



Models for Early Undergraduate Research to Attract and Retain STEM Graduates

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Background and context

- The University of Nebraska at Omaha
 - A metropolitan university of ~14,000 students

- Chemistry Department
 - Undergraduate only
 - 500-600 students in general chemistry I per year

- Math-Science Learning Center
 - Opening fall 2007

 **METROPOLITAN**
COMMUNITY COLLEGE

UNIVERSITY OF
Nebraska
Omaha





The Goals

To improve student attitudes towards science and to increase citizen-level scientific understanding through authentic scientific experiences

- Increase **student retention**
- Increase **recruitment of majors**
- Increase curricular concentration in science **for 'science phobic' students**, including pre-service teachers

To increase the number of STEM graduates

- Expand, diversify and incorporate **new STEM degrees**
- Develop agreements for the articulation of **complete programs of study**
- Attract and retain students through the use of **scholarships**
 - Particularly under-represented and non-traditional students
- Improve the quality of and access to **experiential education** opportunities and student support services
- Increase **outreach and recruitment** activities





2 Models of EUR

Bring the research to the students

- Utilize existing courses
- Reach more students
- Mostly academic years
- More abbreviated experience

Attract the students to the research

- Traditional research model
- Longer duration
- Mostly summer





Model I – Bring the Research to the Students

- Drinking water analysis
- Soils analysis

- Analysis of archeological samples
- Phytoremediation studies and geochemical prospecting
- Acid and mineral analysis of rain water
- Collaboration with sociology studying lead in hair samples





Model I – Important Factors

- Relevant
- Accessible
- New/fun/exciting
- Repeatable

- Equipment availability and cost
- Modern/high-tech





Model I – Structure

- Geology students collect samples which are then distributed to the chemistry students
- Chemistry students analyze samples and return the analysis data
 - Accompanied by an oral presentation of the method, techniques and experimental uncertainty
- Geology students analyze the data for geologic/geographic correlations
 - Followed by an oral presentation of the findings/conclusions to the chemistry students





Model I – Vertical Integration

- Standards are prepared and used by upper level chemistry students responsible for instrument calibration
 - Collaborative experience
 - Check each others work
- These students visit each chemistry lab section to share
 - about the calibration process
 - measurement precision and uncertainty





Drinking Water EUR

Drinking water analysis by Ion Chromatography

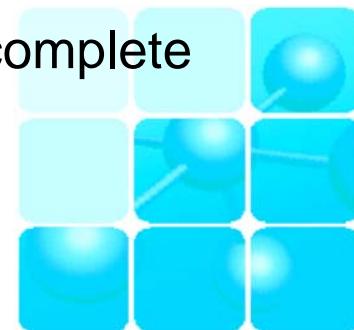
- Why IC?
 - Modern instrumental technique
 - Commonly used for water analysis
 - Short analysis time (~10 minutes)
 - Understandable by general chemistry students
- Why drinking water?
 - **We all use/consume it on a daily basis**
 - It is variable
 - By day, geography, home, etc.
 - Its quality is closely monitored/regulated





Drinking Water EUR

- Half of the students begin with paper chromatography separation of ink using four different markers and two different eluents.
 - Provides a good visual experience of chromatography in general
 - Illustrates the effect of using different eluents
 - Provides experience with using and understanding retention factors
- The other half of the students moves to the undergraduate chromatography lab to analyze their water samples
 - 6 IC instruments are available, 3 anion and 3 cation
 - Students run their sample twice and log the data into a web site
- After each half completes their first task, they switch and complete the other activity





Lead in Soils EUR

- Why ICP-MS?
 - To increase the variety of potential research questions
 - Versatility, speed, detection limits and dynamic range
 - Ability to measure isotopic abundance
 - Can provide information about geographic/geologic origin
 - **Pedagogical simplicity**
 - Theory based in atomic structure (accessible to gen chem students)
- Why lead in soil?
 - Within the city of Omaha is a well documented area of lead contamination currently being remediated
 - Multiple possible sources of lead origin
 - Lead smelting plant, paint chips, leaded gasoline, others?





Lead in Soils EUR

- Soils collected from students' own homes or public land
 - Samples are quartered prior to analysis
 - Measure intra-sample variability
- Chemistry students are responsible for
 - Sample grinding
 - Sample splitting
 - Digestion with nitric acid
 - Sample dilution
 - Initial data analysis





Communication

- Project website – water.unomaha.edu
 - Background information
 - Science/Instrumentation animation and explanation
 - Data collection and retrieval
 - Review of past results





Student Presentations

Chemistry → Geology

- Chemistry students share details about the science used and the accuracy of the data
- A single oral presentation prepared collectively by 4-8 volunteers
 - Required 10-12 hours of preparation
 - First given to each lab section before being given to geology
 - Allows all chemistry students to benefit from the presentation
 - Provides for peer evaluation and feedback
 - More practice presentation before presenting to geology

Geology → Chemistry

- Geology students share their analysis of the data
 - Geologic/Geographic correlations





Feedback (student comments)

Positives

- It was an experiment that directly **related to me** so it was more interesting
- Interaction** with both classes
- The fact that we as students were able to take part
- Being able to **connect the two sciences** and to learn more things about each because otherwise we learned facts but not their significance.
- This experiment was **something that we can relate to**





Feedback (student comments)

Positives

- It gave me more **perspective on what scientists actually do**, it puts you in that position and makes you think about how important the job is.
- It was interesting to see the differences around town.
- “**This is real life..** real ways of measuring w/ programs and instruments. Not just hypothetical situations of mixing in tubs.”





