Undergraduate Research as an Integrated Four-Year Academic Experience

Barry Falk
Chris Hughes
James Madison University

Shila Garg
Heather Fitz Gibbon
The College of Wooster

UNDERGRADUATE RESEARCH AT JMU

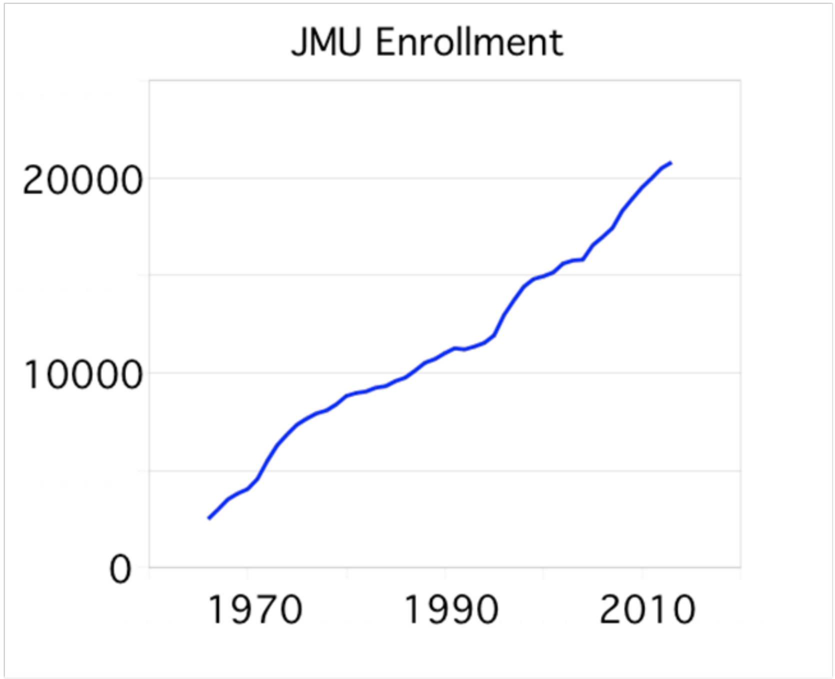
Barry Falk, Honors Program

Chris Hughes, Dept. of Physics and Astronomy

James Madison University

Background - Who We Are

- State supported comprehensive university
- Located in Shenandoah Valley of Virginia
- Founded 1908
- Primarily Undergraduate Enrollment



Undergraduate Research at JMU

- Undergraduate engagement with the faculty is a JMU Hallmark
- Departments across JMU's colleges actively support and promote undergraduate research, in many cases as soon as the freshman year
- Departmental symposia highlighting undergraduate research are common
- NSF REU Programs
- Students frequently participate in off-campus conferences, including those focused on undergraduate research (NCUR) as well as regional and national professional conferences
- In many, but not all, cases the research is done by Honors Program students in preparation for and as part of their senior projects

Conflict Transformation:
2nd International Undergraduate Research Conference

James Madison University
School of Communication Studies
Harrisonburg, Virginia, USA

April 15 and 16, 2010
Papers may be presented live at the conference or via video-teleconferencing

Second Call for Papers
Please carefully note submission terms and deadlines:

Deadline for Submission: Extended Abstracts (7 to 10 pages) for Papers, and Proposals for Poster Displays (500 words) must be received no later than
Monday, March 1, 2010.

MAD-RUSH Undergraduate Research Conference

Saturday, 27 March 2010

James Madison University

Harrisonburg, VA

This coming spring, the School of Liberal Arts at James Madison University will host its first annual undergraduate research conference.

The Madison Research by Undergraduates in the Social Sciences and Humanities MAD-RUSH Conference seeks outstanding **undergraduate research or writing** (both critical and creative) in any **Humanities** or **Social Science** discipline. Information on submissions and the abstract format may be found at the MAD-RUSH website--http://urcjmu.wordpress.com/

Undergraduate Research at JMU

Some Challenges -

- Providing adequate financial resources to the students and their supervisors to perform and disseminate the research

- Finding adequate release time and other incentives to increase faculty involvement in research with undergraduates, especially outside of the laboratory sciences

- **Keeping track of the entire range of undergraduate research activities taking place on campus**

- **Preparing honors students to begin their capstone research projects (finding a mentor, finding a topic, learning how to conduct research)**

The JMU Honors Program

The JMU Honors Program is working to meet the last two of these challenges:

- **Keeping track of the entire range of undergraduate research activities taking place on campus**
- **Preparing honors students to begin their capstone research projects (finding a mentor, finding a topic, learning how to conduct research)**

The JMU Honors Program

- Approximately 800 Students (slightly less than 5% of the undergraduate student body)
- Several entry points with different requirements to graduate with honors distinction
- Honors sections of existing classes, honors seminars, honors “options”
- **Regardless of the entry point, a senior honors project must be completed to graduate with the honors distinction**

The JMU Honors Program

The JMU Honors Program is working to become the information center of the university’s undergraduate research enterprise

Data Collection:

- Mentored research taking place on campus
- Symposia taking place on campus; Presenters; Topics;
- Off-campus conference attendance and presentations
- REUs

The JMU Honors Program

The JMU Honors Program is working to become the information center of the university’s undergraduate research enterprise

Recognition and Data Dissemination:

- Website
- Undergraduate research journal (JMURJ)
- Annual campus-wide event celebrating, recognizing, and rewarding undergraduate research

The JMU Honors Program

The Senior Project

- The senior project is typically a three-semester, six-credit project
- Begins in the second semester of the junior year with the selection of a faculty advisor and two readers and the completion of a project proposal
- Concludes with a thesis approved by the committee, the department, the college, and the honors program

The JMU Honors Program

The Senior Project - Benefits to the Student

- Active learning experience
- Engagement with faculty, especially the advisor
- Immersion in and ownership of a research project
- Signal to and preparation for graduate and professional schools
- The joy and confidence following the completion of the project

The JMU Honors Program

Major Challenges for Students –

- Research? What’s that? How do I choose a topic? How do I choose an advisor?
- A lot of uncertainty and fear among students, many of whom leave the honors program at this point (though many also begin at this point).
- Inefficiency – each advisor is starting from scratch with his/her student(s) in facing these issues

The JMU Honors Program

Response to these challenges?

The Honors Research Track (under consideration)

- At the beginning of the sophomore year, honors students select a track (research, service, leadership, international)
- Students who select the research track will take a seminar in the fall semester which will be a general introduction to research. Each college will offer an honors research seminar
- The introduction to research seminar will be followed by a mentored experience with junior and senior students, leading up to the senior project
- The research seminar and mentoring will facilitate the transition into the senior project.

