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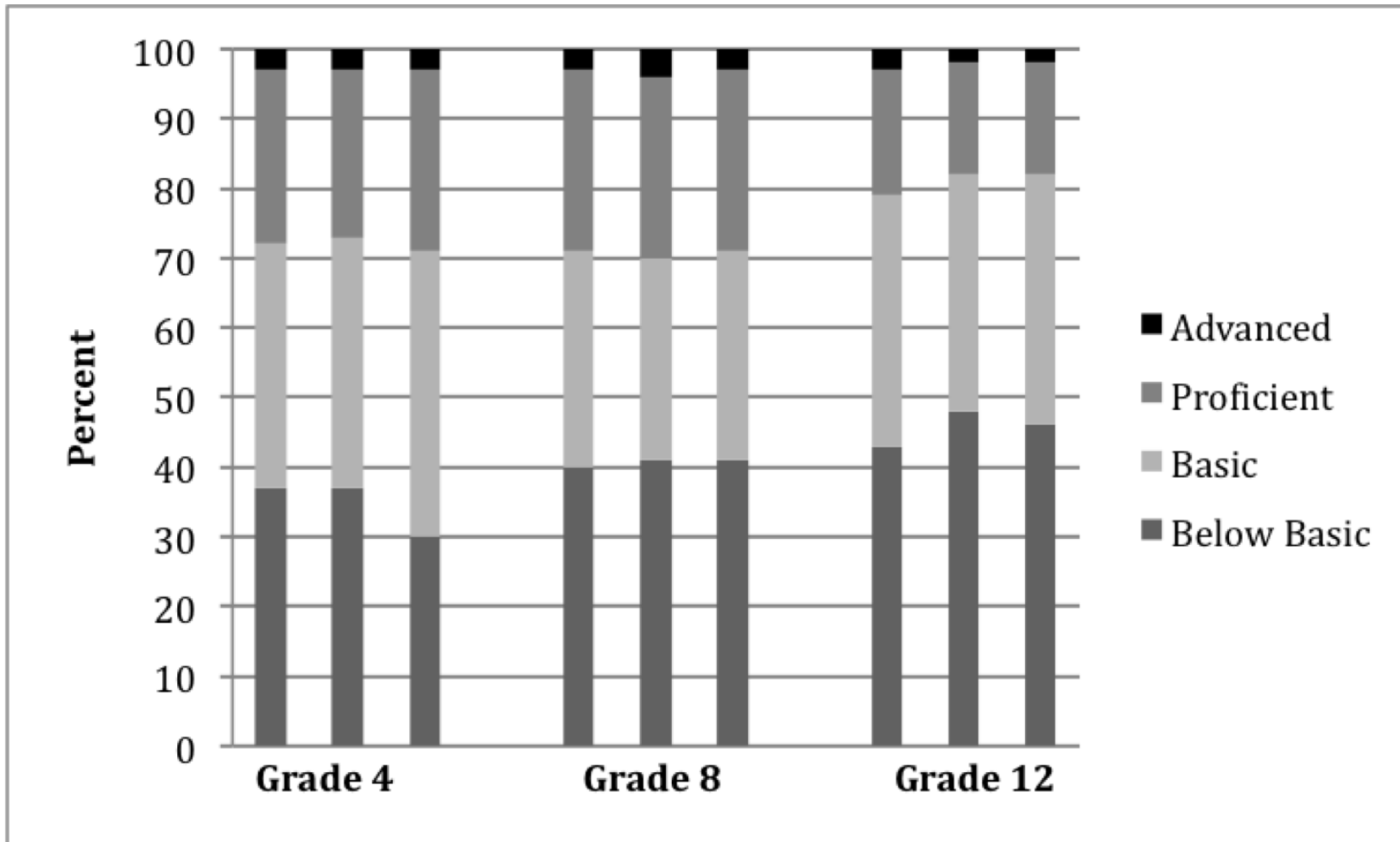
Green Chemistry Curriculum and Training at the K-12 Level