Feedback (student comments)

Negatives

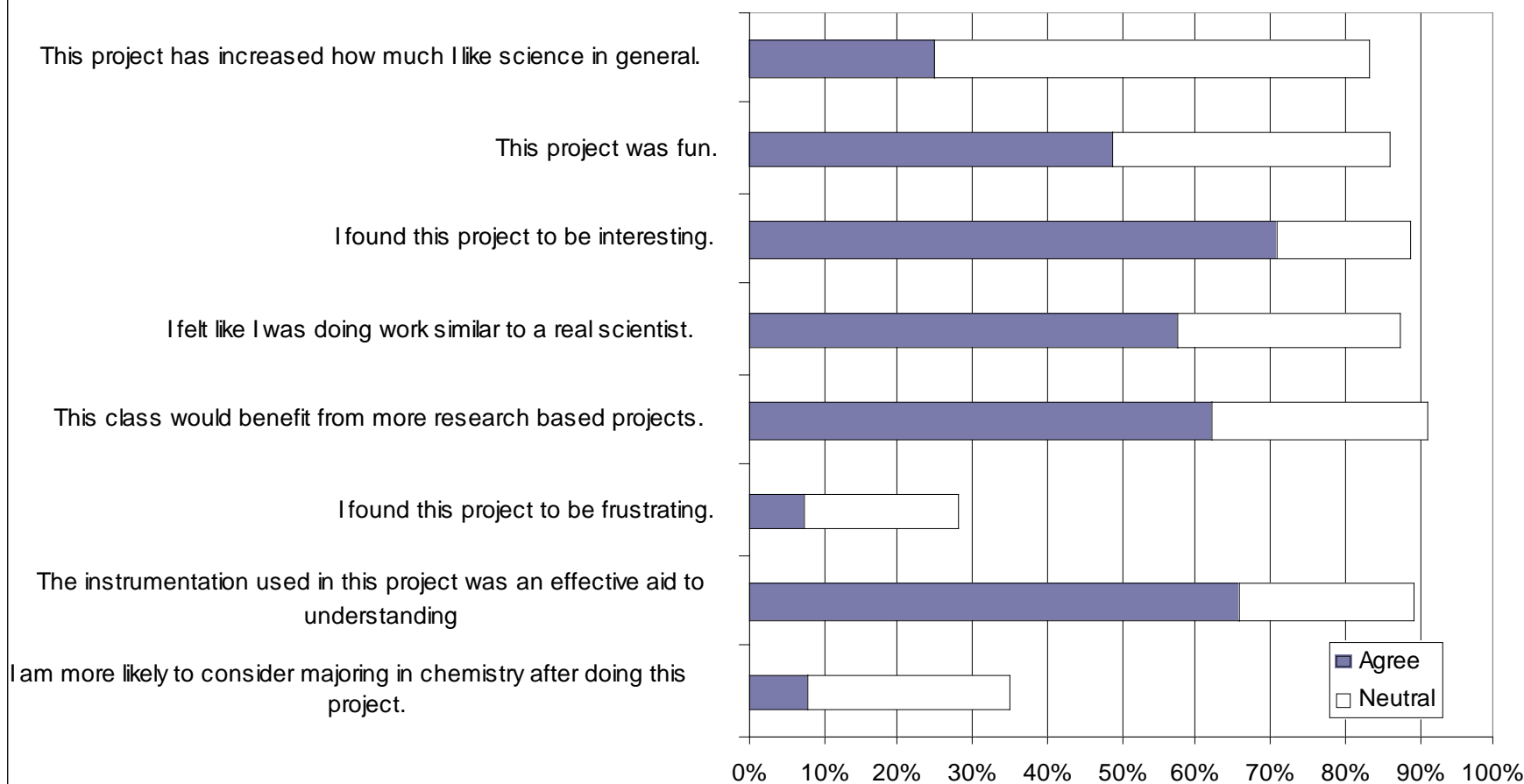
- Risk of students perceiving this experiment as ‘black box’ work
 - “with the ion-o-meters, we squirted something into it and got a picture out of it...I had no clue.”
- Presenting students learned a lot more about the research
 - “I think that a lot of people (not doing the presentation) missed out on a very important part of class.”





Water Analysis Feedback (chemistry)