Undergraduate Research at JMU

Barry Falk, Honors Program

Chris Hughes, Dept. of Physics and Astronomy

James Madison University

The Strategic Plan (c. 1997)

- Place More Emphasis on Undergraduate Research
- Institute Multi-Track Major Program
  - Fundamental Studies
  - Applied
    - Electronics and Instrumentation
    - Computational
    - Materials Science
  - 3/2 Program
  - Individual Option

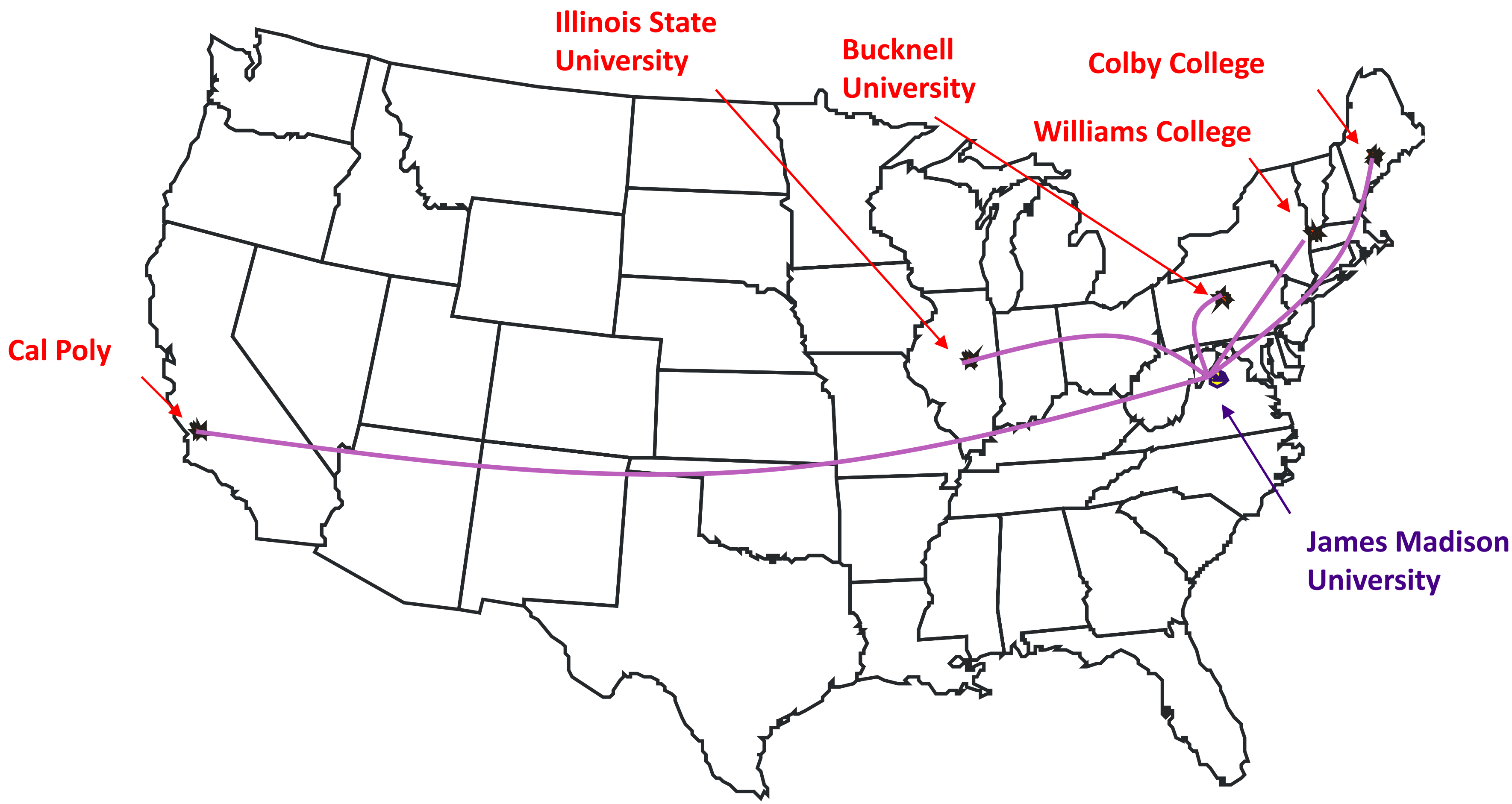
More Emphasis on UG Research

- All new hires focused in one of four areas:
  - Nuclear
  - Astrophysics
  - Materials/Soft Condensed Matter
  - Non-Linear Dynamics
- Hires:
  - 1997 – Hughes
  - 1998 - Mattson
  - 1999 – Miller, Gfroerer
  - 2000 – Balasubramanian
  - 2001 – I. Niculescu, Alexander
  - 2003 – G. Niculescu
  - 2004 – Scully, Paulson, Utter
  - 2007 – Butner
  - 2009 – Scarel, Constantin
- Now – 19 full-time faculty, 11 research active

The Problems

- Incoming faculty are expected to be “research-active”
  - Department still must teach service load for university as a whole.
  - Educational leaves only available after 6th year (post-tenure only).
- Students are expected to do research
  - Up 20 grads per year means possibly 40-50 UG students needing research projects at a time.
  - Students take research for credit but these don’t count in teaching loads.

Research Corp. Funded Trips (2006)



Consolidated Teaching Loads

- Created an internal leave program in which one faculty member has a reduced teaching load in order to concentrate fully on scholarship.
- This teaching assignment rotates through the department's research active faculty.
- Typically assigned to tenure-track faculty in spring of third year. (Though this is flexible.)
- The reduced teaching assignment:
  - All Research and Honors Credits.
    - Sole duty is reporting grades to registrar at end of term.
  - Advanced Lab Course.
    - Must send email reminders to students, maintain some records, and report grades at end of term.

The “New AdLab”

- *Starting Point*
  - Juniors signed up for a 3 credit Advanced Lab course taught by an individual faculty member doing primarily historical experiments.
- *1st Iteration*
  - Students must complete 17 competencies that can be completed in a traditional experiments, undergrad research, or external internships.
  - 3 credit course is taken during the semester in which they complete these competencies.

The "New AdLab"

- <u>Group A Competencies</u> (*All competencies in group A are required of all students.*)

1. Write an abstract that is suitable for submission to an external conference or meeting.
2. Prepare and present a 15 minute or longer oral presentation on a scientific topic.
3. Assemble a piece of equipment or instrumentation.
4. (2 times) Perform a quantitative measurement that is of historical relevance such as Frank-Hertz, Hall Effect, etc.
5. Perform a measurement involving low level electrical signals.
6. Perform a measurement involving low temperatures.
7. Perform an optical measurement such as taking and analyzing an atomic spectrum.
8. Develop a computer program on a standard language such as FORTRAN, VB, Java, or C+.
9. Interface a PC with a piece of instrumentation using LabView or equivalent.
10. (2 times) Prepare a referenced, complete report of an experiment you have performed.
11. Prepare a clearly written set of instructions for an experiment you have performed.

12. Fit experimental data to equations using a least squares method showing the actual detail of the method (not using Excel or some other

The “New AdLab”

- Group B Competencies (*Students must complete half of the items on this list.)*

1. Guide another student through the set-up and execution of a measurement.
2. Specify supplies and/or equipment that needs to be ordered to complete a job including suppliers and lead time.
3. Manufacture a component for an experiment or measurement or otherwise demonstrate competence on the mill and lathe.
4. Perform a computational simulation of a physical problem using a mathematical model.
5. Perform measurements using equipment that has vernier adjustments.
6. Perform a measurement involving high speed signals or precise timing.
7. Sketch or draft a legible design for a piece of apparatus that needs to be manufactured.
8. Analyze an image and obtain quantitative data from it.