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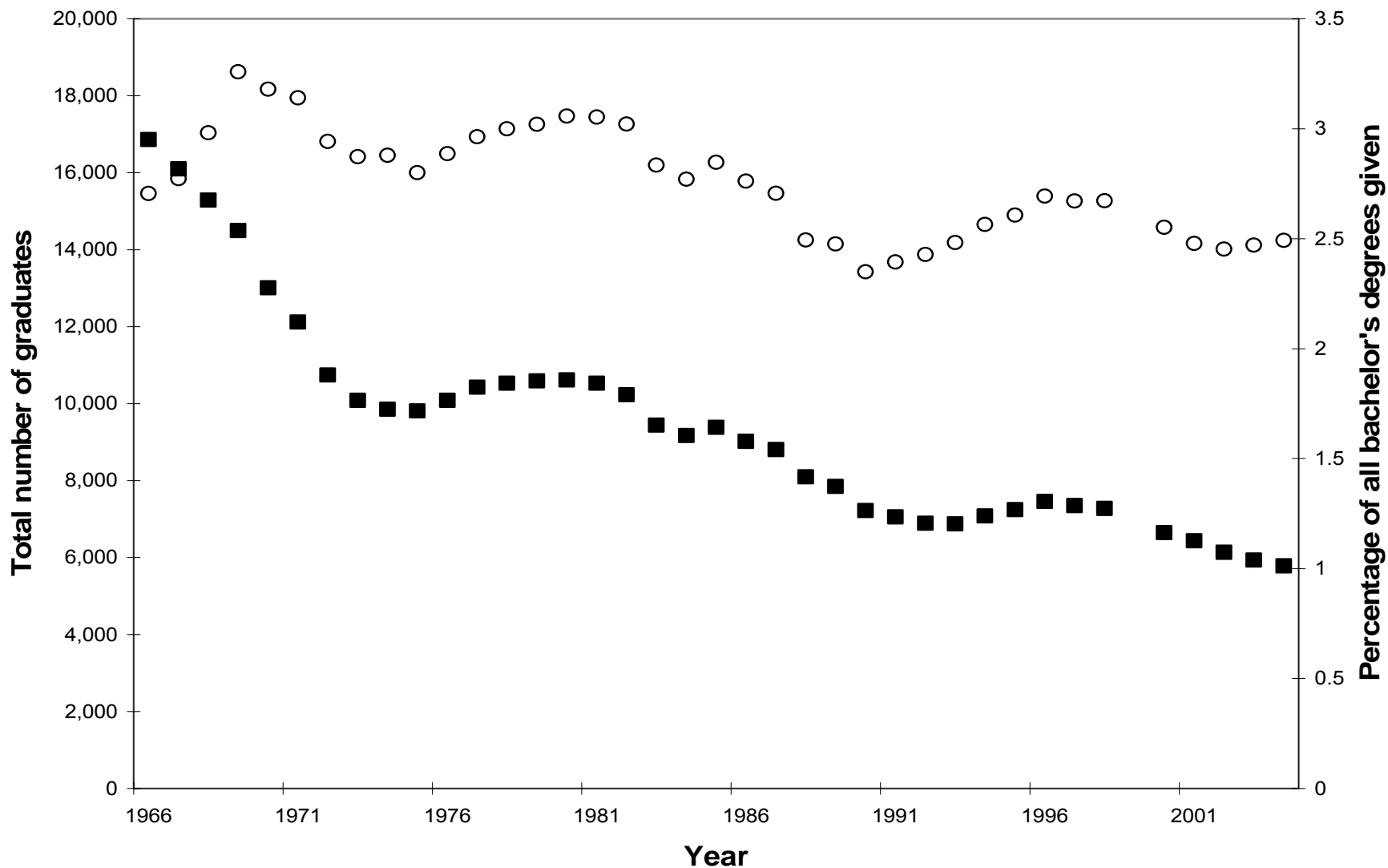
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What's going on in science education ?

- 92% of U.S. High School students report that Chemistry was their most difficult subject in high school
- 1 % of U.S. citizens attending university are enrolled in a degree in the physical sciences



Science achievement-level performance reported by:
 National Assessment of Educational Progress (NAEP) at the U.S. Department of Education, 2005



The degrees given in the physical sciences in the U.S. from 1966-2004, represented as: (○) the total number of graduates and (■) the percentage of all bachelor's degrees given, as reported by the National Science Foundation.