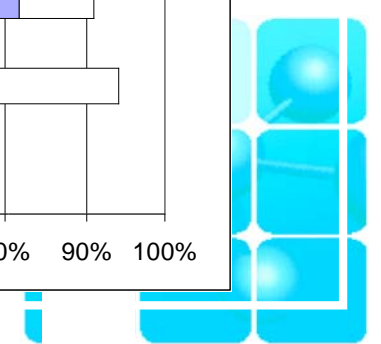
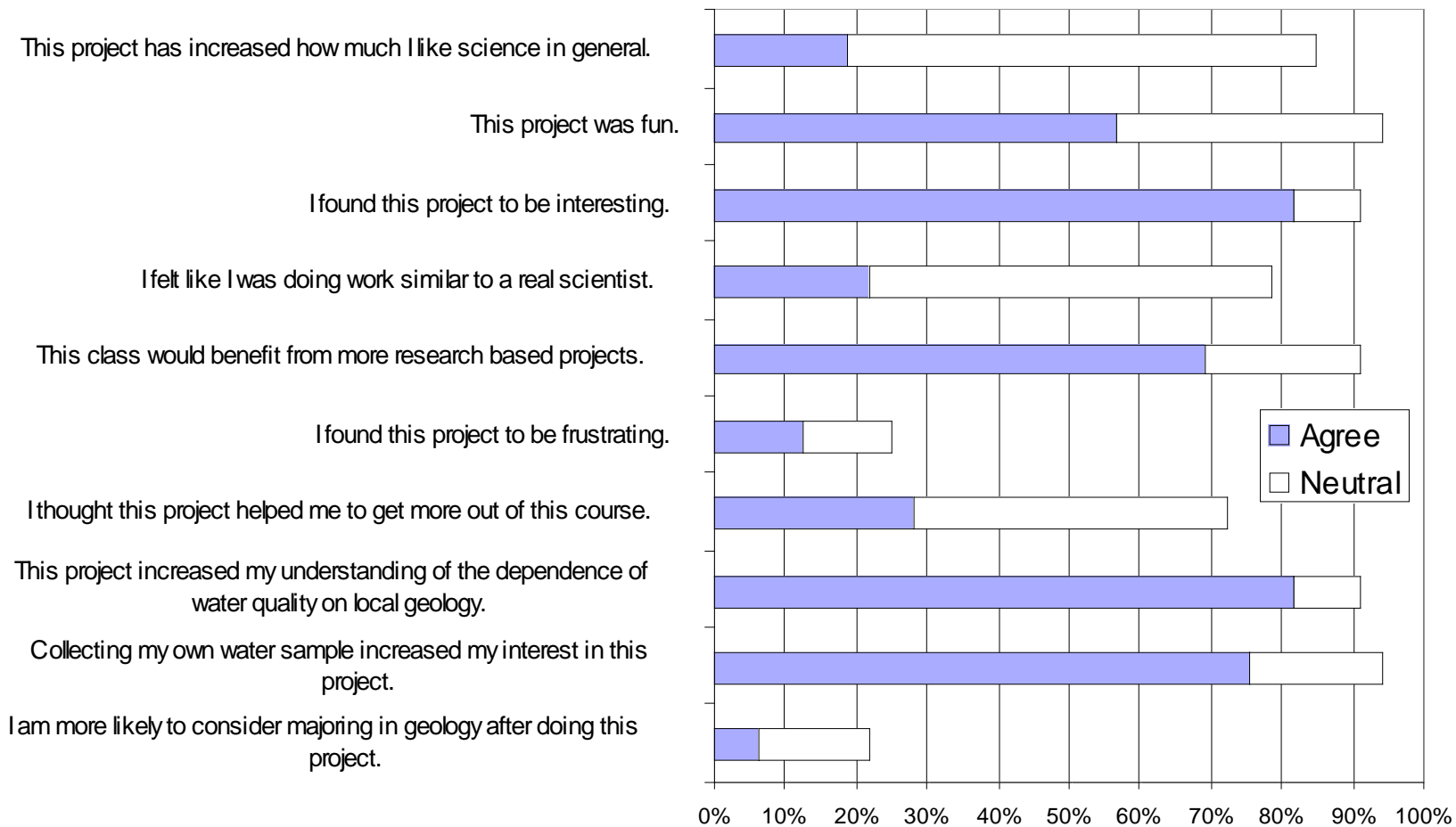
Percent of Chemistry Students Agreeing with Aspects of the Project





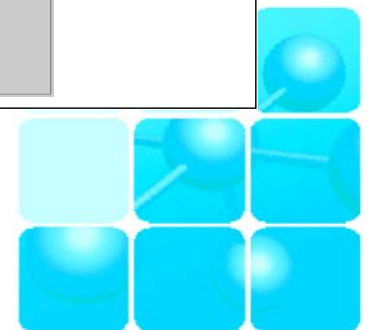
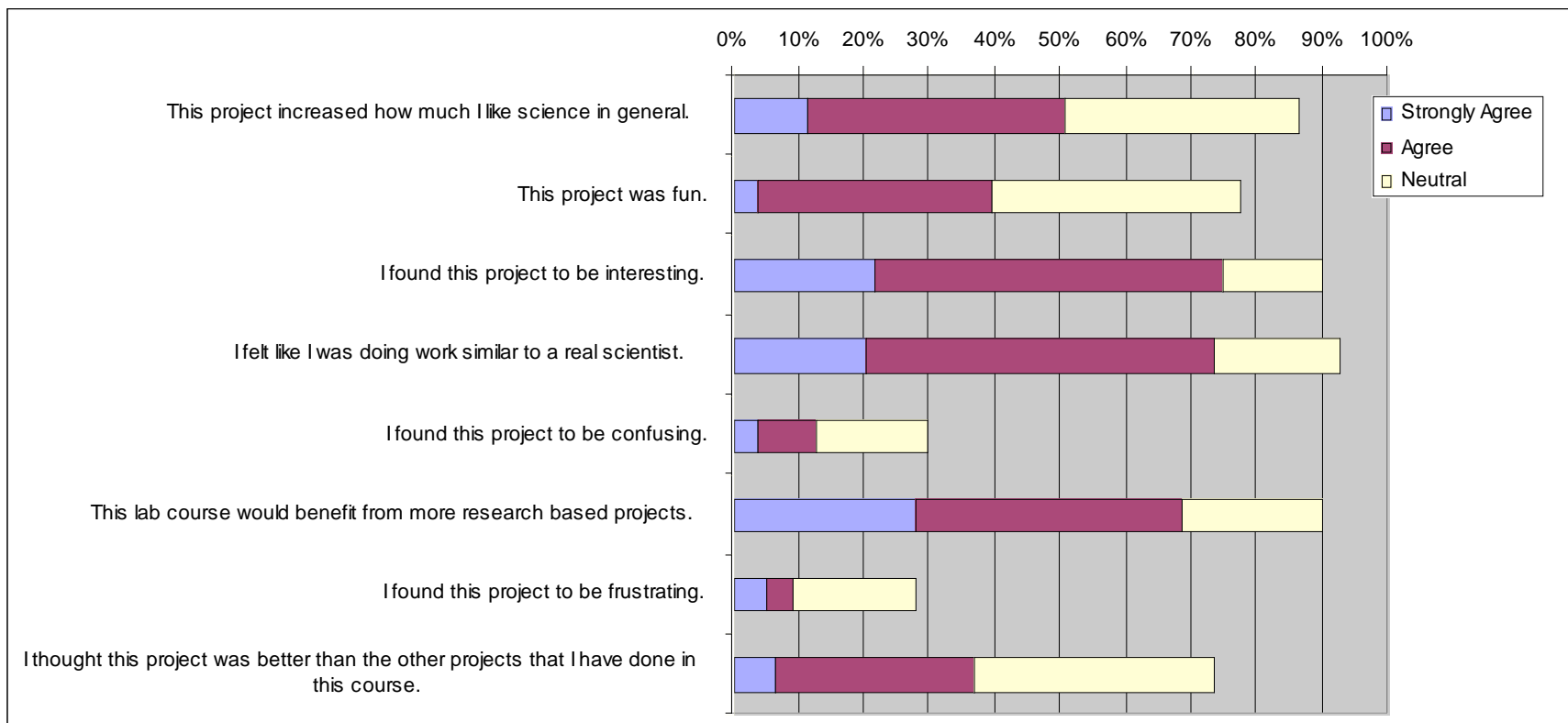
Water Analysis Feedback (geology)