What We Learned

- Need to trust each other
  - What one faculty member counts for credit another might not.
- How do we assign grades?
- Too much freedom for UG’s
  - Now have three 1 credit courses in sequence
- What happens when the student doesn’t finish?
  - Do we have the guts to not let someone graduate just because they didn’t finish every item on the list?

The New AdLab 2.0

- Course is now a sequence of three 1-credit courses
- Writing an abstract, writing a report, and keeping a lab notebook are required in each semester.
- Performing a computational simulation must be done by the end of the second semester.
- Failure to complete all tasks in one semester leads to a reduction in grade and a roll-over of requirements to the next semester.

Thanks

The faculty of the JMU Department of Physics and Astronomy

Undergraduate Research as an Integrated Four-Year Academic Experience

Shila Garg
Physics, Interim Provost

Heather Fitz Gibbon
Sociology, Dean for Faculty Development

The College of Wooster

Goals for Undergraduate Research: Mission Statement

The mission of the Office of Undergraduate Research is to provide opportunities for students to engage in intensive scholarship, research, and/or creative activity in their chosen field of study across their four years. As a result of this experience, students will become true partners with faculty in the research process and will acquire an understanding of the process involved in conducting research from developing a research question to presenting the research to a wider audience, including peer review.

The Structure of the UG Research Program at the College of Wooster

- Summer Early Engaged Research (SEER)
- Sophomore Research Program (SOREP)
- Howard Hughes Medical Institute (HHMI)
- NSF-REU Site Program (REU)
- Applied Mathematical Research Experience (AMRE)
- Independent Study (IS)

Timeline of UG Research

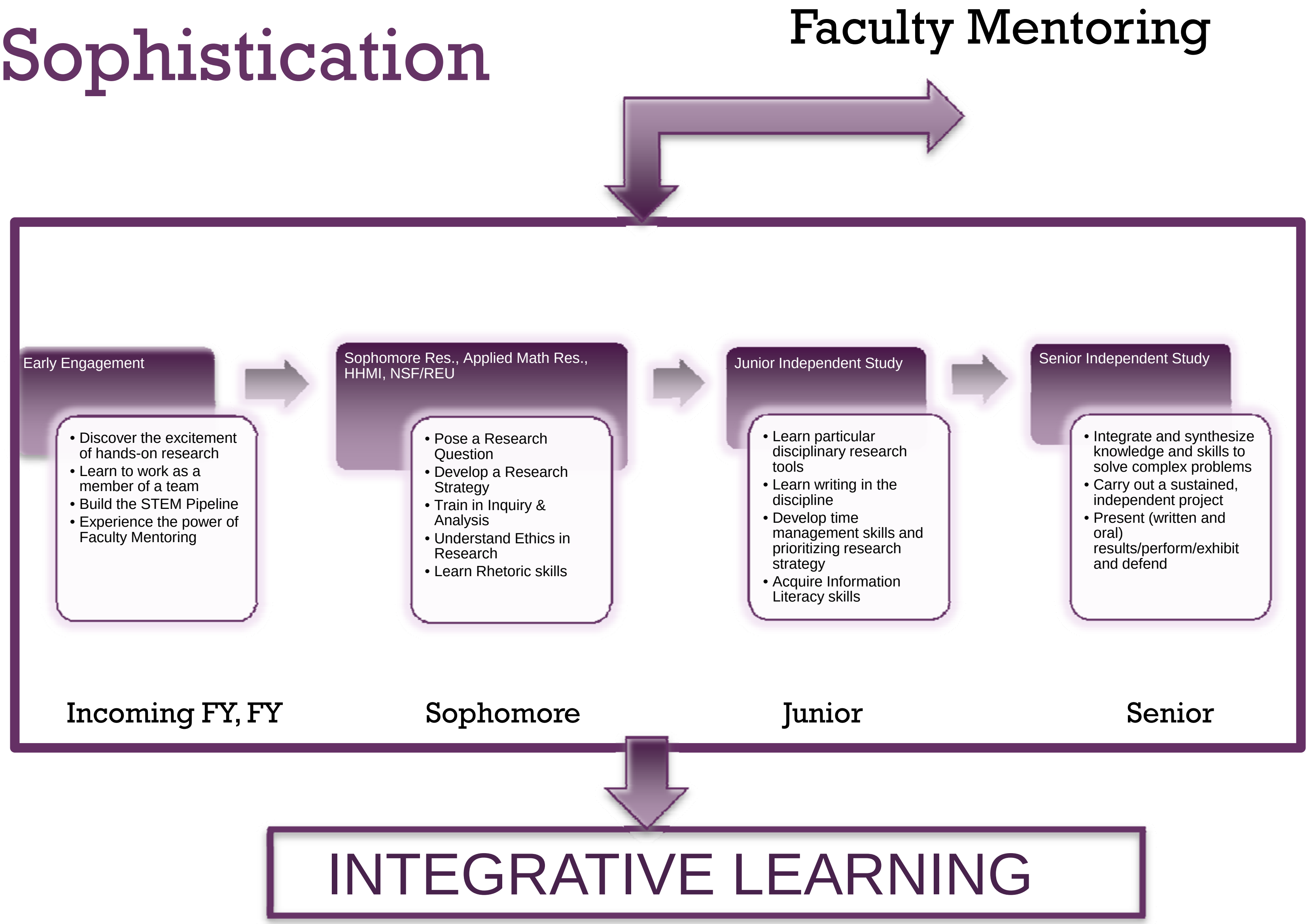
First Year
- Early Engagement
- Sophomore Research

Sophomore
- Sophomore Research
- HHMI
- Applied Math Research
- NSF/REU

Junior
- Sophomore Research
- HHMI
- Applied Math Research
- NSF/REU
- Junior I.S.

Senior
- HHMI
- Applied Math Research
- Senior I.S.

Student Research Sophistication



Institutional Infrastructure: Material Support

- Lab Space
- Materials/Equipment
- IT Support
- Library Resources

Institutional Infrastructure: Student Support

- Undergraduate Research Office: organizes grants, student activities, student housing
- Student Travel fund: about $15,000/yr for students presenting papers
- Senior I.S. travel grants: about $100,000 per year to enhance I.S. project
- Oral and Poster Presentation Workshops
- Ethics Training

Institutional Infrastructure: Faculty Support

- Faculty Credit for Independent Study
- Leave Policy
- Grant Writing Support
- Matching Grants
- Travel Grants

Integration with Curriculum: Course Level

- Introductory courses
  - Active Learning (POGIL)
  - Methods
  - Focus on Posing Research Questions
- Methods Courses
  - Greater depth
  - Clearer integration with all courses
  - Larger range of methods

Integration with Curriculum: General Education Goals

- First Year Seminar
- Writing Requirement
- Interdisciplinary Courses: Aimed at finding resources across disciplines to answer a question
- Independent Study

W

Independent Minds, Working Together.

