</td>
<td>5-ESS2-1</td>
</tr>
<tr>
<td>4</td>
<td>Watershed</td>
<td>Mapping how Water Flows</td>
<td>3</td>
<td>5-ESS3-1</td>
</tr>
<tr>
<td>5</td>
<td>Watershed</td>
<td>Modeling a Watershed</td>
<td>3</td>
<td>5.3-5-ETS3-2</td>
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<tr>
<td>6</td>
<td>Stormwater Runoff</td>
<td>Urban vs. Rural Runoff</td>
<td>4</td>
<td>5-ESS3-1</td>
</tr>
<tr>
<td>7</td>
<td>Stormwater Runoff</td>
<td>Reducing Runoff with BMPs</td>
<td>5</td>
<td>5-ESS3-1</td>
</tr>
<tr>
<td>8</td>
<td>Stormwater Runoff</td>
<td>Engineering a BMP</td>
<td>5</td>
<td>5.3.5-ETS3-2</td>
</tr>
<tr>
<td>9</td>
<td>Sewer System vs. Stormwater</td>
<td>The Two Separate Systems</td>
<td>6</td>
<td>5.3-5-ETS3-2</td>
</tr>
<tr>
<td>10</td>
<td>Sewer System vs. Stormwater</td>
<td>Catch Basin Model</td>
<td>67</td>
<td>5.3.5-ETS3-2</td>
</tr>
</tbody>
</table>

**Lesson 6: Impervious vs. Pervious Surfaces**

*Teacher Guideline*

*Overview:* Urban and Rural environments have different effects on stormwater runoff; a main factor being the increased impervious surface in an urban environment.

*Note to Educator:* Acting as a facilitator, force the students to derive the essential questions by asking triggering questions.

*Instruction:*

- First break the students into groups of 3-5.
- Show Dr. Drain: The Rain Brain Stormwater 101 Video. This video is easily found on youtube.com by searching “Dr. Drain the Rain Brain Stormwater 101”.
- Have two clear paint pans to demonstrate the difference between impervious and pervious surfaces (This can also be done in groups of 4). Cover one paint pan with soil, and the other with a canvas wrap. Ask the students what they think each pan represents. Now have a student come to the front of the class and pour 8 oz. of water on the top side of each pan. Ask a driving question of in which environment the water reached the bottom of the pan first? Why? (Explain to the students that these two pans represent different environments, one being a rural environment and one being an urban environment. The canvas wrapped pan is the urban environment with a very high percentage of impervious surfaces. The soil pan represents a rural environment where water can infiltrate the ground.)
- Show the students two photos on the worksheet and pass out the worksheet, one being an urban setting, another being a rural setting:
  - Have the students investigate with their group and discuss the differences of what will happen when it rains.
  - Have the groups identify various things that create an increase/decrease in stormwater runoff in each environment.
- Have the students think of items stormwater runoff could pick up along its way to the storm drain in an urban environment.

*Extended Learning with Extra Time*

- Now, pull out google maps on the board (Have the students pull it up on their tablets) and look at the aerial view of your school. Have each group identify an impervious area (parking lots, roofs, streets/sidewalks, compacted clay softball/baseball fields). As each group identifies an area, using google maps calculate the area of that space (Right click, measure distance, place points on each edge of the space) have the students write this area down. It will be needed later. (This step can also be done with a printed out aerial view of the school with a grid placed on top of it to manually calculate the area)
  - Once each group has an area specific to a space in the aerial view, have them identify some pollutants that could be found in that area. Next, explain how in a typical rain storm it can rain more than an inch. Using 1 inch of rain as the event, have the students calculate how many gallons of stormwater runoff is created by their impervious area on the school lot. (Review volume formula L*W*H, 1 ft to 0.1 gal conversion, 12 inch to 1 foot conversion)

**Preparation Materials**

- 2 Clear Paint Pans
- Enough Soil to Cover Paint Pan
- 8 oz. Cups of Water

**List of Example Pollutants**

- Salt, sand
- Animal waste
- Fertilizer
- Oils, gas
- Garbage (Cigarettes, wrappers, etc.)
STORMWATER EDUCATION & ENVIRONMENTAL STEWARDSHIP: CASE STUDY IN FITCHBURG, MA

STUDENTS: SEAN BURKE MIKE COOKE TOM KOUTTRON CIELO SHARKUS

Project Advisor: Corey Dehner

GOAL

To assist the Fitchburg Department of Public Works and Fitchburg Public Schools with the creation of an environmental education program, which focused on educator support and interactive education, in order to create a generation of environmentally aware and empowered students.

Project Sponsors

Jeff Murawski, P.E., Fitchburg DPW
Nick Erickson, P.E., Fitchburg DPW
Jessica Stodulski, Fitchburg Public Schools
STORMWATER EDUCATION & ENVIRONMENTAL STEWARDSHIP: CASE STUDY IN FITCHBURG, MA

APPROACH

1. Understand STE Curriculum and 5th Learning Environment
   - Independent Research
   - Interview with STEM Specialist
   - Classroom Observation

2. Research Public Education and Outreach Measure
   - Independent Research
   - Interview with State Officer
   - Interview with Local Officer

3. Analyze Effective Education
   - Interview Local Outreach Programs
   - Free-Listing of Students
   - Interview ESL and Special Ed. Specialists

4. Develop Stormwater Program
   - Handbook
   - Outdoor Program
   - Video

5. Pilot Educational Programming
   - Boys and Girls Club of Leominster

6. Develop Recommendations and Revisions
   - Submit for Review

Figure 15: Pilot at Boys and Girls Club Science Festival

Figure 17: Interview of Most Optimal Grade
STORMWATER EDUCATION & ENVIRONMENTAL STEWARDSHIP: CASE STUDY IN FITCHBURG, MA