Percent of Geology Students Agreeing with Aspects of the Project



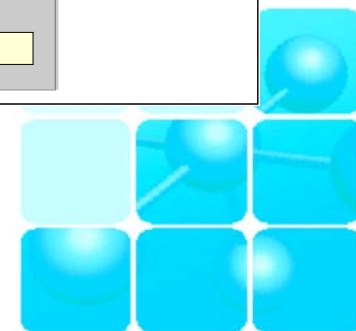
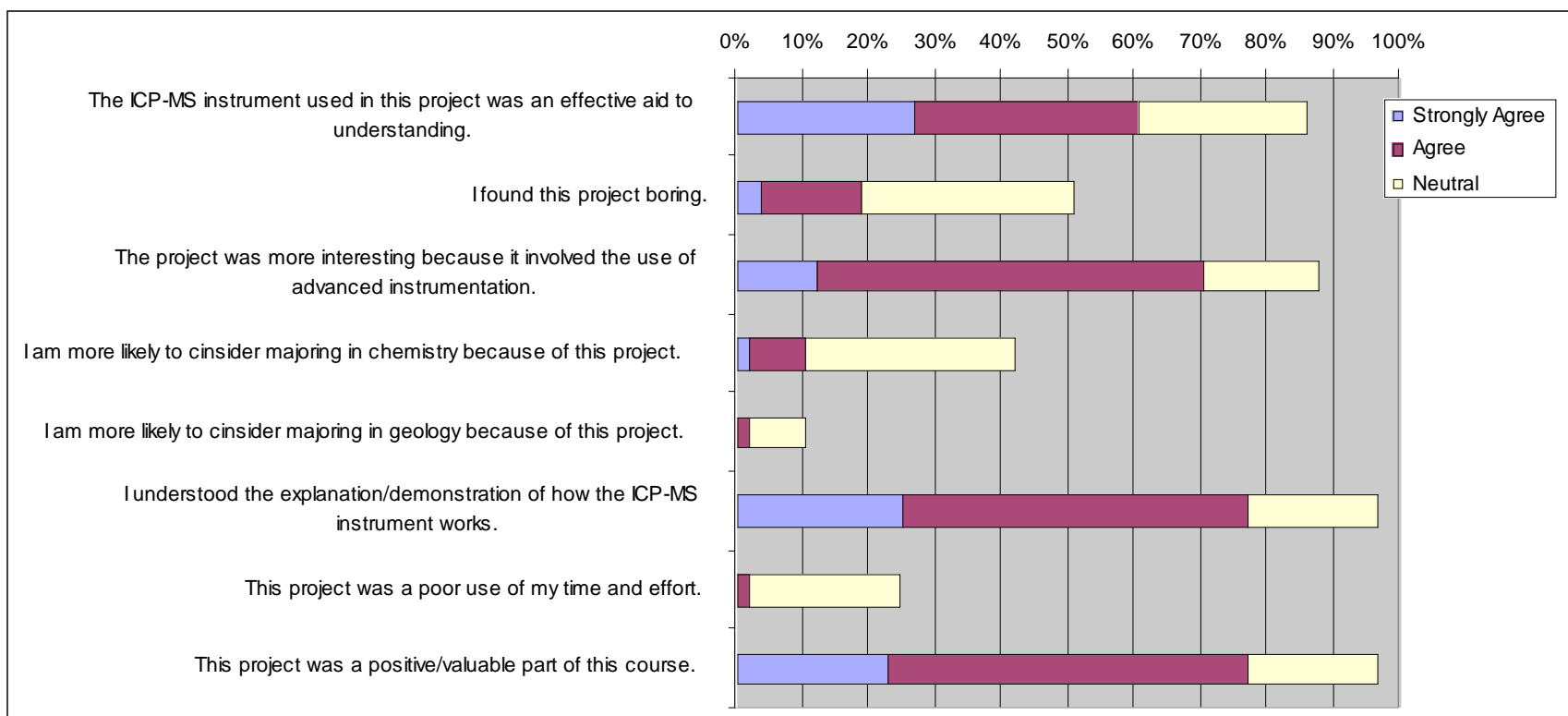