High Impact Undergraduate Research: Assessment

The Questions:

- **RESEARCH SOPHISTICATION: are College of Wooster students prepared to conduct research?**
  - Research Practices Survey of the Higher Education Data Sharing (HEDS) Consortium (direct and indirect measure)
- **WRITING: are College of Wooster students prepared to write critically?**
  - First Year Seminar (FYS) and General Curriculum Critical Writing Assessment (direct measures)
- **LEARNING GAINS: what are the learning gains from undergraduate research?**
  - Survey of Undergraduate Research Experiences (SURE II and III) by David Lopatto, Grinnell College (indirect measure of learning gains of summer research)
  - Independent Study – College of Wooster departmental assessment of learning gains (direct and indirect measures)

W

Independent Minds, Working Together.

High Impact Undergraduate Research: Student Learning & Development Goals

Student Learning Goals

(LEAP - Essential Learning Outcomes)

- Understand and locate appropriate resources for research in the libraries (Information Literacy)
- Define a research question and develop a research strategy (Inquiry)
- Apply problem-solving skills to a research question (Analysis)
- Learn to operate new equipment and/or computer programs
- Develop stronger writing skills
- Communicate the results of research (Written & Oral communication)
- Understand ethical issues in research (Ethical Reasoning)

Student Development Goals

- Develop time management skills
- Learn how to negotiate effectively a working relationship with a supervisor
- Gain Enhanced self-confidence
- Develop a greater understanding of possible career/vocational opportunities
- Learn to work as a member of a team (Teamwork)

W

Independent Minds, Working Together.

High Impact Undergraduate Research: Student Learning Goals and Assessment Methods

Student Learning Goals in Undergraduate Research

Current Assessment Methods	Library resources	Research question & strategy	Problem solving	Equipment / Technology	Writing	Communication of Research Results	Ethical Issues
HEDS Research Practices Survey	X						
First Year Seminar Critical Writing Assessment (CWA)					X		
General Curriculum CWA					X		
Survey of Undergraduate Research Experiences (SURE II / III)		X	X	X	X	X	X
30 Senior Independent Study Rubrics	19 majors	9 majors	23 majors	2 majors	21 majors	27 majors	2 majors
Teagle Capstone Consortial Project	X	X	X		X	X	

W

Independent Minds, Working Together.

High Impact Undergraduate Research: Student Development Goals and Assessment Methods

Student Development Goals in Undergraduate Research

Current Assessment Methods	Time Manage-ment Skills	Faculty Mentor Relationship	Self Confidence	Career Understanding	Team Member
HEDS Research Practices Survey	X				
Survey of Undergraduate Research Experiences (SURE II / III)		X	X	X	X
Teagle Capstone Consortial Project	X	X	X	X	X

1. LEARNING GOALS	2. MEASURES USED	3. RESULTS	4. ACTIONS
Chemical knowledge / content-oriented goals (Goals 2,3,4,7 from Chemistry Assessment Plan)	ACS standardized exams were given in Introductory, Analytical, Organic, and Physical Chemistry courses.	Students have performed above the national norm for the examinations. The rising senior class (2010) is particularly strong based upon the exam results and correlating with class grades.	A central record of ACS exam results for year-to-year tracking and comparison to national averages has been created. We plan to continue use of the current exams and to add a comprehensive final exam for upper level students to assess overall retention of key knowledge.
Techniques and application of knowledge in the laboratory (Goals 1,4 from Chemistry Assessment Plan)	Rubrics were completed by the faculty advisor to evaluate IS. Final exams continue to be part of introductory laboratory courses.	The revised Senior IS process rubrics show good correlation between the final IS grade and assessed score. The abbreviated forms simplify key learning goals for the IS. Lab exams have shown where weaknesses are for students and have been used to guide the revisions to our Introductory Chemistry labs.	We will include a blank copy of the IS rubric that will be completed by the primary advisor in the Sr IS handbook; this will help guide students in their IS. We have adapted the Introductory Chemistry labs for the new curriculum based in part on assessment of present labs and will continue to use laboratory exams or practicums.
Scientific communication (Goals 5,6 from Chemistry Assessment Plan)	Faculty assessed all Senior IS seminars. Revised rubrics were completed by the faculty advisor to evaluate the overall IS process.	Our assessment of the seminars indicated the students are meeting (and exceeding) professional standards for communication. The revised Senior IS rubrics show good correlation between student scores and final IS grades.	We will use both the seminar and IS process evaluation in the coming year. We will include a blank copy of the IS rubric that will be completed by the primary advisor in the Sr IS handbook; this will help guide students in their IS.

Research Practices and Curricular Integration: THE EVIDENCE

- Research Practices Survey (RPS), Higher Education Data Sharing (HEDS) Consortium (pre- and post-measure and comparative benchmark with 12 peer liberal arts colleges)

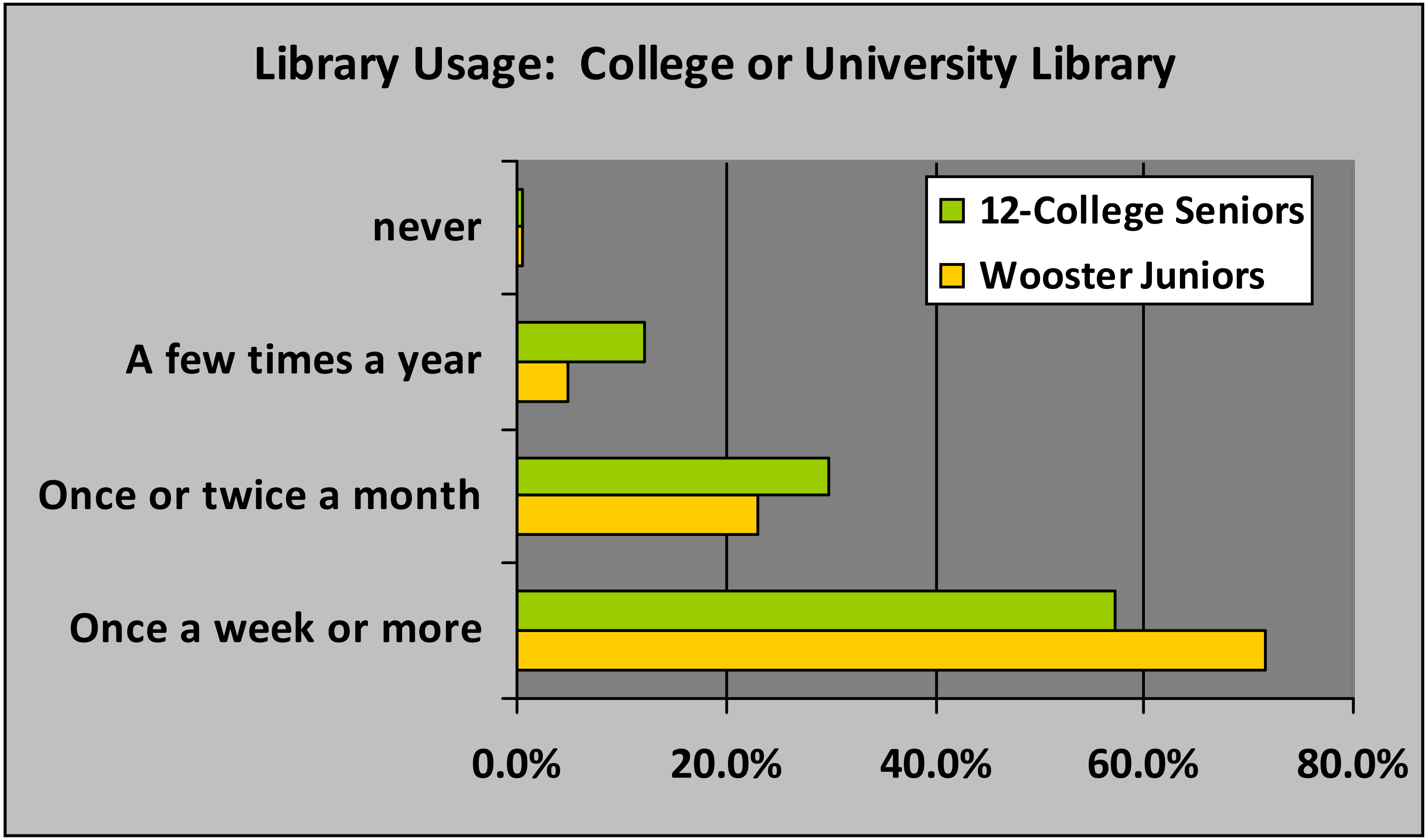
  - Administered:
    - Fall 2006 to College of Wooster Class of 2010 First Years

