Working with teachers to integrate toxicology and green chemistry into high school science courses

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Why work with teachers?

Inquiry and Science Education

Phases of inquiry-based learning: Definitions and the inquiry cycle

Pedaste et al., Educational Research Review, Volume 14, 2015, 47–61
http://dx.doi.org/10.1016/j.edurev.2015.02.003
Best Practices and Case Studies

ERIC
Institute of Education Sciences

Collection
Thesaurus

research experiences for teachers

Search

Peer reviewed only
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I Want to Be the Inquiry Guy! How Research Experiences for Teachers Change Beliefs, Attitudes, and Values about Teaching Science as Inquiry
This qualitative study examined how and why research experiences for teachers (RETs) influenced middle and high school science teachers’ beliefs, attitudes, and values about teaching science as inquiry. Participants reported after participating in the RET that their beliefs about teaching science as inquiry had changed. Changes teachers reported after participating in the RET ranged from modifying a few lessons (belief change) to a comprehensive revision of what they believed about teaching science as inquiry.

Rutgers University Research Experience for Teachers in Engineering: Preliminary Findings
In addressing the nation’s need for a more technologically-literate society, the Rutgers University Research Experience for Teachers in Engineering (RUT-E) is designed to: (1) engage middle and high school math and science teachers in innovative “green” engineering-research during the summer, and (2) support teachers in integrating the results into their classrooms.

Development of Teachers as Scientists in Research Experiences for Teachers Programs
Fiber, Courtney; Martin, Emily; Aiken-Gardner, Liz; Benom, Lisa — Journal of Science Teacher Education, 2014
This study examined the teachers’ development as scientists for participants in three National Science Foundation Research Experiences for Teachers (RET) programs. Participants included secondary science and math teachers with varying levels of education and experience who were immersed in research environments related to engineering and science topics.

Stewart and Ray’s Big Adventure: A Research Experience for Teachers at UMass/Amherst
McCarthy, Ray — Technology and Engineering Teacher, 2011
Late in the winter of 2010, teachers across Massachusetts received invitations to apply for six- to eight-week Research Experiences for Teachers (RET) in which middle and high school teachers and graduate students as they sought to solve real-world problems. This country-wide effort was funded.

MoDRN
Molecular Design Research Network

Baylor University

The George Washington University

University of Washington

Yale
Partners and Potential Partners

• Education and outreach/broader impacts coordinators, if your institution has any
• School of Education professors
• Local education service centers or their equivalent
• State education agencies (great if they manage a science listserve to help you recruit teachers)
• Other organizations that teachers are likely to be involved in like science teachers association, informal science organizations (museums, nature centers, etc.)
Regional Education Service Center
Baylor Research Innovation Collaborative (BRIC)

-A collaboration among Education, Industry, and Higher Education

-Teachers spent a week in the research lab and a week here
Molecular Design Research Network (MoDRN)

- Green Chemistry and Green Engineering initiative, which focuses on the rational design of chemicals and materials to reduce toxicity
- How can we reduce the toxicity of new chemical substances?
- Research
- Outreach
- Education
MoDRN teacher workshops

• Professional Development (PD) for teachers
• 2015: 12 teachers (9 Texas, 3 WA)
• 2016: 10 teachers (including 3 teacher mentors returning from previous year)
• Competitive stipend
• Duration: 2 weeks in summer
• Location: Baylor University
• Conducted by: Dr. Bryan Brooks Research Lab and Educational partners
Goal

Provide an experience that increases teacher engagement of students in inquiry-based investigations around green chemistry and toxicity topics
2015 Cohort
July 6-17

2016 Cohort
July 18-29
Where do they teach?

- Small rural school districts (1 campus serving 134 students total in all grades K-12)
- Large urban school districts (Dallas ISD with 238 campuses serving 158,495 students)
- Predominantly public schools, one private, a public charter and a couple of magnets
- Serve under-represented student populations

Selected demographics for school districts of Texas teachers participating in MoDRN workshop 2015

- African-American: range: 1-30%
- Hispanic: range: 19-58%
- Economically Disadvantaged: range: 30-90%
- English Language Learners: range: <1 - 21%
What do they teach?

- Mirror the interdisciplinary nature of MoDRN research team
- Teachers rarely teach one subject
- Teachers report assignments change from year to year and often with little warning

- Teaching assignments of 2016 participants

<table>
<thead>
<tr>
<th>Subject(s) taught</th>
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</thead>
<tbody>
<tr>
<td>Integrated Physics and Chemistry, Physics</td>
</tr>
<tr>
<td>Environmental Science, Anatomy and Physiology</td>
</tr>
<tr>
<td>Chemistry (College), Physics</td>
</tr>
<tr>
<td>Chemistry, Environmental Science</td>
</tr>
<tr>
<td>Biology, IPC</td>
</tr>
<tr>
<td>Biology, Chemistry, IPC, Environmental Science, Food Science, Health, Marine Biology</td>
</tr>
<tr>
<td>Chemistry, Physics, Engineering</td>
</tr>
<tr>
<td>7th grade science, biology, honor biology, chemistry, anatomy</td>
</tr>
<tr>
<td>Biology, Earth and Space Science</td>
</tr>
<tr>
<td>Chemistry, Pre-AP chemistry, physics, Pre-Ap physics, Principles of Technology, Principles of Engineering</td>
</tr>
</tbody>
</table>
What did teachers do?

• Learned about MoDRN and Green Chemistry
  – Lectures (by researchers), green chemistry videos, background readings, guest speakers (distance), MoDRN modules (website)
• Second year implemented a peer-to-peer teaching component (returning teacher mentors)
• Worked in cross-disciplinary groups in research lab to conduct toxicity tests, analyze and present results
• Designed lesson plans to field test in their own and colleagues classrooms to prepare for broader dissemination
Daphnia magna as a model organism
Field ecology of *Daphnia* sp.

