Authentic Research Experiences in Laboratory Courses

REIL-Biology Network

Nitya Jacob, Gary Reiness, Elisabeth Schussler, Rachelle Spell

non-presenting coauthors: Barbara Abraham, Larry Blumer, Chris Beck, Sibdas Ghosh, Judy Guinan, Lonnie Guralnick, Pamela Hanson, Nitya Jacob, Mary Miller, Kristen Miller, Craig Ogilvie, Gary Patterson, Joanna Vondrasek, Jen Rhode Ward, Larry Wimmers, Kathy Winnet-Murray

IBP Summer Conference
July 1, 2012

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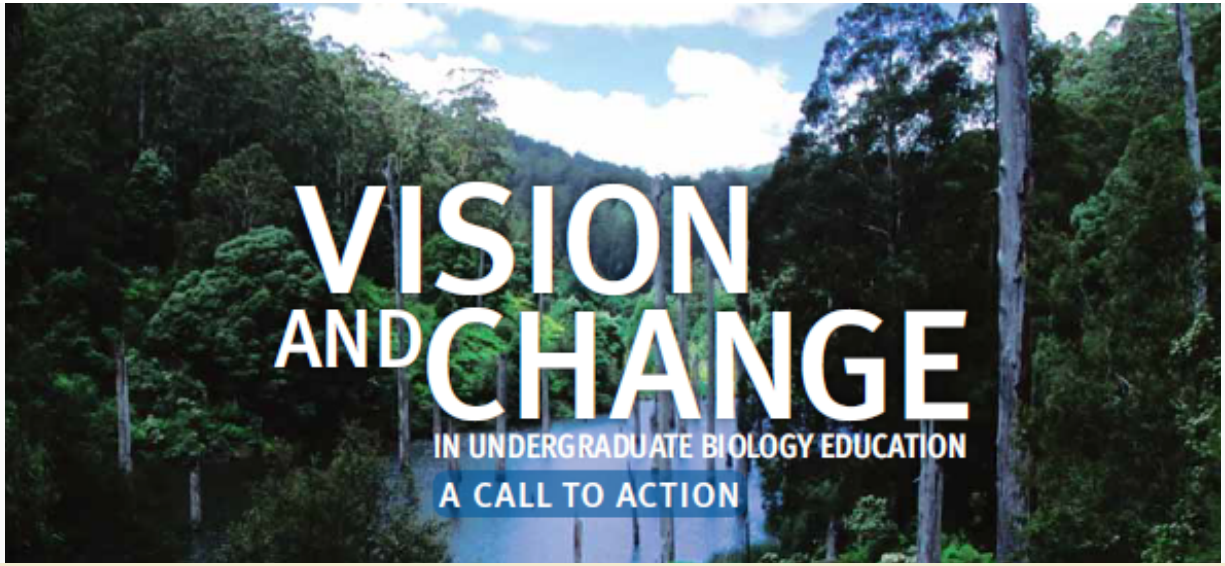
National Science Foundation
WHERE DISCOVERIES BEGIN

Objectives of Interactive Session

1. Describe advantages of Authentic Research Experiences in biology laboratory courses
2. Discuss definitions of authentic research
3. Discuss barriers and catalysts to implementation
4. Present successful implementation examples by REIL-Biology network members
5. Solicit examples of implementation from the audience



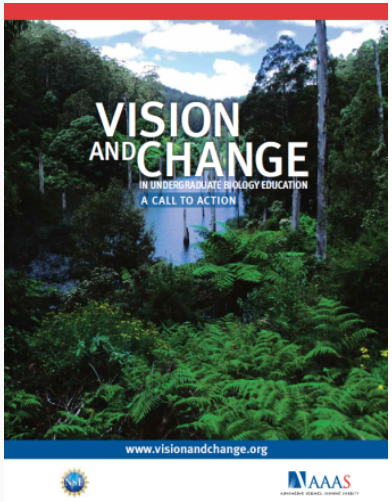
PREFACE

"Appreciating the scientific process can be even more important than knowing scientific facts. People often encounter claims that something is scientifically known. If they understand how science generates and assesses evidence bearing on these claims, they possess analytical methods and critical thinking skills that are relevant to a wide variety of facts and concepts and can be used in a wide variety of contexts."