Beyond Benign promotes science driven by the principles of Green Chemistry in order to create an environmentally, socially and economically prosperous world.

www.beyondbenign.org



- Headquarters located in Wilmington, MA (~20 minutes north of Boston)
- Employees based in MA, CO and CT; Curriculum specialists nation-wide and international
- Co-founded by John Warner and Amy Cannon in August of 2007
- Created to carry on work in Green Chemistry education in the interdependent areas of K-12, Community, Industry and Government



The Learning Center at Beyond Benign





K-12

- Curriculum Development and Teacher Training
 - Green Chemistry
 - Green Math & Engineering
 - Biotechnology



Community

- K-12 and Community Outreach
 - K-12 classroom visits
 - Community events
 - Informational/promotional events
- Community Building (Regional and International)



Workforce Development

- Curriculum Development and Training
 - Community College
 - Technical Training
- Community Building
- Government

K-12 Education

We aim to deliver teaching and learning tools to K-12 educators in order that they may share dynamic science experiences with their students with an emphasis on objective reasoning through the consideration of economy, society and the environment in equal measure



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Core Philosophies

- ✓ Teachers teaching teachers
- ✓ Classroom tested teaching materials
 - ✓ Classroom support
 - ✓ Hands-on, inquiry-based activities
- ✓ Science for all in an interdisciplinary format
 - ✓ Open Access education materials
 - ✓ Industry partnerships
 - ✓ Neutrality



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**Recipe for Sustainable
Science:**

An Introduction to
Green Chemistry in the
Middle School



**Solutions in
Green Chemistry:**
An Introduction to
Green Chemistry in the
High School



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Green Chemistry Education

- **Beyond Benign**
- **Greener Educational Materials (GEMs) Database (University of Oregon)**
- **American Chemical Society's Green Chemistry Institute**
- **GCEdNet – Green Chemistry Education Network**
- **University of Scranton Greening Across The Chemistry Curriculum**
- **Fisher Science Education**
- **Books**



The Middle School Green Chemistry Module: “Recipe for Sustainable Science”

- Interdisciplinary: Science, Math, Language Arts, Social Studies
- 47 lesson plans
- Sustainable business simulation
- Mapped to National education standards
- Contains all teaching materials
- Available in Spanish and country modifications

Recipe for Sustainability: The challenge

- Game show intro
- Company formation
- R & D
- Market analysis
- A few curve balls
- Product manufacturing
- Evaluation
- The Green Chemistry Award



The Final Product



“Middle School students can’t possibly understand the principles of green chemistry”

- 367 middle school teachers fully trained and implementing all or part of the curriculum
- Over 10,000 students exposed to green chemistry in a single year



The High School Module: “Solutions in Green Chemistry”



- Tool for high school science teachers
 - Curriculum to introduce green chemistry
 - Resources to implement green chemistry
- Chemistry intensive but still engaging to high school students
- 31 lesson plans
- Sustainable business simulation
- Mapped to national education standards and green chemistry principles
- Available in Spanish and country modifications

About the curriculum package



- Activities that ingrain the 12 principles of green chemistry
- Replacement lesson plans
- Online product R & D challenge
- Case studies of Presidential Green Chemistry award winners – Petretec, Sea-nine 211, TAML
- Analyzing the way products are made currently
- Experimenting with alternative methods to make a product
- Analysis of all materials and processes against the 12 principles of green chemistry

“Maybe you could introduce some of the labs at the AP level”

- 131 high school teachers fully trained and implementing all or part of the curriculum
- Over 3,000 students exposed to green chemistry in a single year