      (known as First Year Information Literacy in the Liberal Arts (FYILLA))
    - Administered Spring 2009 to College of Wooster Class of 2010 Juniors
    - Administered Spring 2009 to Seniors from 12 peer liberal arts colleges
  - Findings
    - College of Wooster Juniors report that they use the library more frequently, receive more library instruction, and use more print and online resources than Seniors from 12 colleges
    - Significant gains in 18 out of 24 DIRECT measures for Wooster's Class of 2010 from First Year to Junior Year

W

Independent Minds, Working Together.

Research Practices and Curricular Integration: THE EVIDENCE

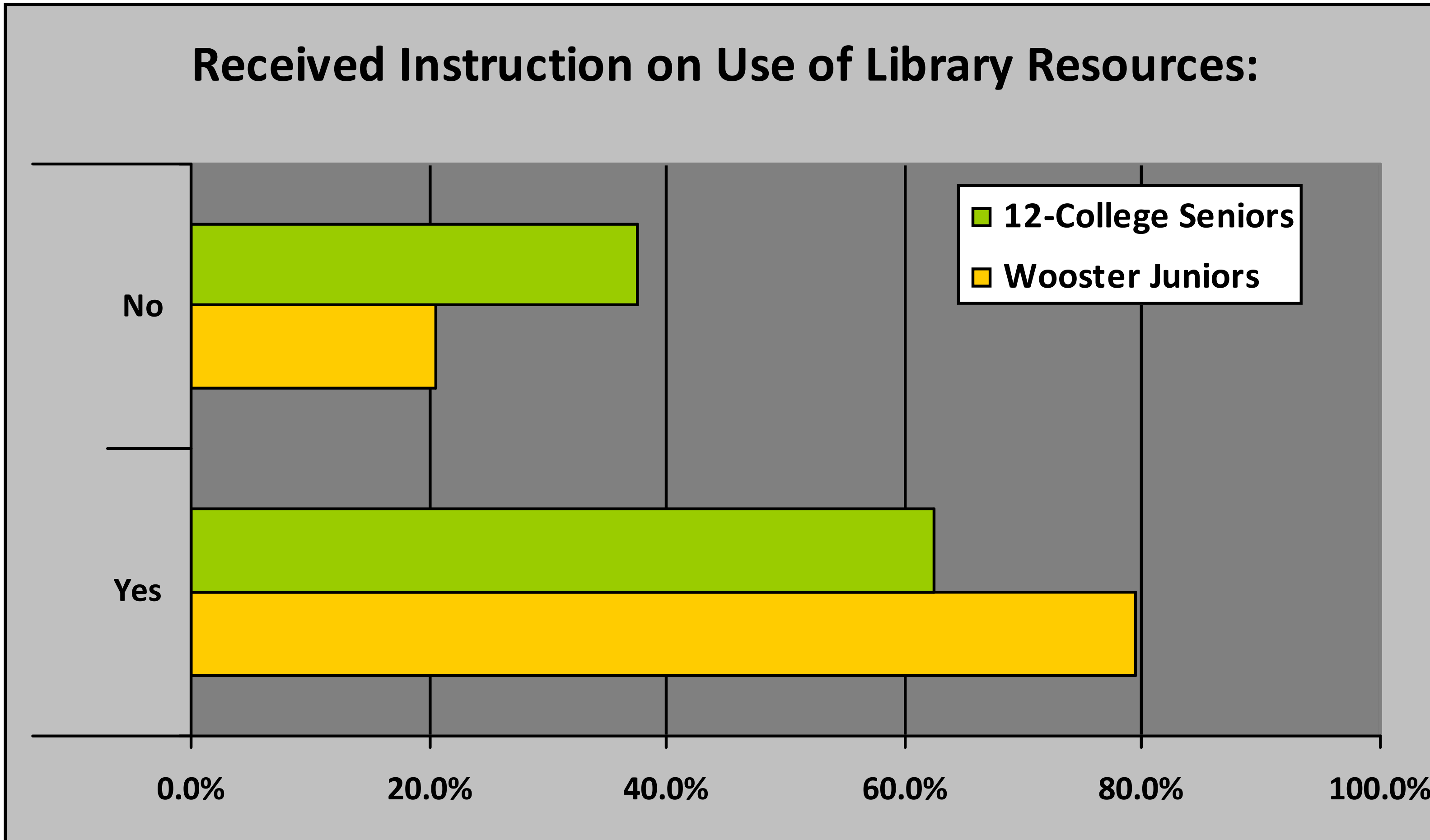


Source: Higher Education Data Sharing Consortium (HEDS). ***Research Practices Survey, Spring 2009.***

W

Independent Minds, Working Together.