—National Science Foundation, Science and Technology Indicators, 2008

Cultivating Biological Literacy

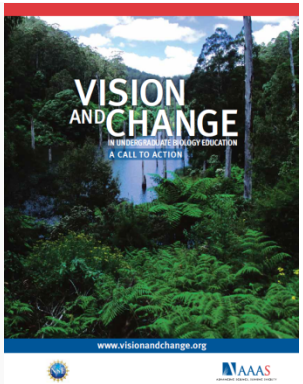
Action Items



Introduce <u>research experiences</u> as an integral component of biology education for <u>all</u> students, regardless of their major.

Vision and Change –

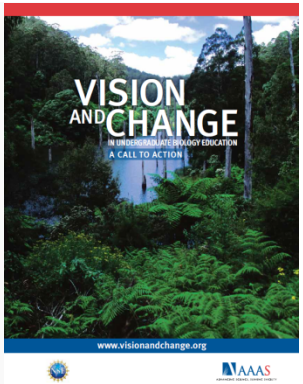
Integrating Undergraduate Research Experiences



"Results from the SURE survey … indicate that <u>even a short immersion experience is sufficient t</u>o effect long-term gains in student motivation for learning, independence and understanding of science (Lopatto, 2007)."

Vision and Change –

Integrating Undergraduate Research Experiences



"Undergraduate participation in some kind of <u>research in introductory courses,</u> therefore, may be the key to developing an enduring understanding of core concepts for <u>all</u> undergraduate students."

REIL Biology

(Research Experience in Introductory Laboratories in Biology)

- Funding: National Science Foundation Research Coordination Network for Undergraduate Biology Education Incubator Grant (NSF RCN-UBE)
- Goal: Increase authentic research experiences in introductory biology laboratory courses

REIL Biology Members

- in conjunction with
  - Association for Biology Laboratory Education (ABLE)
  - Council on Undergraduate Research (CUR)
  - and invitees

REIL Biology
Goals

1. Survey on authentic research in introductory biology laboratories
2. Disseminate findings
3. Develop a full RCN-UBE proposal
    a. best practices and examples
    b. overcoming barriers