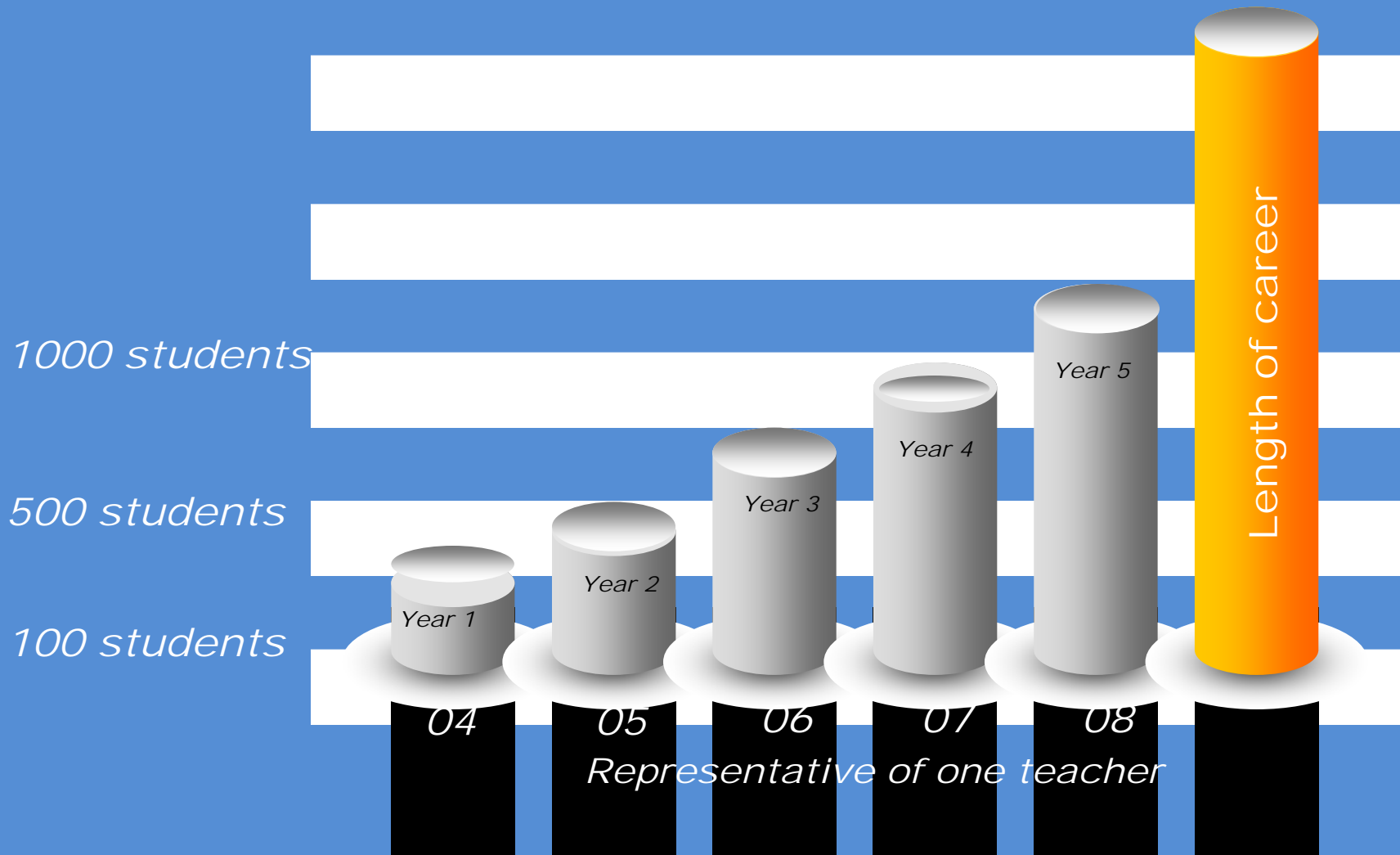
Metrics

- Teacher feedback – workshop and implementation surveys:
97% of teachers who take the workshop training are implementing 10 or more of the lesson plans
- Student Feedback – Pre/post surveys:
92% of middle school students are able to list (many in their own words) at least 8 of the 12 principles of green chemistry

87% of high school students are able to list at least 10 of the 12 principles of green chemistry and relate them to an industry example