Research Practices and Curricular Integration: THE EVIDENCE

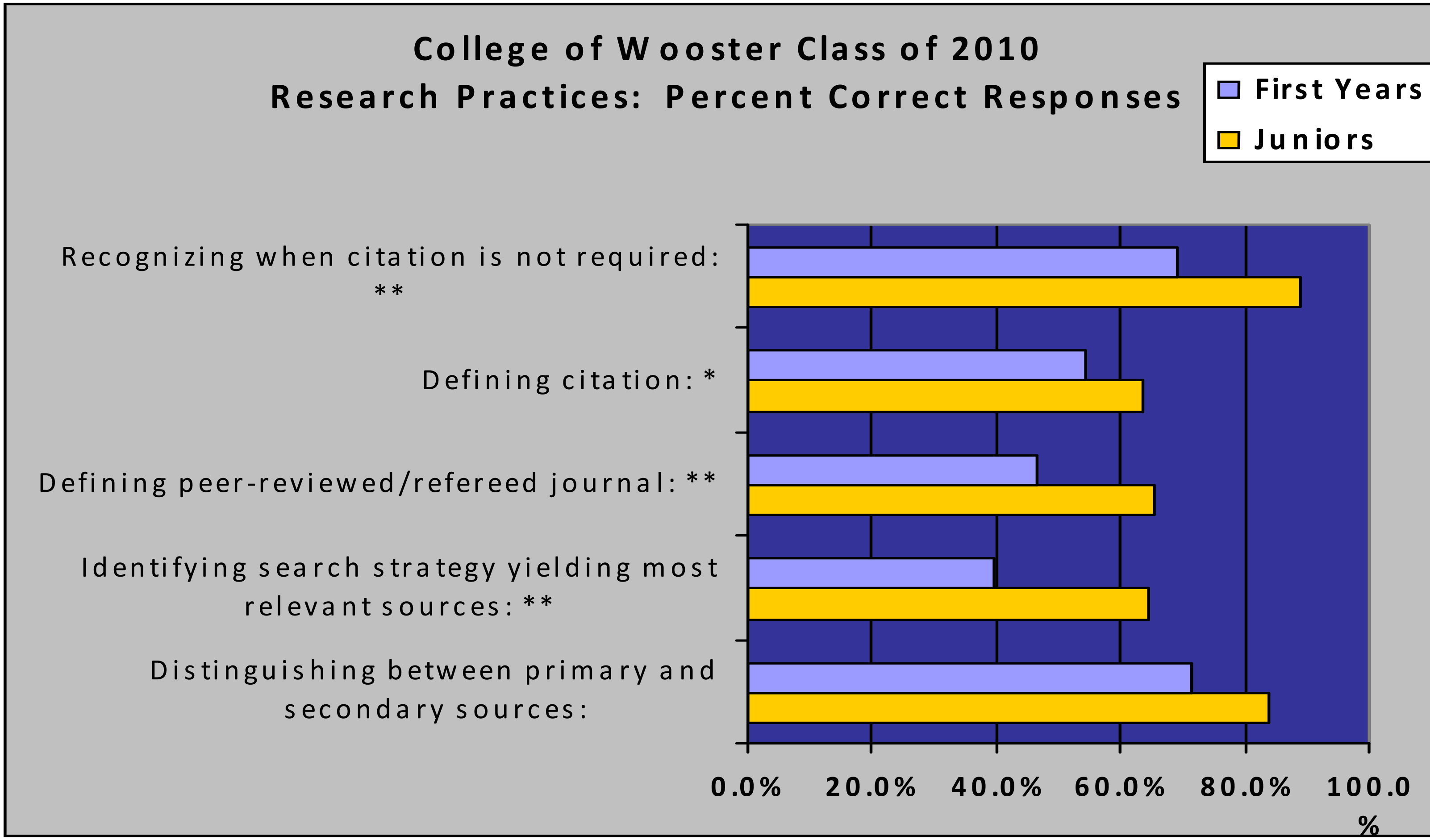


Source: Higher Education Data Sharing Consortium (HEDS). ***Research Practices Survey, Spring 2009.***

W

Independent Minds, Working Together.

Research Practices and Curricular Integration: THE EVIDENCE



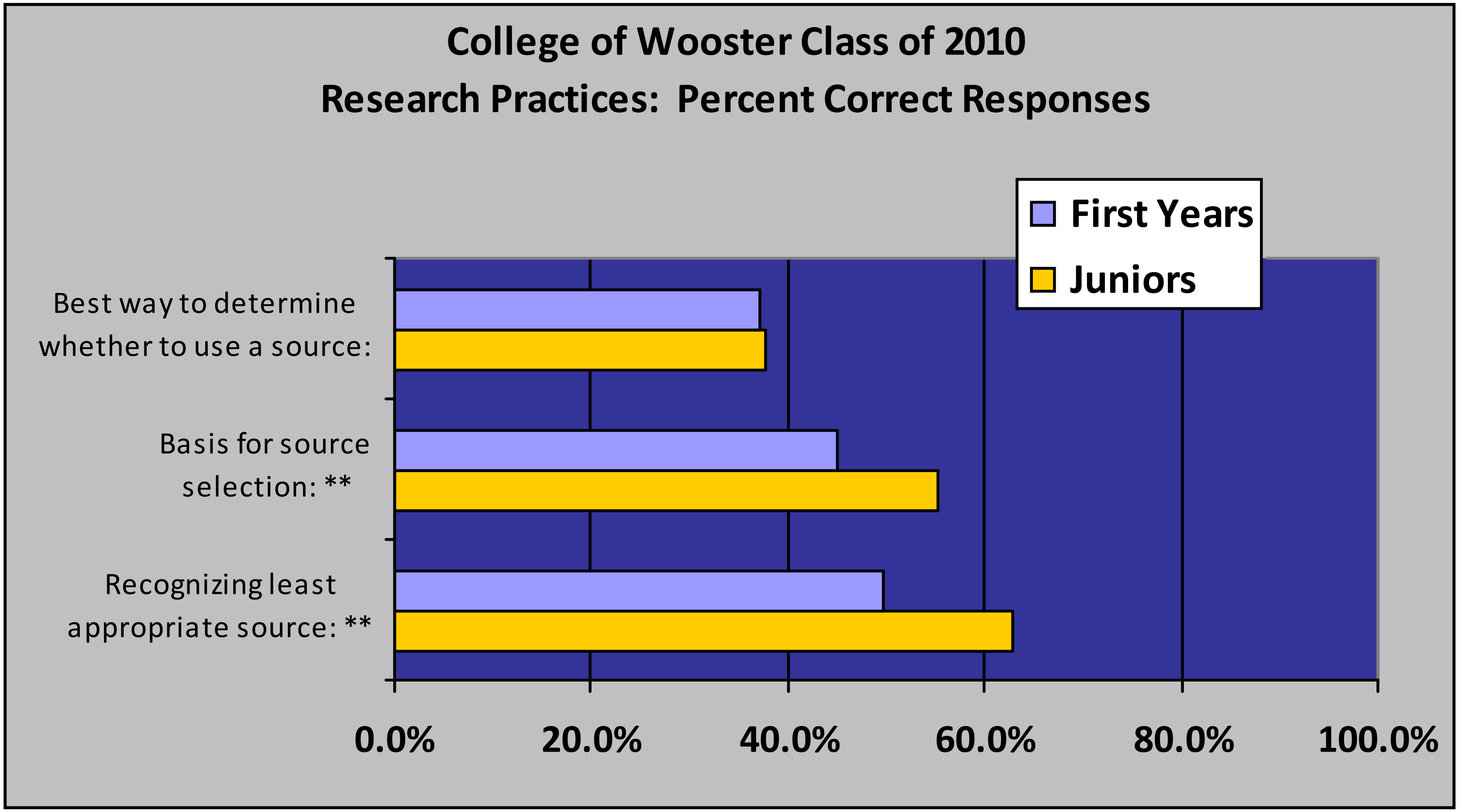
* p < .05 ; ** p < .01

Source: Higher Education Data Sharing Consortium (HEDS). ***Research Practices Survey, Spring 2009.***

W

Independent Minds, Working Together.