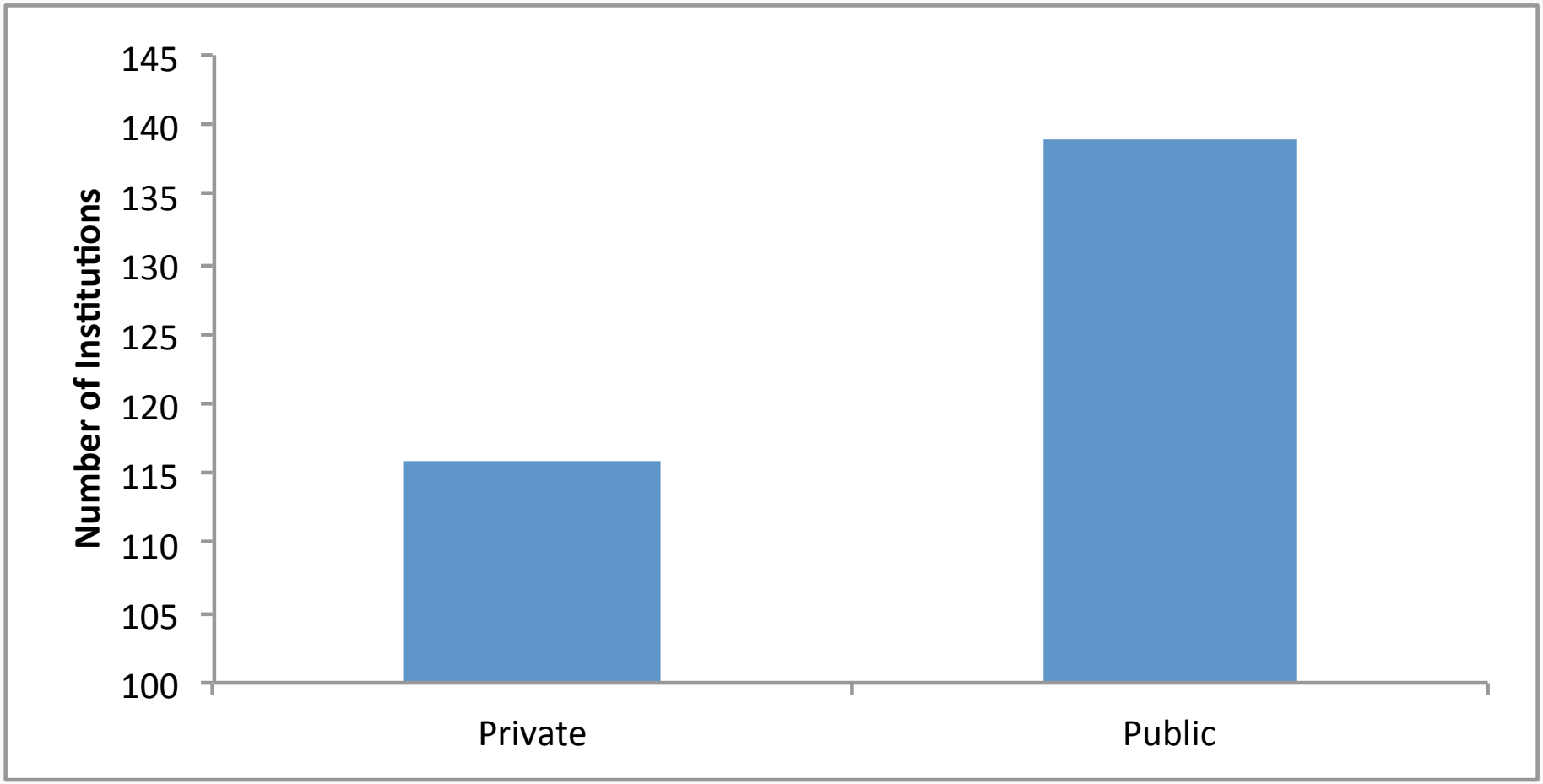
Special Mention

1. Writing the Survey – all of Core REIL-Biology
2. Quantitative Analysis –Chris Beck, Judy Guinan
3. Qualitative Analysis – Kris Miller, Chris Beck, Rachelle Spell