Plankton sampling gear

Not a daphnia

Also not a daphnia
Teacher research presentations

- Is there a difference in toxicity to *D. magna* between consumer products marketed as green versus those not specifically marketed as green in four different product categories?
**Evaluation Research**

- Evaluations conducted both summers (Dr. Suzanne Nesmith, Baylor School of Education, PI)

- What is impact of participating in Baylor MoDRN professional development on inquiry-based instruction, particularly in regards to green chemistry?

- Pre- and post-workshop evaluations (2 types)

- Classroom observations

- Open-ended survey items

- Reliable and valid instrument for assessment of quantity and quality of inquiry in K-12 math and science classrooms was adapted for use (EQUIP, Marshall et al. 2009)
Preliminary Research results

Table 1. Inquiry Data

<table>
<thead>
<tr>
<th>Inquiry Items</th>
<th>Pre</th>
<th>Post</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instructional Factors</td>
<td>2.67 (.527)</td>
<td>2.98 (.639)</td>
<td>3.44</td>
<td>.003**</td>
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<tr>
<td>Instructional Strategies</td>
<td>2.89 (.832)</td>
<td>2.89 (1.08)</td>
<td>.00</td>
<td>.94</td>
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<tr>
<td>Order of Instruction</td>
<td>2.06 (.938)</td>
<td>2.50 (.985)</td>
<td>3.44</td>
<td>.003**</td>
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<tr>
<td>Teacher Role</td>
<td>2.83 (.514)</td>
<td>2.89 (.583)</td>
<td>.00</td>
<td>.98</td>
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<tr>
<td>Student Role</td>
<td>2.83 (.707)</td>
<td>3.28 (.669)</td>
<td>1.86</td>
<td>.08</td>
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<tr>
<td>Knowledge Acquisition</td>
<td>2.72 (.669)</td>
<td>3.33 (.594)</td>
<td>1.86</td>
<td>.08</td>
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<tr>
<td>Discourse Factors</td>
<td>2.89 (.720)</td>
<td>3.19 (.705)</td>
<td>1.86</td>
<td>.08</td>
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<tr>
<td>Questioning Level</td>
<td>3.28 (.752)</td>
<td>3.28 (.669)</td>
<td>1.86</td>
<td>.08</td>
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<tr>
<td>Complexity of Questions</td>
<td>2.89 (.963)</td>
<td>3.17 (.857)</td>
<td>1.86</td>
<td>.08</td>
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<tr>
<td>Questioning Ecology</td>
<td>2.78 (.943)</td>
<td>3.00 (1.09)</td>
<td>1.86</td>
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<td>Communication Pattern</td>
<td>2.83 (.942)</td>
<td>3.28 (.826)</td>
<td>1.86</td>
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<td>Classroom Interactions</td>
<td>2.67 (.907)</td>
<td>3.22 (.943)</td>
<td>1.86</td>
<td>.08</td>
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<td>Assessment Factors</td>
<td>2.82 (.692)</td>
<td>3.11 (.694)</td>
<td>1.86</td>
<td>.08</td>
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<tr>
<td>Prior Knowledge</td>
<td>2.78 (1.00)</td>
<td>3.00 (1.09)</td>
<td>1.86</td>
<td>.08</td>
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<tr>
<td>Conceptual Development</td>
<td>3.17 (.786)</td>
<td>3.39 (1.778)</td>
<td>1.86</td>
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<td>Student Reflection</td>
<td>2.44 (1.04)</td>
<td>3.11 (.963)</td>
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<td>Assessment Type</td>
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<td>1.86</td>
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<td>Role of Assessing</td>
<td>3.11 (.963)</td>
<td>3.17 (.786)</td>
<td>1.86</td>
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<td>Curriculum Factors</td>
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<td>Content Depth</td>
<td>3.11 (.676)</td>
<td>3.39 (.608)</td>
<td>1.86</td>
<td>.08</td>
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<td>Learner Centrality</td>
<td>2.67 (.767)</td>
<td>3.06 (.802)</td>
<td>1.86</td>
<td>.08</td>
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<td>Integrate Content &amp; Investigation</td>
<td>2.67 (.970)</td>
<td>3.11 (.900)</td>
<td>1.86</td>
<td>.08</td>
</tr>
<tr>
<td>Organize &amp; Record Information</td>
<td>2.44 (1.04)</td>
<td>3.22 (1.00)</td>
<td>1.86</td>
<td>.08</td>
</tr>
</tbody>
</table>

*aMeasured on a 4-point scale where 1 = pre-inquiry; 2 = developing inquiry; 3 = proficient inquiry; 4 = exemplary inquiry

**Significant at .01 level (two-tailed)

• Significant gains resulted from the pre- to post-workshop scores related to teacher participants’ perceptions of inquiry instructional factors and curriculum factors

• Analysis of qualitative data (responses to open-ended items) regarding teachers beliefs about inquiry and their understanding of green chemistry are underway
Presentations by teachers at professional conferences:

– Conference for the Advancement of Science Teaching, Nov 2015 Fort Worth TX (4 TX teachers)

– National Science Teacher Association (NSTA) regional conferences (2 Washington teachers)

– NSTA National meeting: March 30-April 2, 2017 Los Angeles CA (3 TX teachers and evaluation research PI)
MoDRN at a current HS summer advanced academics camp

“We are incorporating STEM activities centered around the theme of "Destination Mars". The students will work for two weeks on developing solutions for space exploration to Mars, including building a go-cart for travelling on martian terrain and MoDRN green chemistry investigations aimed at the careful selection of taking safe products into outer space”
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