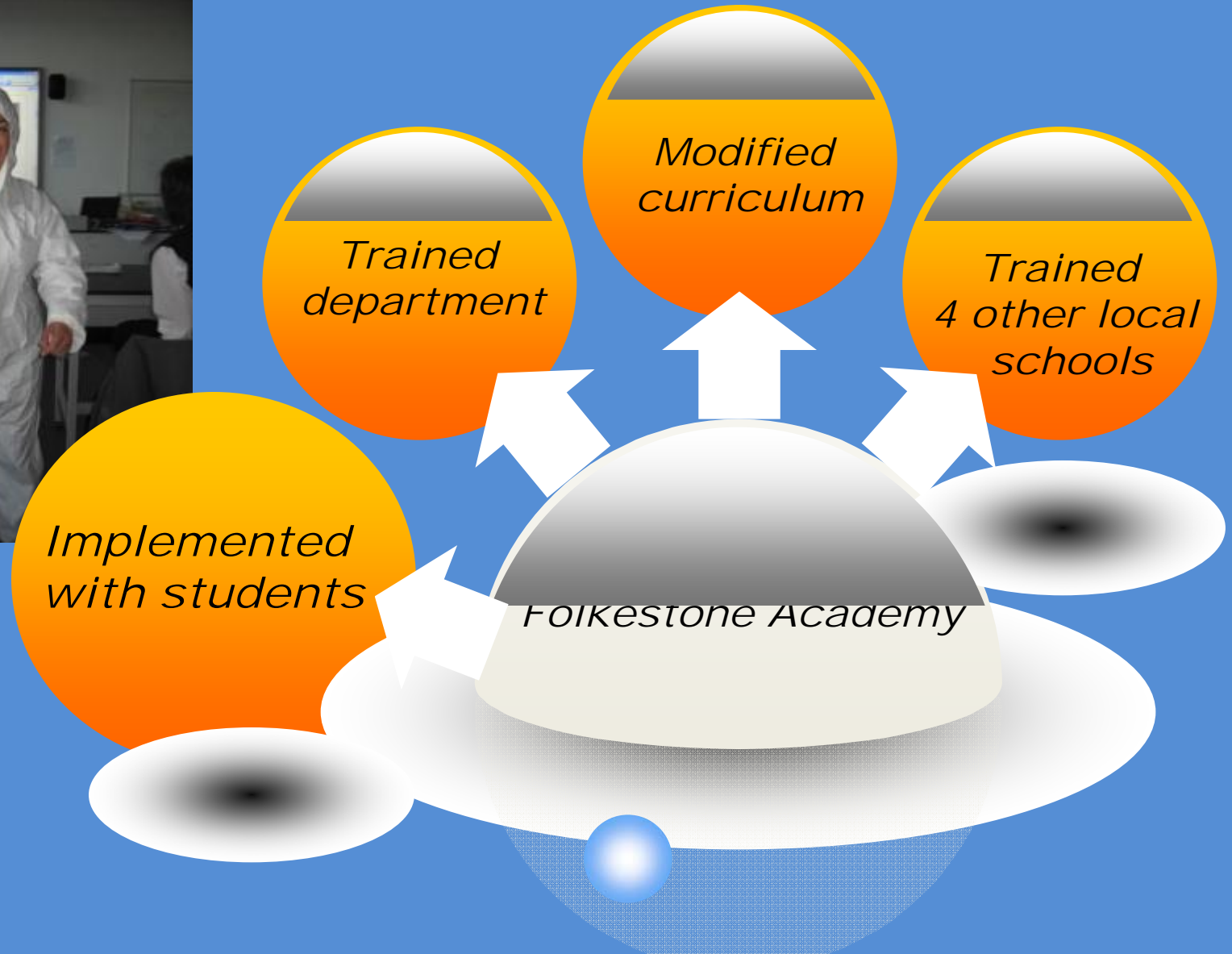
Multiplier of impact

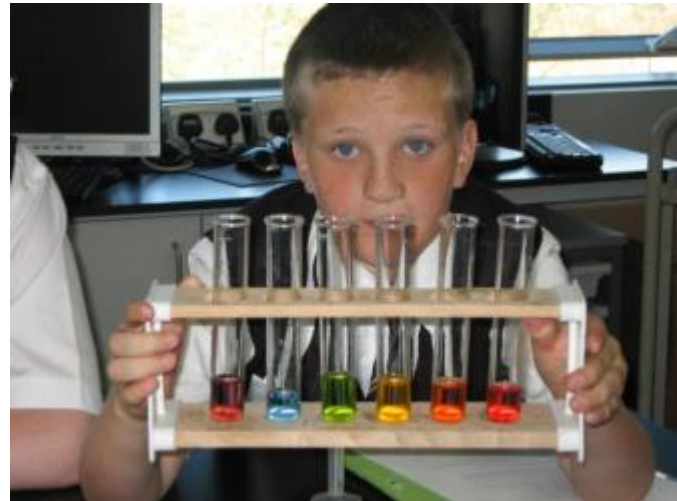
1 teacher x 120 students per semester x 2 semesters per year