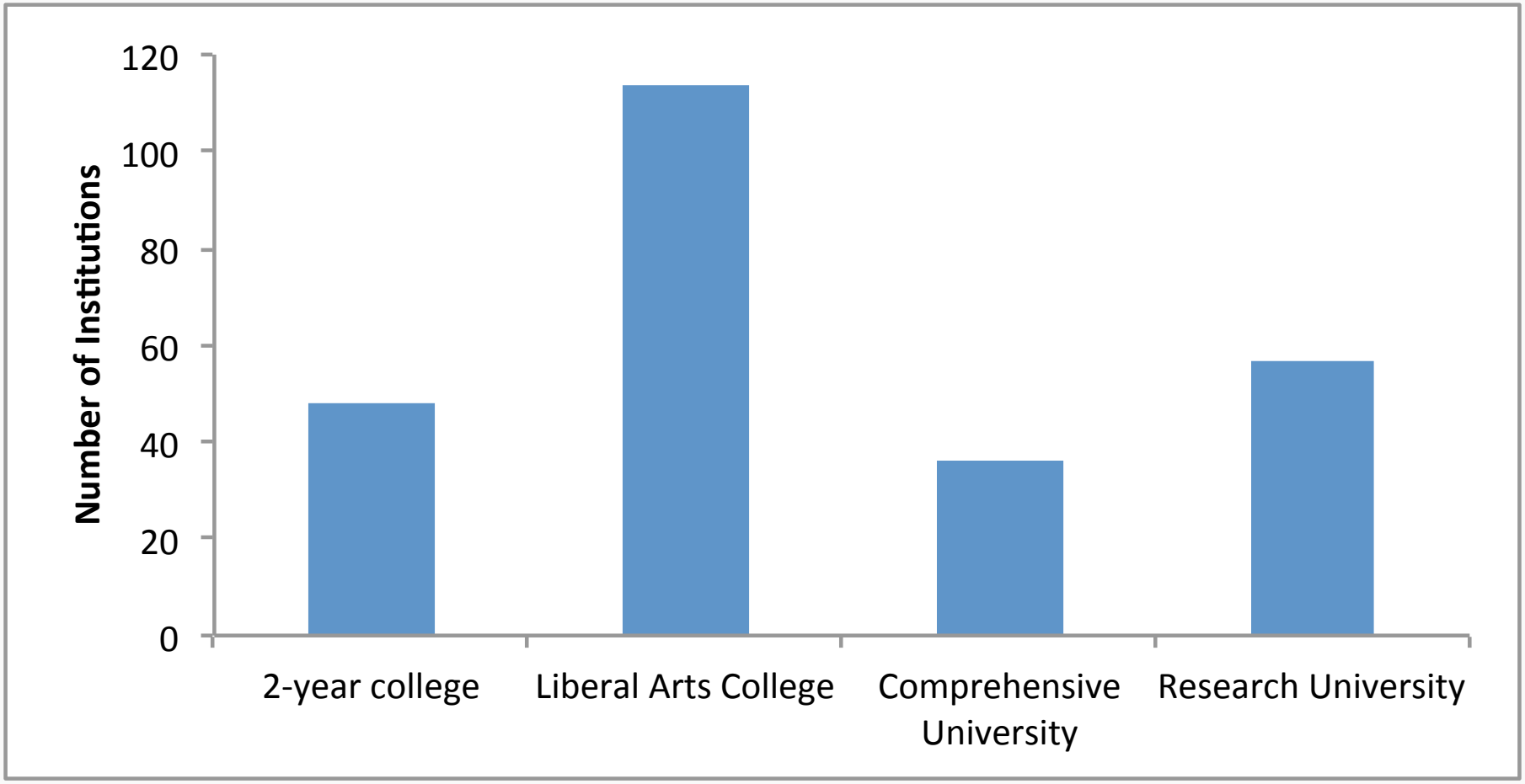
Survey of Research in Intro Labs

- 279 respondents
- 532 courses
- diverse institutions
  - 17% (48 of 279) 2-year colleges
  - 41% (114 of 279) liberal-arts colleges
  - 13% (39 of 279) comprehensive universities
  - 20% (57 of 279) research universities.
- diverse student body
  - 14% (39 of 279) minority-serving institutions