Soils Analysis Feedback (chemistry)



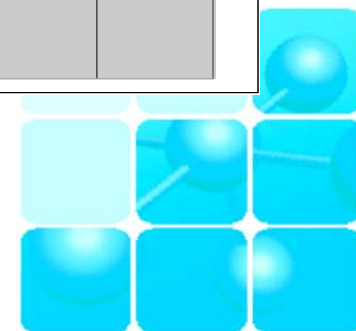
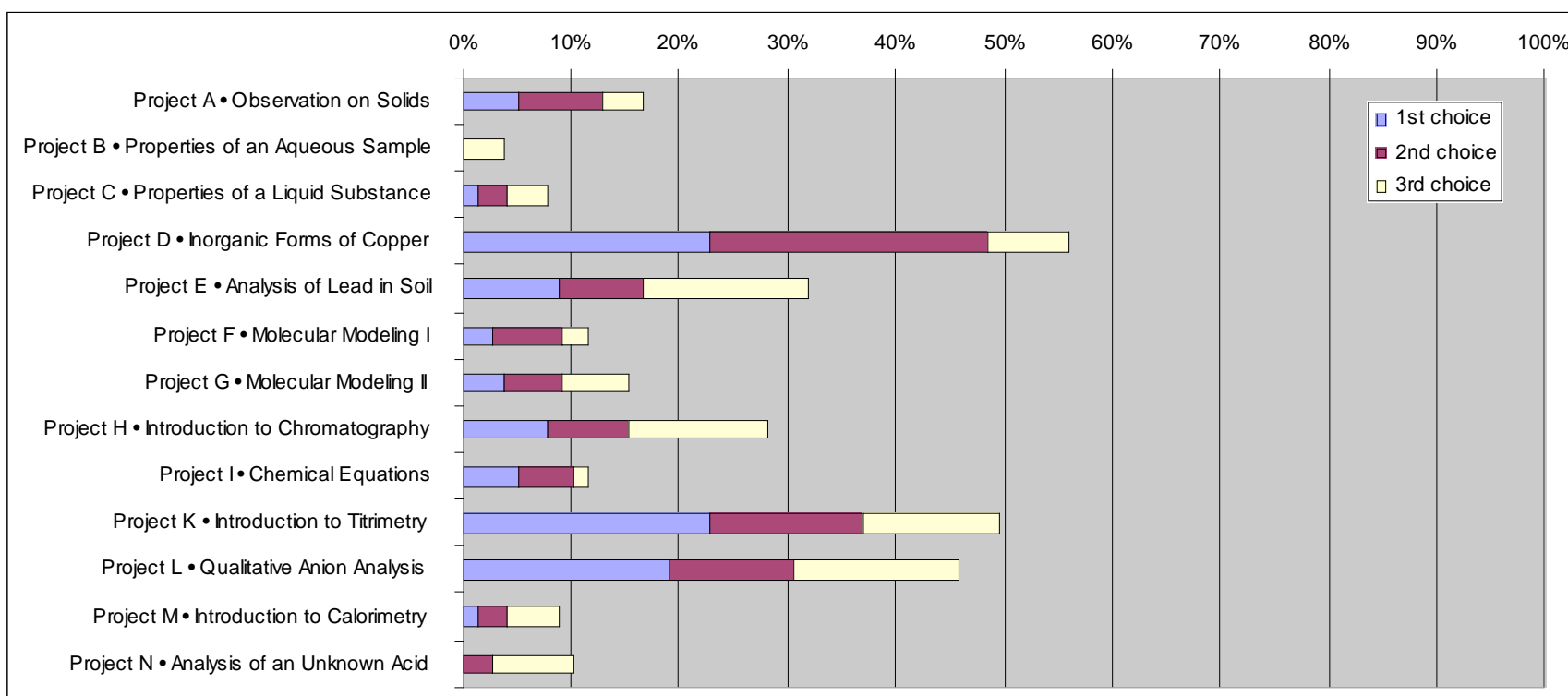


Soils Analysis Feedback (chemistry)



