

Where do we go from here?
Educating green citizens and
scientists

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Green Community: Who we are → who can we be?

- Present **green** community:
75 attendees at this workshop
- Future **green** community :
create **green** curricula to educate all undergraduate majors

10,155 undergraduate degrees in chemistry in 2003-04

4,759 undergraduate degrees in engineering in 2003-04

14,914 possible undergraduate green scientists/year

* American Chemical Society 2003-2004



Green Community: Who we are → who can we be?

In 2000, there were 2.5 million first-time college freshmen.*

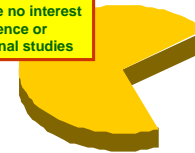
* Statistical Abstracts of the US 2004-2005; 124th edition, US Census, Washington, D.C.



Green Community: Who we are → who can we be?

Areas of interest reported by first-time college freshmen (2000)*

70% = state no interest
in science or
professional studies

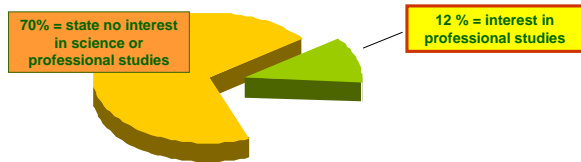


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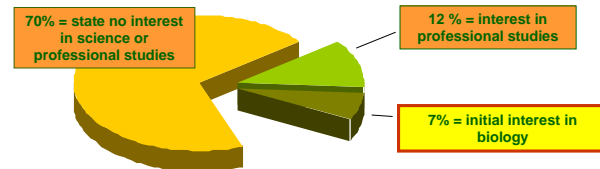


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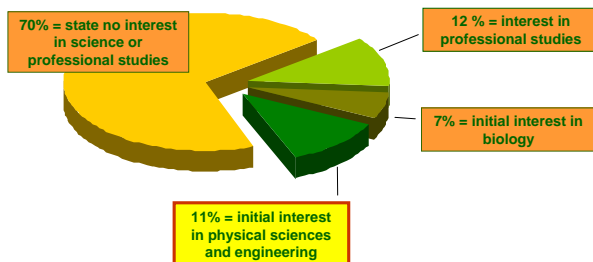


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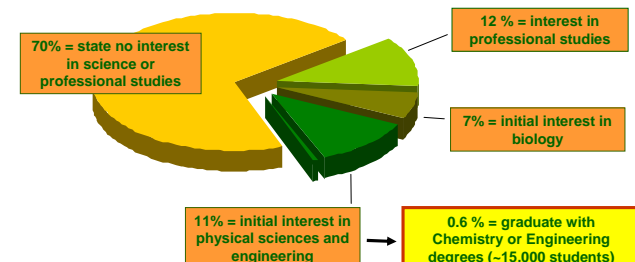


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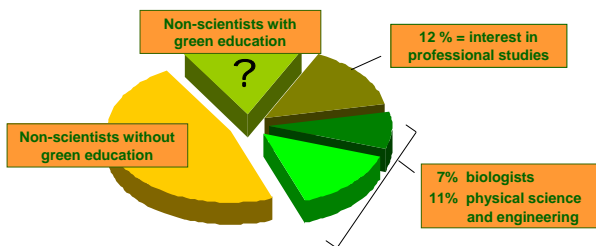
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Green Community: Who we are → who can we be?

Green Introductory Science Courses

0.6 % graduates → 18 % *prospective* scientists & engineers



Green Non-Science Majors' Courses

18 % → 25 - 50 % of all college students

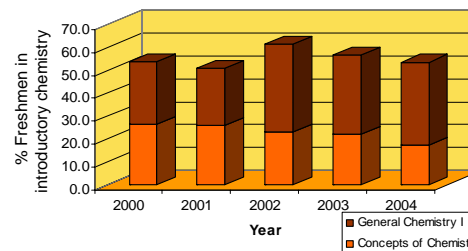
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Think Green Globally; Educate Green Locally

At Hendrix College

- < 4% of the freshmen become chemistry majors
- ~ 50% finish either General Chemistry I or Concepts of Chemistry



Educate Green Locally: *Green-SWAT*^s Laboratory Program

§Green-Soil and Water Analysis at Toad Suck*

Green, analytical, environmental chemistry for introductory students

Green

- chose simple, safe, and environmentally important analytes
- used instrumental methods
- involve students in green discussions

Analytical

- modified established protocols (EPA & AAOAC)
- build analytical skills slowly & repeat & repeat

Environmental

- wrote scenarios to establish local relevance
- created primers to link introductory chemistry to analytical information and environmental topics



*Toad Suck is the historically accurate name for the Arkansas river crossing at Conway, Arkansas.