Demographic breakdown



Demographic breakdown



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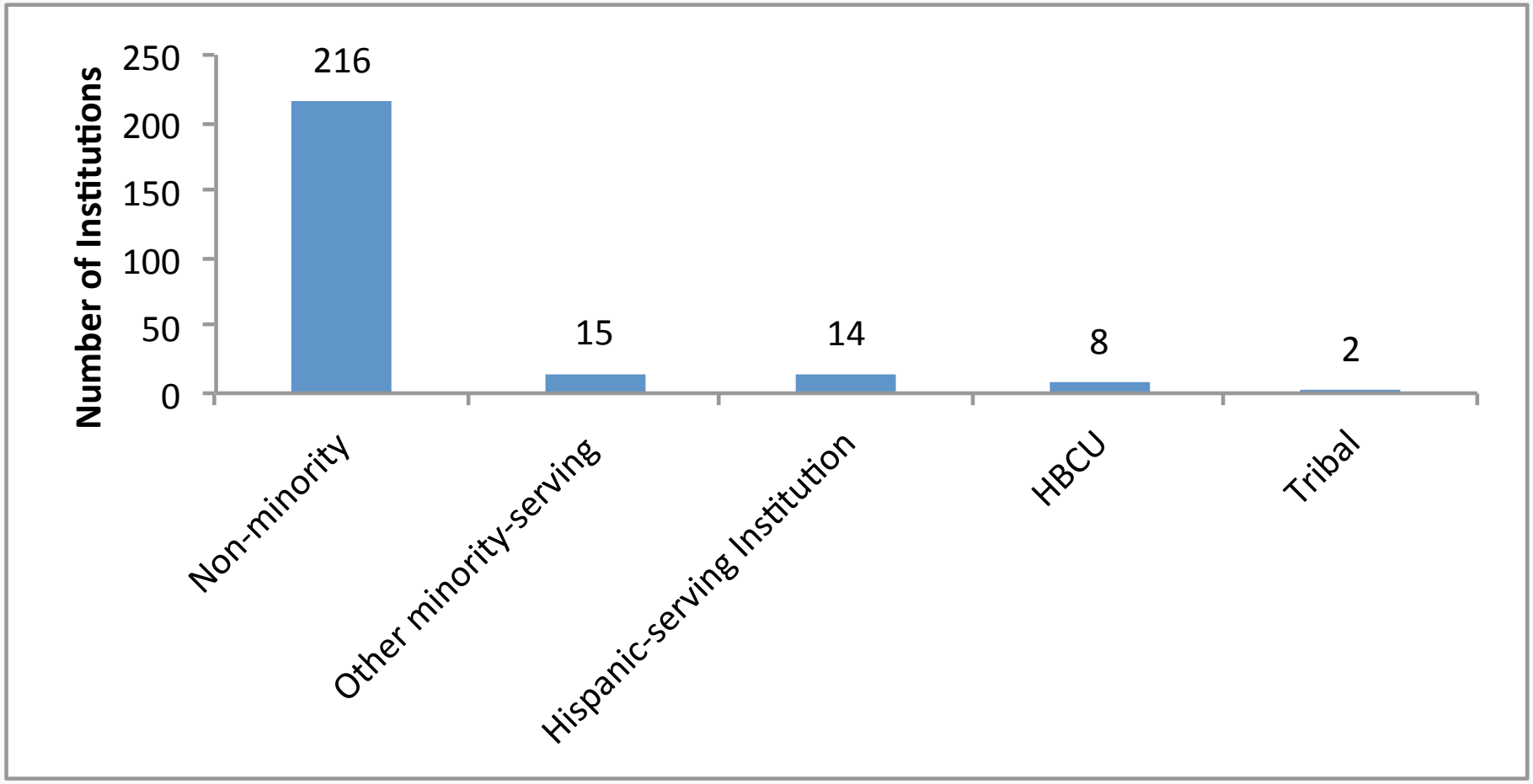
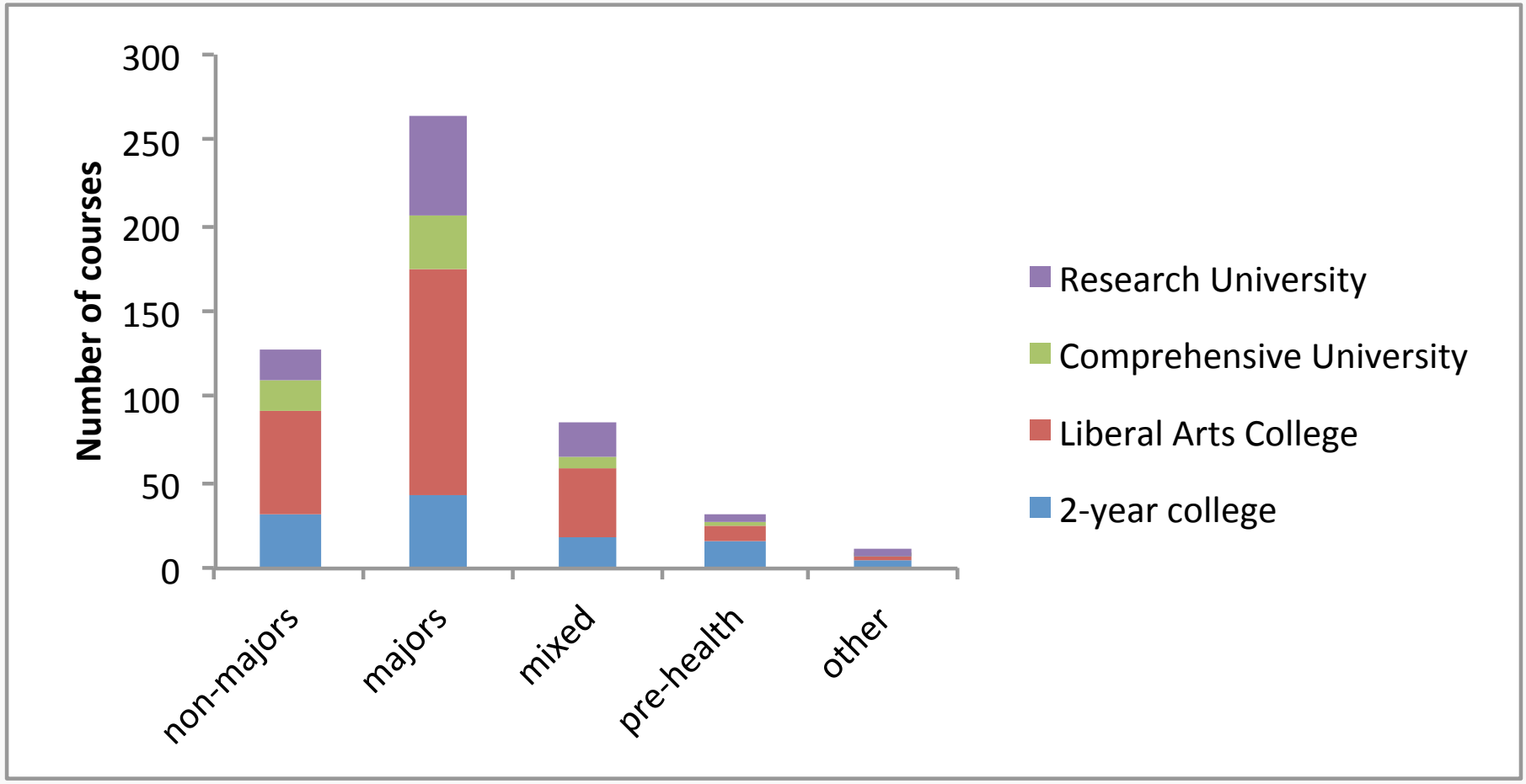