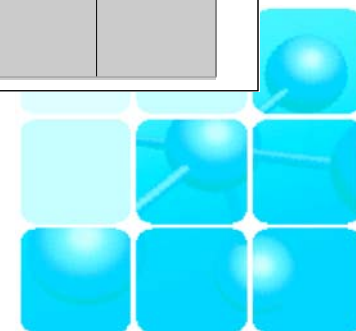
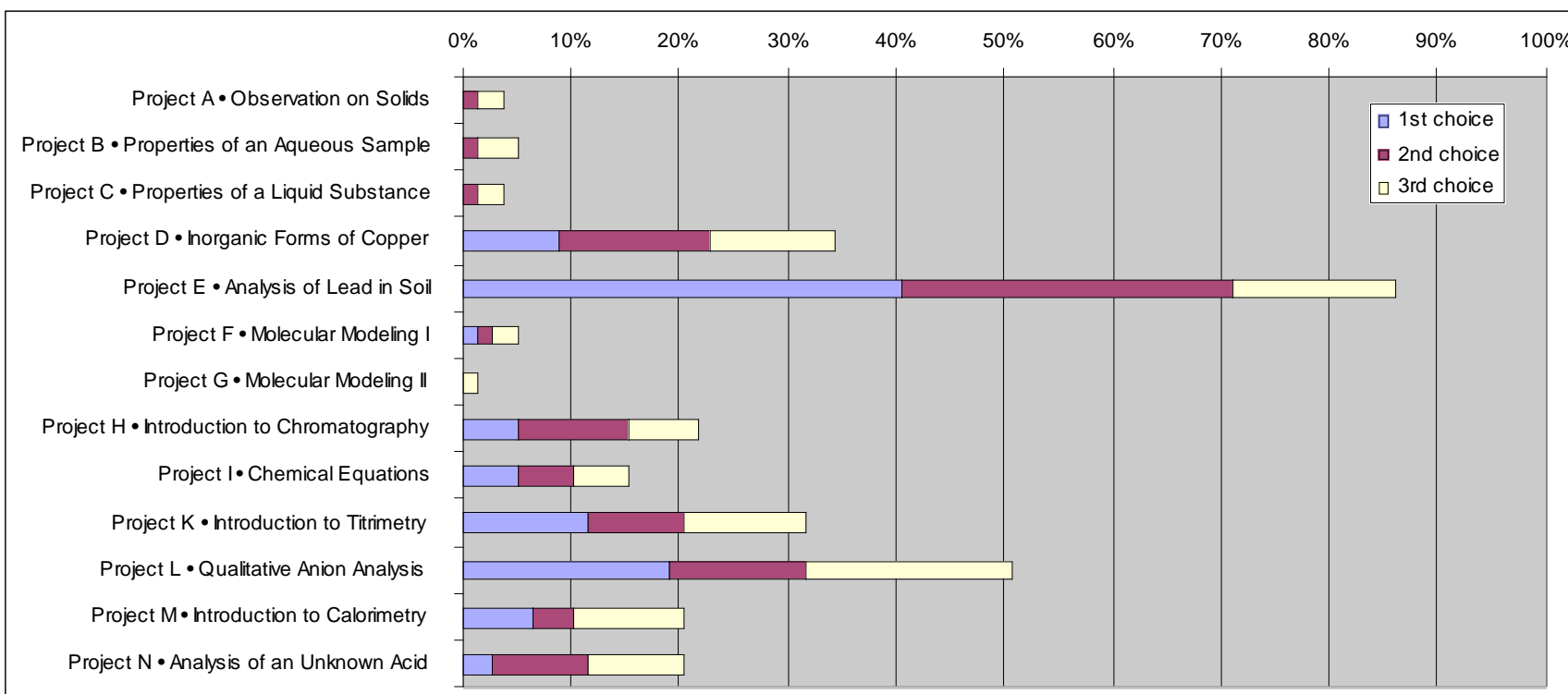


Which experiment most increased how much you like science in general?



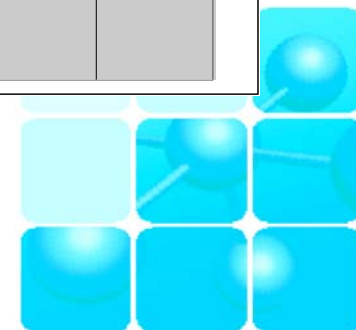
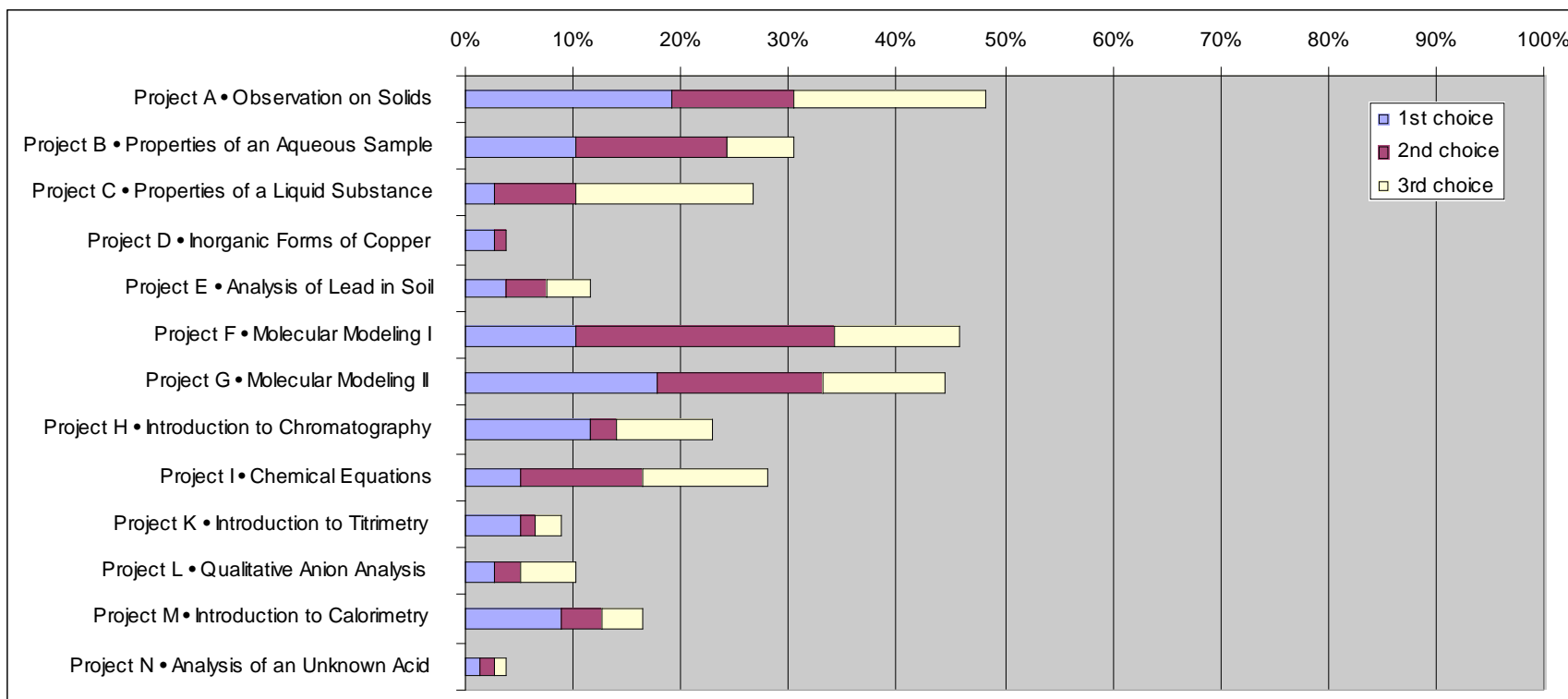