One teacher

*Attended workshop in
2005 & 2007*





2003

2004

2005

2006

2007

2008

Plans for the future

Teachers, students and industry

2009 and beyond

1

Summer institutes

2

Curriculum adoption in national standards

3

Full online resource for replacement labs

4

More country specific/language versions

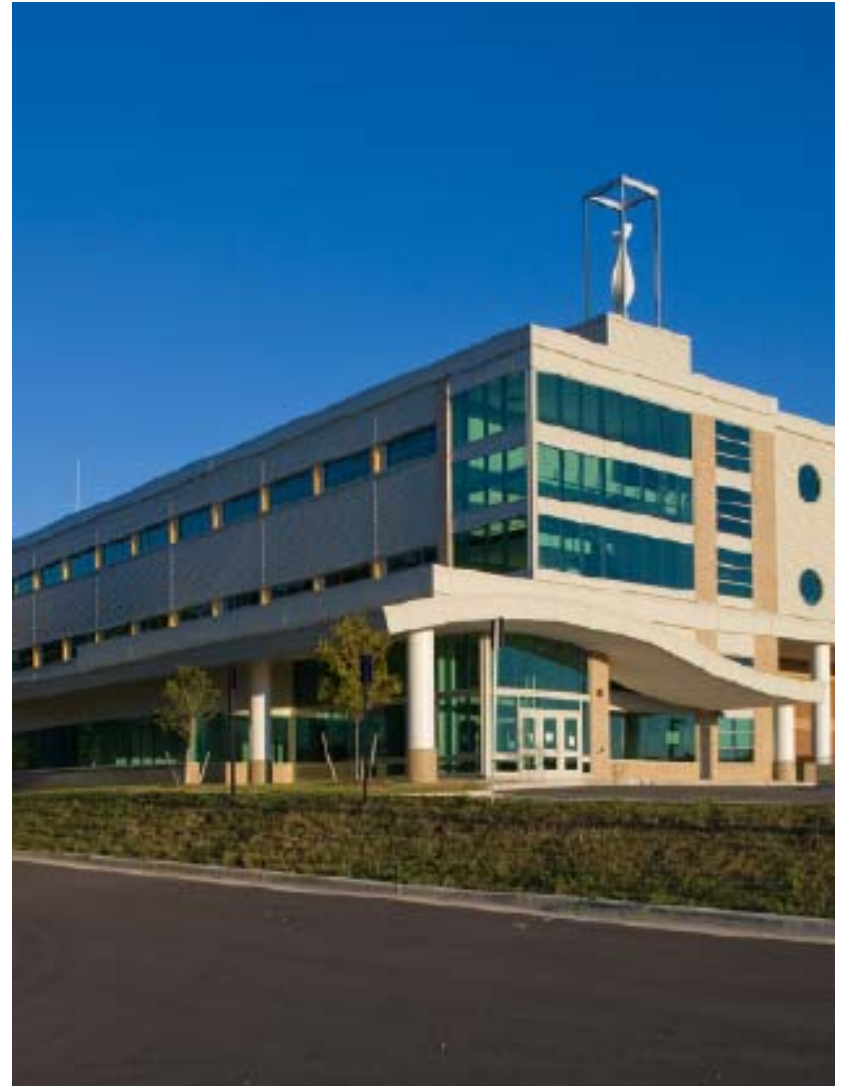
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Continue to respond to needs of teachers



Skyline High School, Ann Arbor, MI

- LEED certified building
- Geo-thermal
- Recycled materials
- Wind Turbine
- Motion Sensor lights
- Waterless urinals
- Retention ponds
- Planting of native plants
- Restoration of wetlands



Science at Skyline

- **ACIS I and ACIS II**
 - Accelerated Integrated Science - 9th and 10th - Environmental emphasis
- **Sustainable/Green Chemistry**
 - Third trimester 10th
 - **Advanced Sustainable/Green Chemistry** -11th
- **Environmental Science and Ecology** - 12th



Science at Skyline

- **Sustainable/Green Chemistry**
 - What are the 12 principles of Green Chemistry?
 - In industry
 - In a high school chemistry course
 - What are green chemistry technologies
 - Blackberry solar cells
 - Super critical carbon dioxide for extraction of orange oil



The Footprint of a Chemistry Teacher

- Science teachers are acutely aware of the environment.
- We also have a footprint in our chemistry classrooms that can have a profound effect on the earth.
- We tend to conduct labs with very little thought as to the impact of our classroom on the environment.

Two most important topics that are missing
in most chemistry courses in lab work

- Toxicity
- Impact on the environment



Chemistry in the 21st Century

- Before we begin an experiment: How have our starting materials been made?
- Can we trace them back to renewable resources?
- How much waste is generated from the process?
- What happens to our waste?
- From where do we get the energy needed for the reaction and how is it generated?
- Finally we will end up with a complete picture of not only what happens in our experiment but how our reaction interacts with the environment.
- In most cases it will be difficult to determine all parameters in exact measures, but even rough estimates allow the identification of problems and opportunities for improvement.
- Asking these questions in our laboratory courses will change the way students look at a chemical reaction and prepare them much better for the professional tasks.



July 24-28, 2011

Chemistry Grows in Michigan
Western Michigan University

Theme Ideas:

- Green Chemistry
- Chemistry of Food
- Chemistry of Agriculture
- Chemistry of Materials

Considerations:

- Green Chemistry
Workshop held before or
after conference

Green Chemistry Education

- The essential component to a sustainable future
- Future and current students educated in green chemistry principles and practices



Green Chemistry Education

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HS and MS Curriculum: <http://www.beyondbenign.org/K12education/kthru12.html>

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