Green-SWAT Laboratories Learning Goals & Experimental Techniques

Fall Semester

1. **Introduction: Green Chemistry, Environmental Analysis and Analytical measurement** balance use and glassware accuracy
2. **Scrap Al cans → useful materials (alum)** processing salt waste, atom economy, basic laboratory skills
3. **NO₃⁻ and PO₄⁻³ in Surface Water** fertilizers, agricultural runoff, ppm units, standards, calibration curves, burette use, dilutions, ion chromatograph.
4. **Data Analysis & Statistics** spreadsheet equations, average standard deviation, random error, t-test
5. **Zinc on Galvanized Nails** acid rain, gas collection and calculations, partial pressure, stoichiometry, statistics, confidence intervals, comparison of methods, % difference
6. **Iron as a Model Toxic Metal** atomic and molecular absorption spectroscopy, Beer's law, transfer pipettes, dilutions, chemical hygiene, linear regression, calibration curves, standard series, molecular versus atomic analysis, technical graphing, EXCEL, precision and accuracy

Laboratory Skills Practical and Written exam



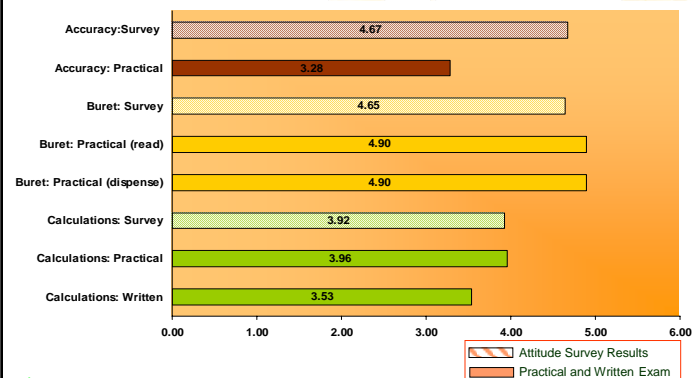
Assessment Is this working?

- **Assess:**
 - Are they learning analytical chemistry?
 - Are they learning green chemistry?
 - Are they learning any environmental chemistry?
- **Tools:**
 - Attitudinal Survey
 - Laboratory Practical Results (in random pairs)
 - Written Exam Results
 - Experimental Precision and Accuracy Results (pairs)



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Assessment Attitude Survey versus Exam Results



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Think Green Globally; Educate Green Locally

Green-SWAT Program:

Green, analytical, environmental chemistry for all students

- dispels exclusivity of environmental chemistry by teaching green chemistry with environmental topics to introductory students

*Everyone can participate in caring for the environment,
not the exclusive purview of science majors.*

- creates environmentally and scientifically "savvy" students through analytical chemistry

*Students won't know all the answers,
but can ask tough questions.*

- instills a green ethic into our students. This influences their future professional, business, and personal choices.

*Small effect locally, large effect through the students:
student biomagnification.*



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Acknowledgments

Testing Friends:

Tom Goodwin – who got me interested and helped me keep the project going
Camille and Henry Dreyfus Foundation Special Grants in the Chemical Sciences
All those students who patiently endured the kinks in the project

Legend of Toad Suck:

Long ago, steamboats traveled the Arkansas River. When river conditions were poor, captains and their crew tied up to wait where the Toad Suck Lock and Dam now is. While they waited, they refreshed themselves at the local tavern, to the dismay of the locals, who said: "They suck on the bottle 'til they swell up like toads."

from www.toadsuck.org



A Few Projects

- **Phosphate and Nitrate**

- Relevant local problem: poultry and hog farms; eutrophication of lakes, Mississippi River dead zone

- Analytical methods

- Colorimetric: Cadmium (EPA 353.2) or

- Hydrazine reduction method (EPA 353.1)

- Ion Selective Electrode (ISE)

- titanous chloride method (APHA)

- Ion Chromatography

- Chemicals: NaHCO_3 , NaNO_3

qualitative green scale 







- **Iron as a Model Toxic Metal**

- Nuisance in water (discoloration of appliances, color & taste)

- Protocol with atomic and molecular spectroscopy

- Test for laboratory hygiene - luminol to test students for contamination

- Platform to discuss real toxic metals (Pb^{+2} , $\text{Cr}^{+3/+6}$, As) – web exercises landscape timbers-Green Chemistry Presidential Award in 2002.

Everyone can participate in caring for the environment.

It is not the exclusive purview of science majors.



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