Course breakdown



Defining Authentic Research

Defining Authentic Research-Reflections

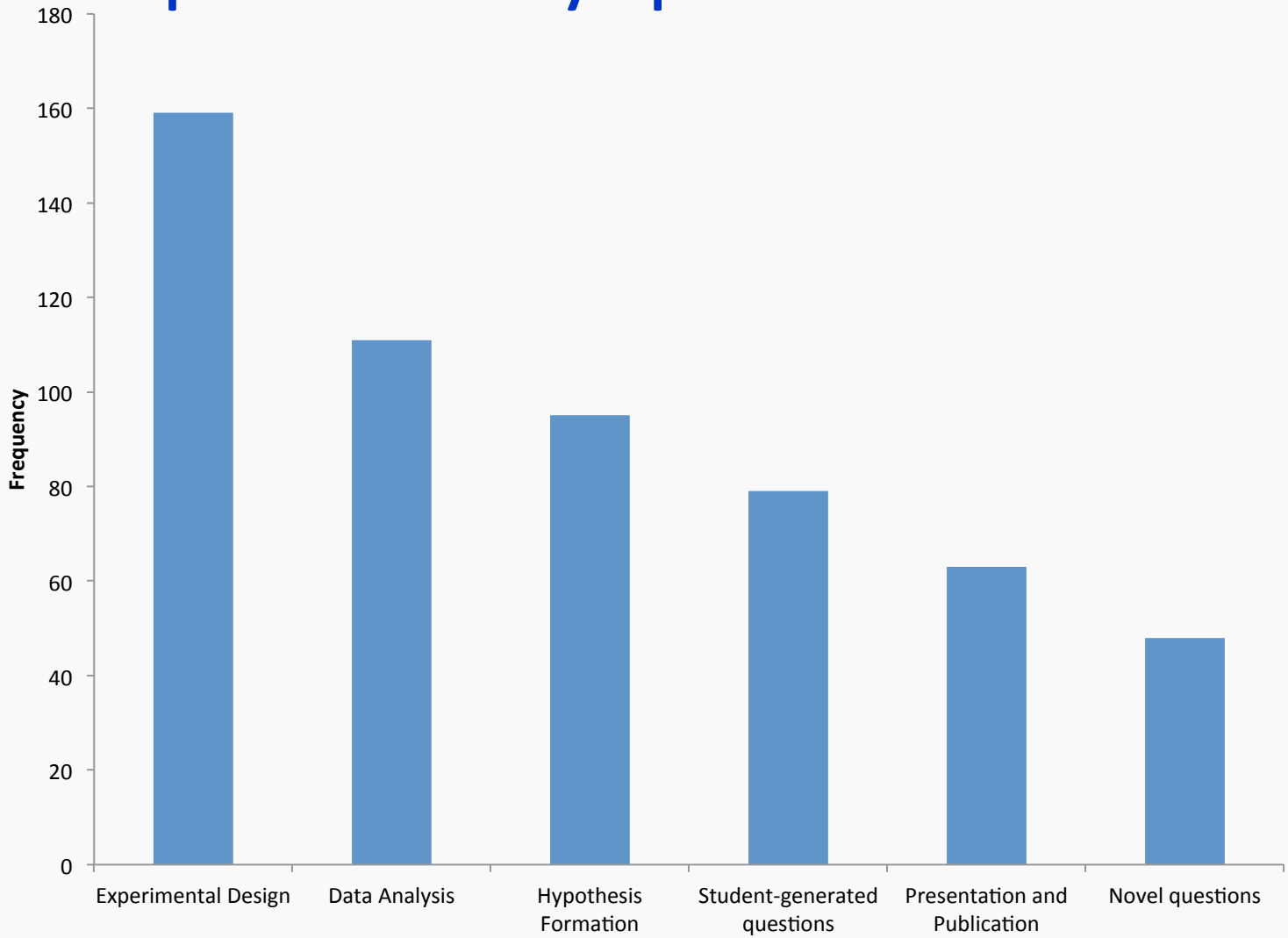
- Key terms?