Which experiment did you feel most like you were doing work similar to a real scientist?



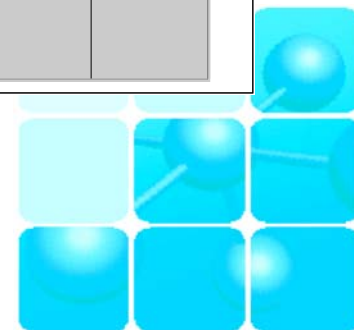
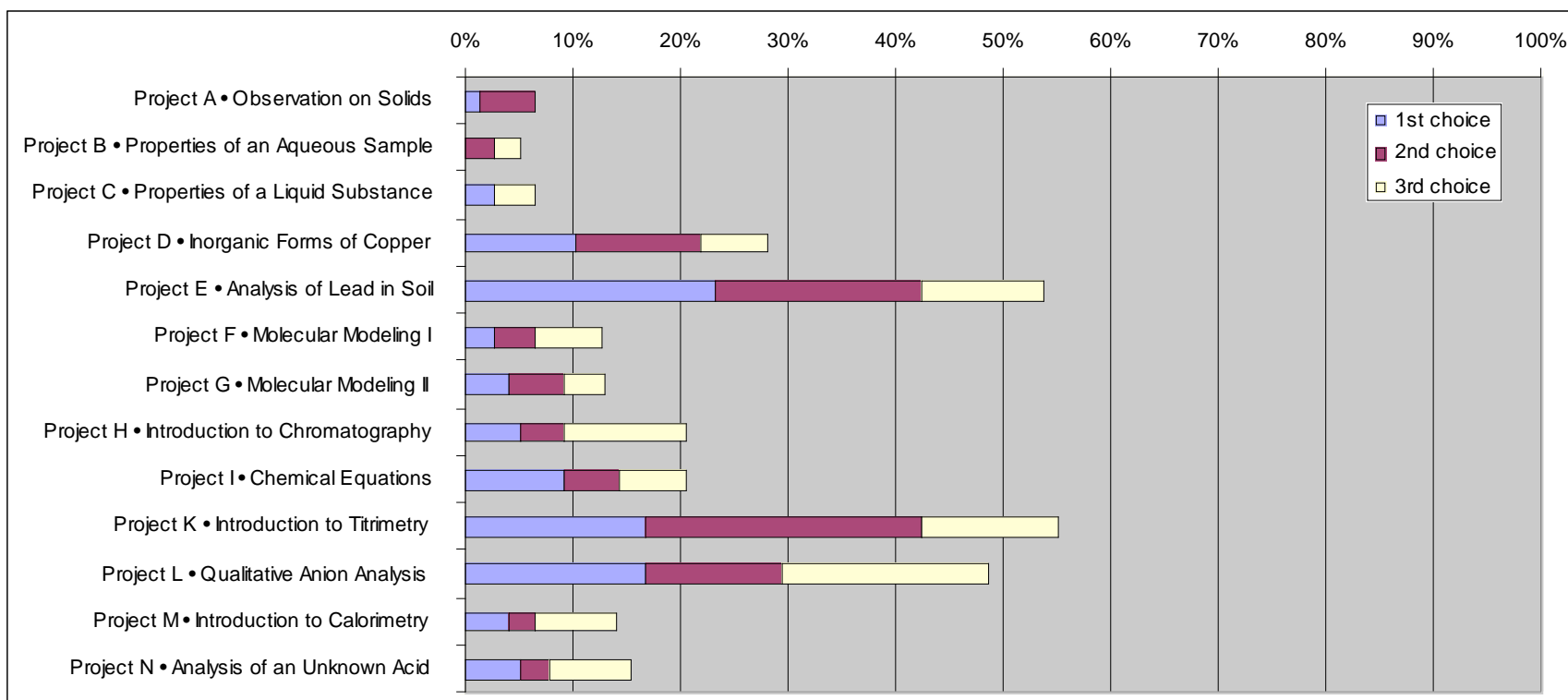


Which experiment was the poorest use of your time and effort? (aka, I should have skipped class!)





Which experiment was the most meaningful?