FINDINGS AND MATERIALS

• Cities may not have the resources to implement watershed programs due to a number of factors, including
  • A shortage of ELL teachers
  • High turnover rates for teachers
  • Time shortages
• Educators often deal with underfunded classrooms, tight time constraints, and requirements for class content.
• Educators need support throughout the education program

A resource guide was created to maximize time and usefulness of stormwater materials through the use of:
• a community resource index that directly benefits classrooms.
• a curriculum guide aligned with MS4, 2016 STE Frameworks, and 8 Science & Engineering Practices
• An educational support index of educational and environmental professionals
STORMWATER EDUCATION & ENVIRONMENTAL STEWARDSHIP: CASE STUDY IN FITCHBURG, MA

FINDINGS AND MATERIALS

Figure 14: Community Resources Index
Image: NRWA Logo
(Nashua River Watershed Assoc. Archives, 2012c)

Table 5: Educational Support Index
Jessica Stodulski  STEM Specialist
Bonnie Baer-Simahk  ELL Director
Kristin Gallo  Special Ed. Educator
Fred Civian  Stormwater Coordinator

Figure 18: Student Workbook Cover Page

Congratulations!!!
Thank you for completing the environmental education workbook. Due to your success and hard work throughout this workbook you have just become a Rain Wrangler. What is a Rain Wrangler you ask? Well they are community scientists. That's right, right here in your own neighborhood you are someone who is watching out for the future of our environment. Rain Wranglers are also community leaders. Whenever you see someone harming the environment in any way, go ahead and spread the message about what polluted water does to your ecosystem. Lastly, Rain Wranglers are community leaders. How you might ask? Well, they make a conscious effort to reduce their community's impact on the environment from pollution.

In order to become a full fledged Rain Wrangler, say the pledge and cut out your badge!!!

I pledge to be a community scientist.
I pledge to take care of my surrounding environment.
I pledge to spread awareness among my friends and family about stormwater pollution.
STORMWATER EDUCATION & ENVIRONMENTAL STEWARDSHIP: CASE STUDY IN FITCHBURG, MA

FINDINGS AND MATERIALS

• BONNIE BAER-SIMAHK, ENGLISH LANGUAGE LEARNER DIRECTOR FOR FITCHBURG PUBLIC SCHOOLS
• BRUTUS CANTOREGGI, DEPARTMENT OF PUBLIC WORKS DIRECTOR FOR FRANKLIN, MA
• LISA CARLIN, ASSISTANT SANCTUARY AND CAMP DIRECTOR FOR MASSACHUSETTS AUDUBON AT BROAD MEADOW BROOK CONSERVATION
• FREDERICK CIVIAN, STORMWATER COORDINATOR FOR MASSACHUSETTS DEPT. OF ENVIRONMENTAL PROTECTION
• STEPHANIE COVINO, PROJECT COORDINATOR FOR MASSACHUSETTS AUDUBON
• JENNA DAVID, ENVIRONMENTAL DIRECTOR FOR THE MONTACHUSETT OPPORTUNITY COUNCIL
• KATE ENGLAND, PROJECT COORDINATOR OF STORM-WATER INFRASTRUCTURE FOR THE BOSTON WATER AND SEWER COMMISSION
• KRISTIN GALLO, SPECIAL EDUCATION TEACHER AT MCKAY ARTS ACADEMY
• ED HIMLAN, EXECUTIVE DIRECTOR OF THE MASSACHUSETTS WATERSHED COALITION
• JAMES MONACO, SENIOR INSTRUCTIONAL MEDIA SPECIALIST FOR THE ACADEMIC TECHNOLOGY CENTER AT WPI
• MARTHA MORGAN, WATER PROGRAMS DIRECTOR FOR THE NASHUA RIVER WATERSHED ASSOCIATION
• JEFF MURAWSKI, DEPUTY COMMISSIONER OF WASTEWATER FOR FITCHBURG DEPARTMENT OF PUBLIC WORKS
• EILEEN SPINNEY, TECHNOLOGY DIRECTOR FOR FITCHBURG PUBLIC SCHOOLS
• KRISTIN STEINMETZ, EDUCATION COORDINATOR FOR MASSACHUSETTS AUDUBON AT WACHUSETT MEADOW BROOK CONSERVATION
• JESSICA STODULSKI, STEM SPECIALIST FOR FITCHBURG PUBLIC SCHOOLS
NEXT STEPS

• MORE PROJECTS!
  • INCREASING WATERSHED AWARENESS IN EDUCATION: DEVELOPMENT OF EDUCATIONAL CURRICULUM – CMRSC; MADEP
  • EVALUATING THE EFFECTIVENESS OF THE THINK BLUE MASSACHUSETTS CAMPAIGN – CMRSC; MADEP
  • ASSESSMENT OF COMMUNITY-BASED APPROACHES TO MANAGE WATER SUPPLY IN AN URBANIZED AREA –
  • MANAGEMENT OF LAKES AND PONDS TO PROTECT THE PUBLIC FROM HARMFUL ALGAL BLOOMS
• DISSEMINATION/COLLABORATION
• STUDENTS:
  • MICHELLE HULL, SAM MALAFRONTÉ, VICTORIA NASSAR, AND CONNOR SAKOWICH,
  • SEAN BURKE, MIKE COOKE, TOM KOUTTRON, CIELO SHARKUS
• ADVISOR/OFFICE DIRECTOR: COREY DEHNER (WPI)
• SPONSORS/COLLABORATORS: ANDREA BRIGGS (MADEP), KERRY REED (CMSWC),

For more information:
wp.wpi.edu/wroc