20 Most Common Words in Definitions of Authentic Research

Themes based on common words in definitions of authentic research

- Novel Questions (i.e., unknown results)
- Student-generated Questions
- Hypothesis Formation
- Experimental Design
- Data Analysis
- Presentation or Publication

Definitions of Authentic Research preliminary quantification



Factors influencing definitions of authentic research

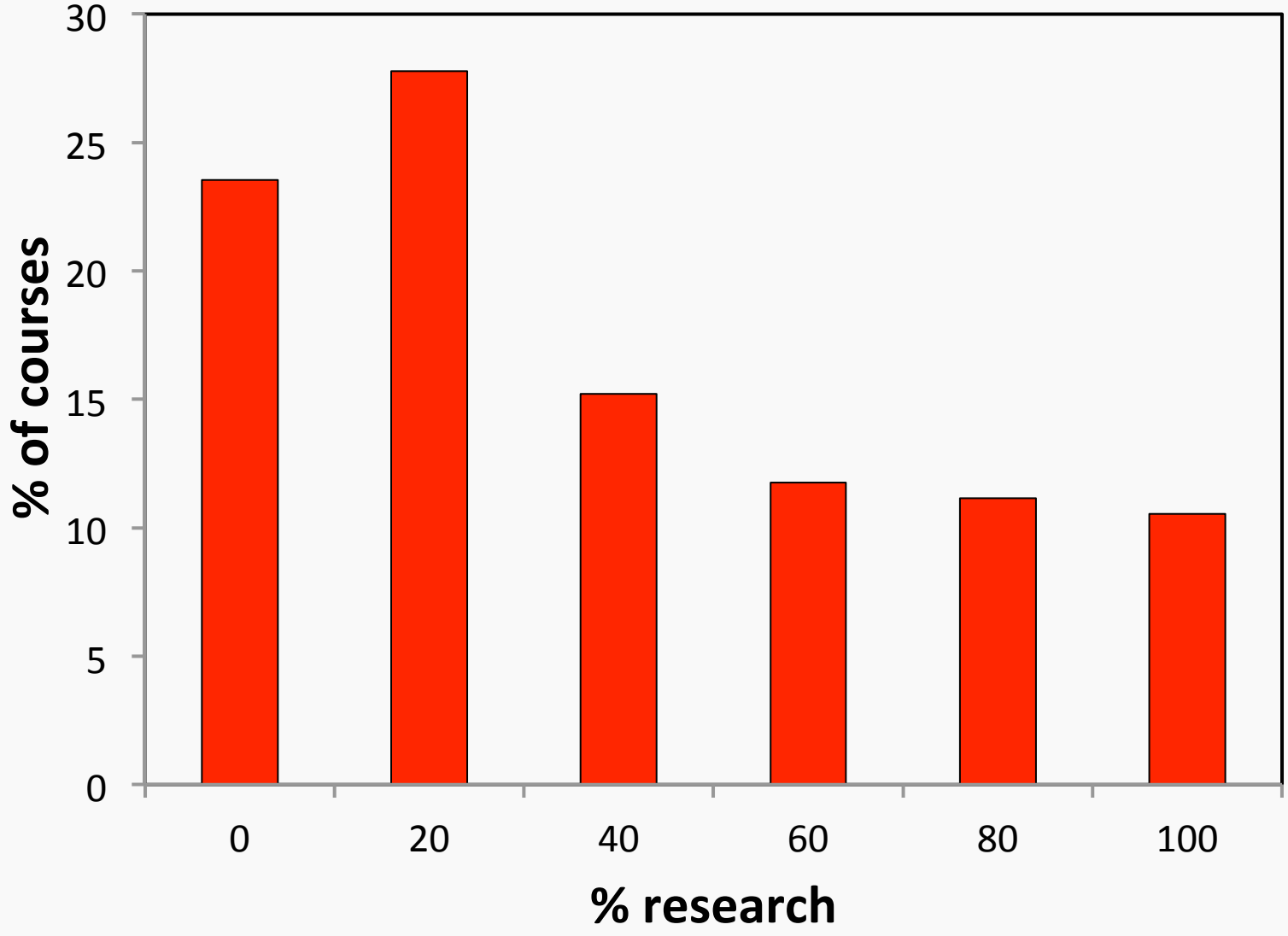
- 2-year college faculty *less* likely to include Experimental Design
- ABLE members much *more* likely to include Experimental Design
- CUR members much *more* likely to include Novel Questions
- NABT members *less* likely to include Hypothesis Formation and Presentations and Publications (marginally significant given number of tests)