Research Practices and Curricular Integration: THE EVIDENCE



** p < .01

Source: Higher Education Data Sharing Consortium (HEDS). *Research Practices Survey, Spring 2009.*

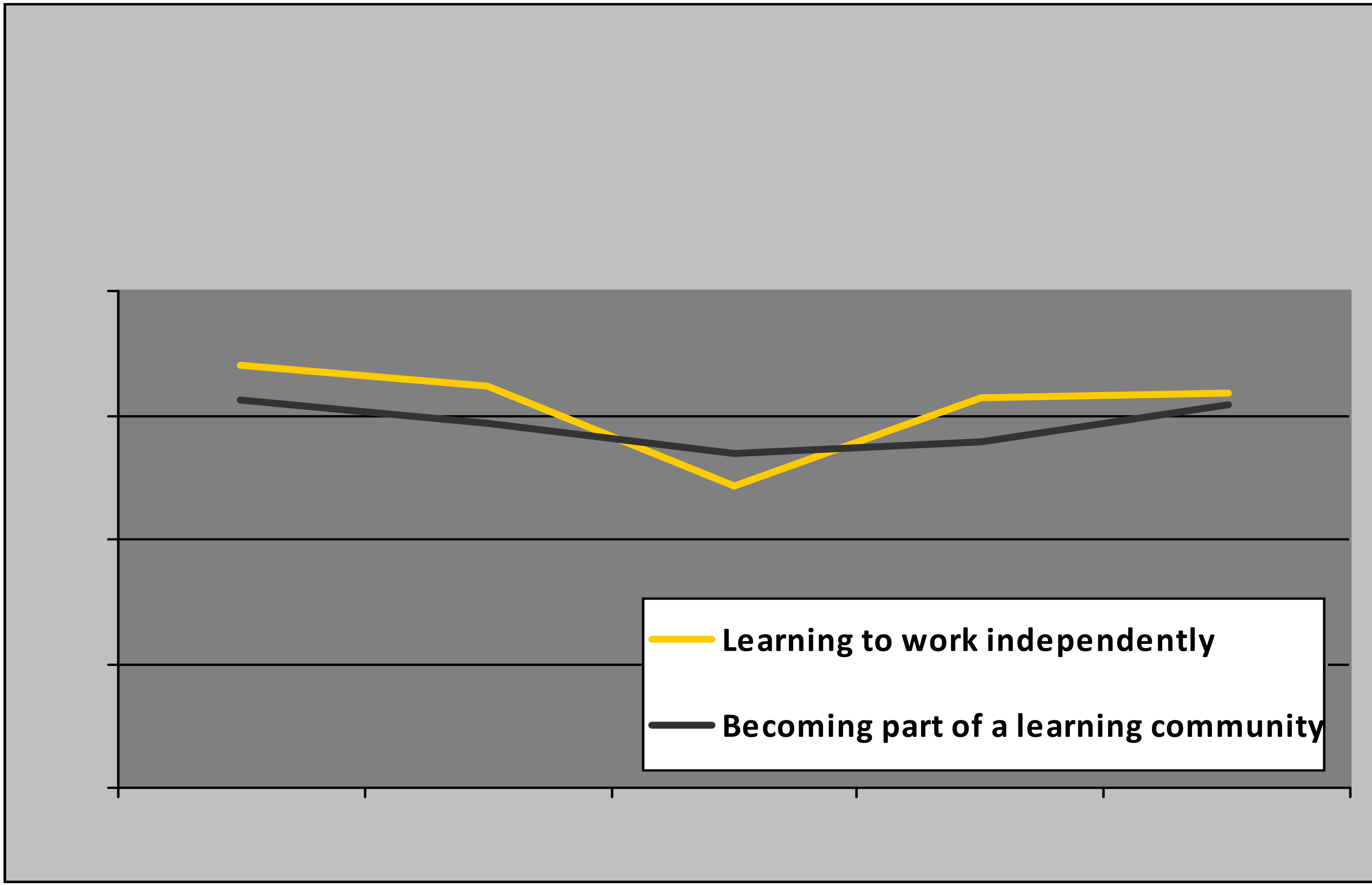
Research Practices and Curricular Integration: THE EVIDENCE

- Survey of Undergraduate Research Experiences (SURE II & III), indirect measure of learning gains and comparative benchmark
  - Administered:
    - Summers from 2005 to 2009 to College of Wooster student researchers in the Howard Hughes Medical Institute (HHMI)-grant funded research program
    - Administered to hundreds of other students in various summer research programs from institutions classified as colleges by the Carnegie classification system
  - Findings
    - College of Wooster students consistently report large gains in 21 learning goals
    - College of Wooster student-reported gains are generally larger than those reported by students from other colleges

W

Independent Minds, Working Together.

High Impact Undergraduate Research: THE EVIDENCE



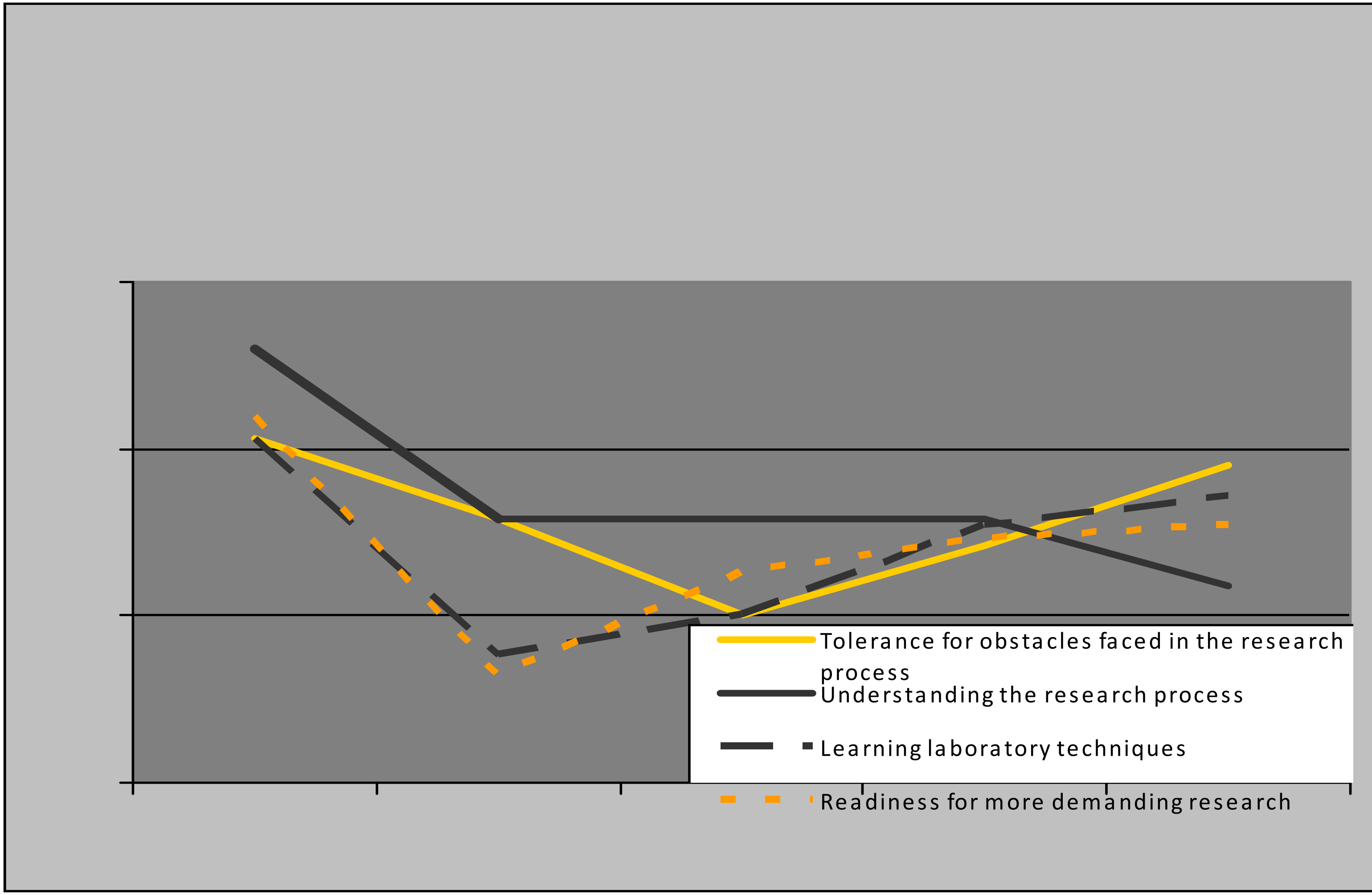
KEY: 1 = no gain or very small; 5 = very large gain