Challenges

- Lab instructor 'by-in' has been a challenge
 - Our chemistry labs are run by non-tenure-track instructors (not professors and not grad students)
- Scheduling
- Ensuring students see the big picture
- Semester to semester communication
- Considerable faculty supervision
- Ordering 'little' things adds up
 - and makes the Dept chair happier when it is paid for by the grant





Model II – Attracting the Students to the Research

- Faculty recruit qualified early undergraduates into a **motivational research activity** and then to supervise the students involved for one or more semesters.
 - Focus on 1st and 2nd year students
 - Encourages these students to consider a STEM major
 - Funding provides for
 - Faculty summer stipend
 - Tuition waivers for students, up to 3 credits/student
 - Limited funds for materials, supplies and travel





Proposals selection criteria

- Evidence for successful recruitment and retention of students into a STEM major
 - On what personal experience or successful external models of EUR is the project based?
- Number of students projected to be involved
- Sustainability
 - Anticipated duration
 - Is it an ongoing project or one-time?
 - Will continuation require additional funding?
- If the proposed research is interdisciplinary
- Projects that specifically target underrepresented groups are especially encouraged.





Results

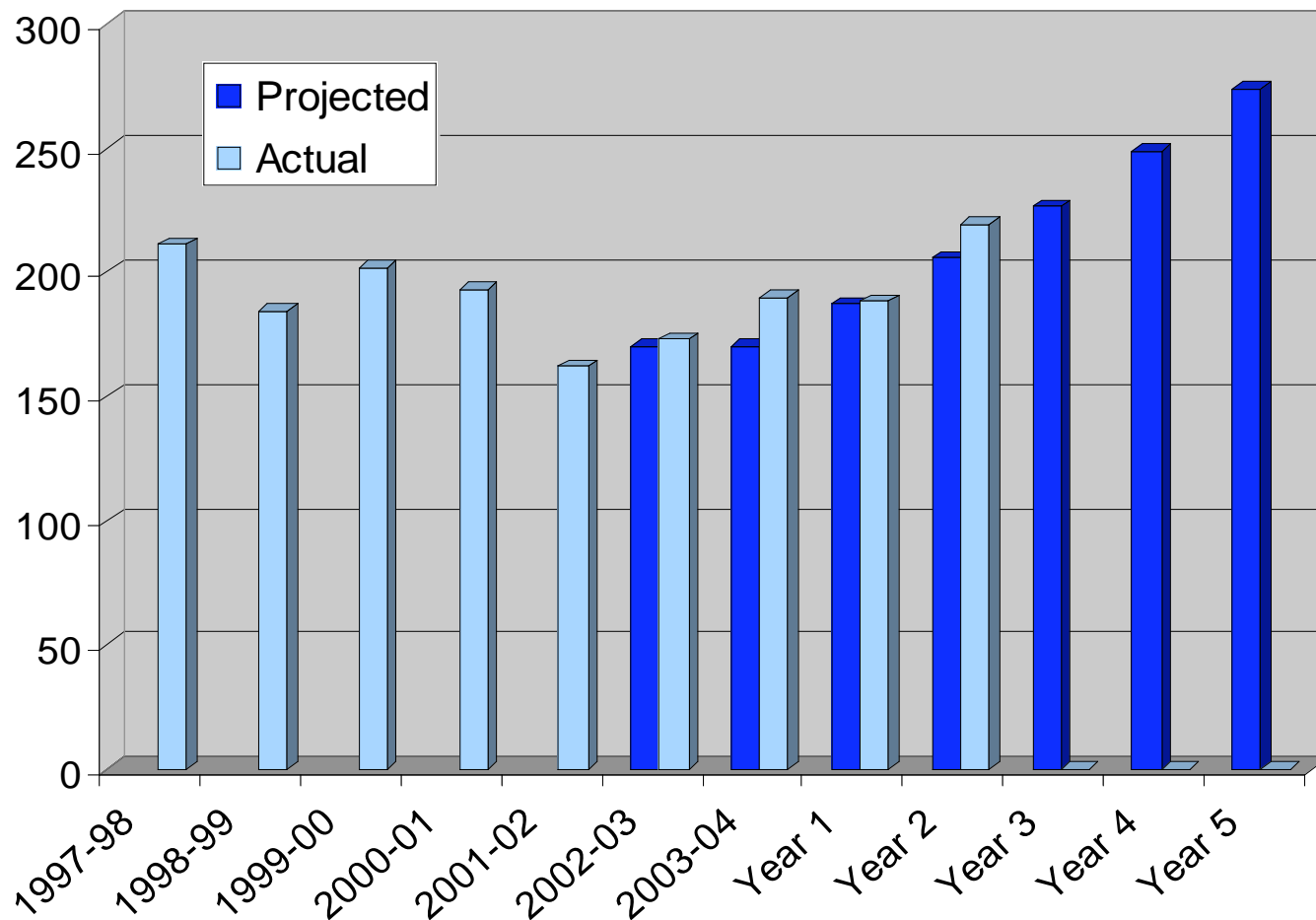
- 2004
 - 6 projects, 37 students
- 2005
 - 6 projects, 24 students
- 2006
 - 7 projects funded, 40 students
- 2007
 - 12 projects funded
 - First MCC project & students

93 of those 101 EUR students from years 1, 2 and 3 are currently pursuing STEM degrees





UNO STEM Graduates





Challenges

- Attracting 1st and 2nd year students
- Attracting students who aren't already STEM majors
- Project cost per student





Future plans

Model I

- Expansion to other disciplines and other chemistry courses
- Improved data quality

Model II

- Greater collaborative emphasis
- Integrate research, service learning, equipment
- Improved means of attracting students
- Better evaluation





Institutionalization in a New Math-Science Learning Center

■ Objectives

- Collaborate with math and science **faculty**
- **Assess** science education effectiveness
- **Collaborate** with other campus units with related missions
- Provide **student learning support**
 - Entry level tutoring
 - Course modules
 - Specialized instruction
 - Study skills training
 - **Peer mentoring**
 - Peer led team learning





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