Source: Lopatto, D. (2005-2009). *Survey of Undergraduate Research, SURE II and III*

W

Independent Minds, Working Together.

High Impact Undergraduate Research: THE EVIDENCE



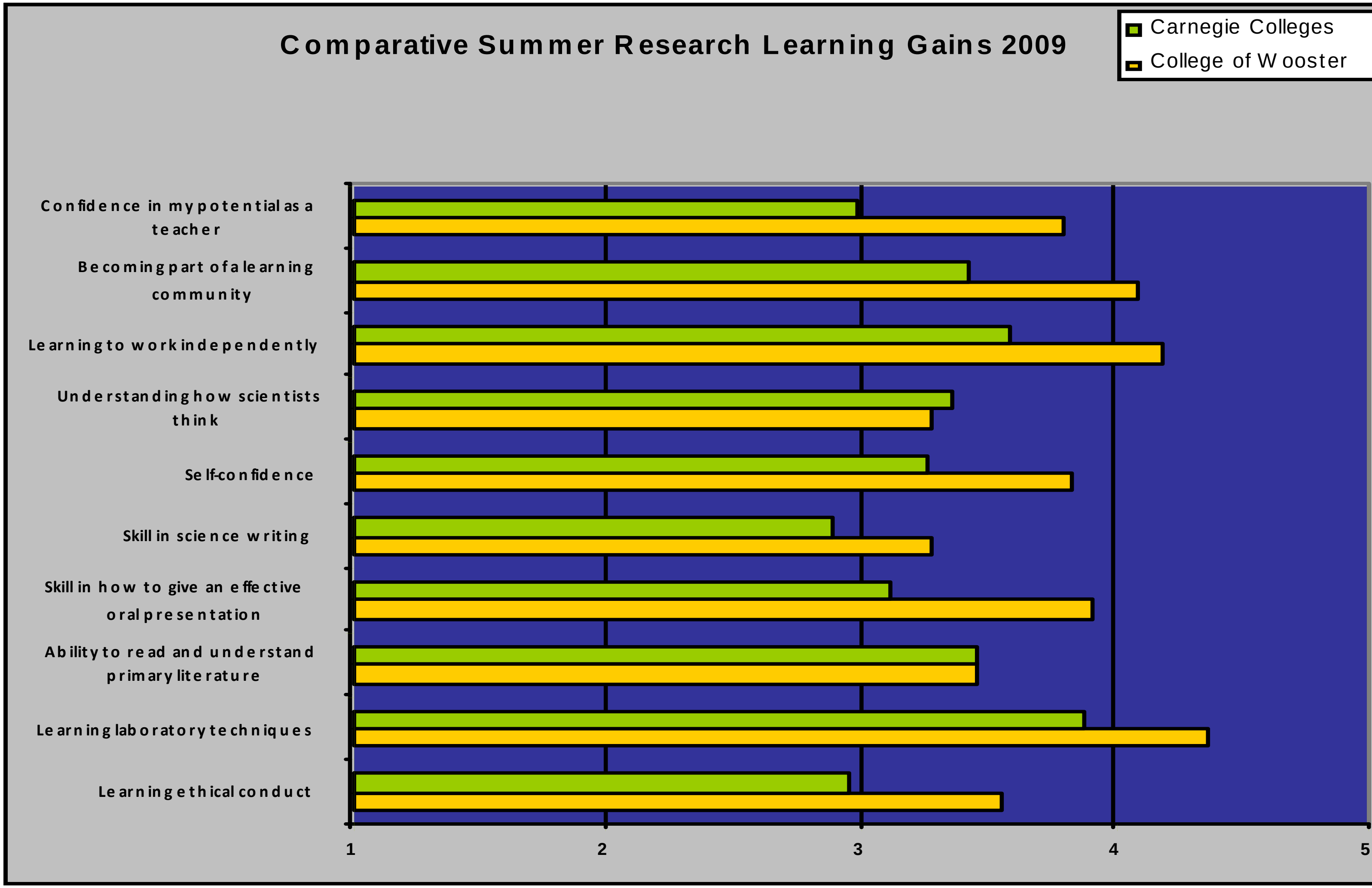
KEY: 1 = no gain or very small; 5 = very large gain

Source: Lopatto, D. (2005-2009). *Survey of Undergraduate Research, SURE II and III*

W

Independent Minds, Working Together.

High Impact Undergraduate Research: THE EVIDENCE



KEY: 1 = no gain or very small; 5 = very large gain

Source: Lopatto, D. (2005-2009). *Survey of Undergraduate Research, SURE II and III*

Research Practices and Curricular Integration: Ongoing Assessment

- Critical Writing Assessment (CWA) in First Year Seminar (FYS) and in the General Curriculum (GC) – direct measure of critical writing learning gains

- CWA rubric measures 7 traits: thesis, organization, clarity, argumentation, critical reflection, grammar and mechanics, and style

  - Administered:
    - GC CWA administered 2008-09 and 2009-10 - @ 100 writing samples/year
    - FYS CWA administered 2009-10

  Findings
    - GC CWA in 2008-09 had inter-rater reliability issues
    - FYS CWA results are pending

W

Independent Minds, Working Together.

Research Practices and Curricular Integration: Ongoing Assessment

- Senior Independent Study (IS): Disciplinary Rubrics – direct measures of learning gains in the major through Senior IS – senior undergraduate research

Administered:

- Administered annually for 30 majors since 2007-08
- Focus varies by major

Research Practices and Curricular Integration: Ongoing Assessment

- Teagle Capstone Consortial Project
  - Project to assess learning gains of capstone projects, including College of Wooster Senior Independent Study, at 4 colleges:

    Allegheny College, Augustana College, College of Wooster, Washington College
  - 3 year project (2009-2011)
  - Multiple direct and indirect measures

Questions

- How do you prioritize undergraduate research vs. other institutional initiatives?
- Does a commitment to undergraduate research as part of the curriculum compromise depth in the discipline? Which approach (intense research experience vs. curricular depth) provides better preparation for our students?
- How do we balance faculty research needs with student research need? How do we include less academically prepared students in the research process without unduly slowing faculty research progress? How do we help junior faculty negotiate this balance?
- What constitutes "research" in undergraduate research?