Conclusions of definitions

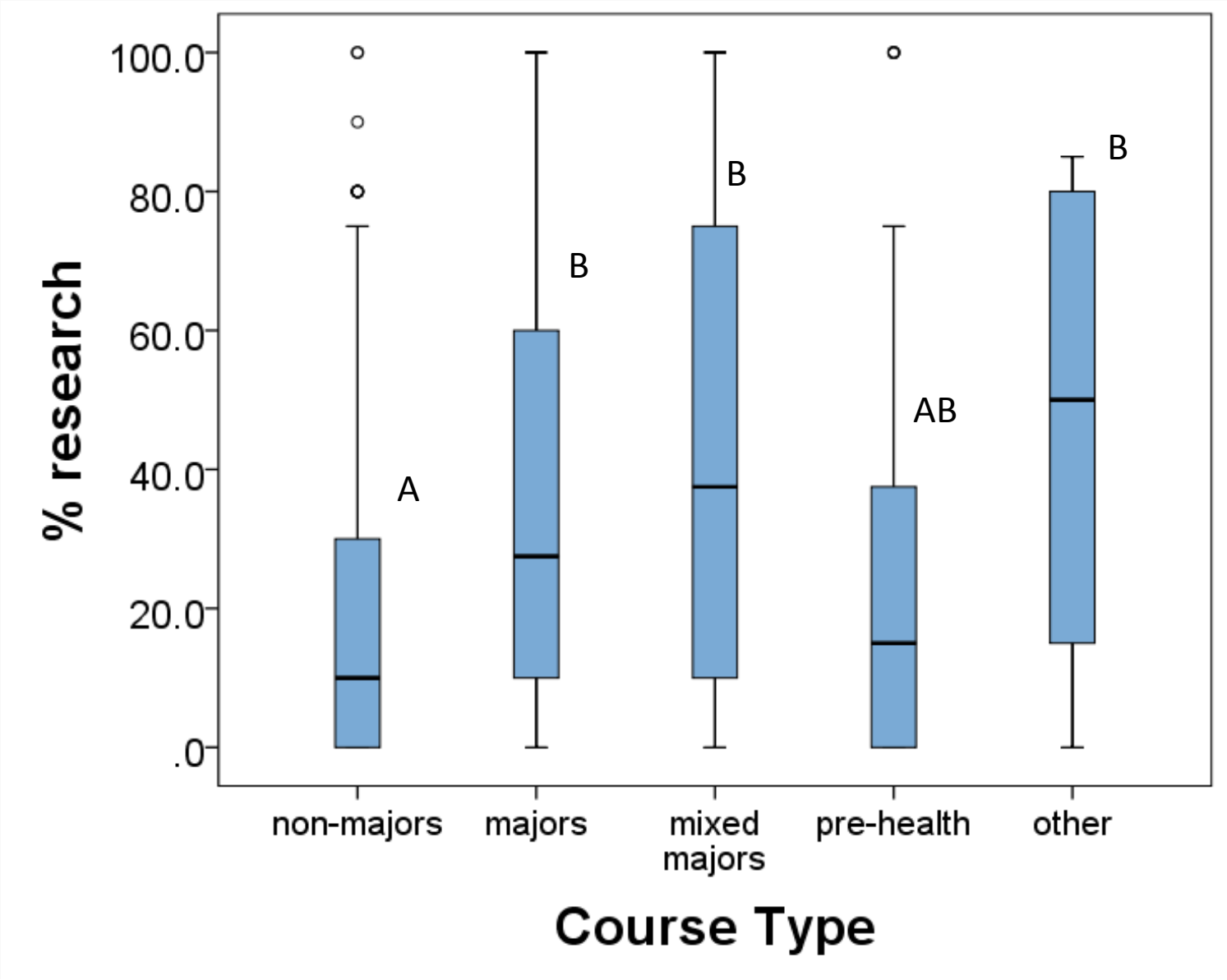
- no one clear definition
- can incorporate several components
- therefore, must support many models of incorporation of research into the curriculum

Implementing Authentic Research

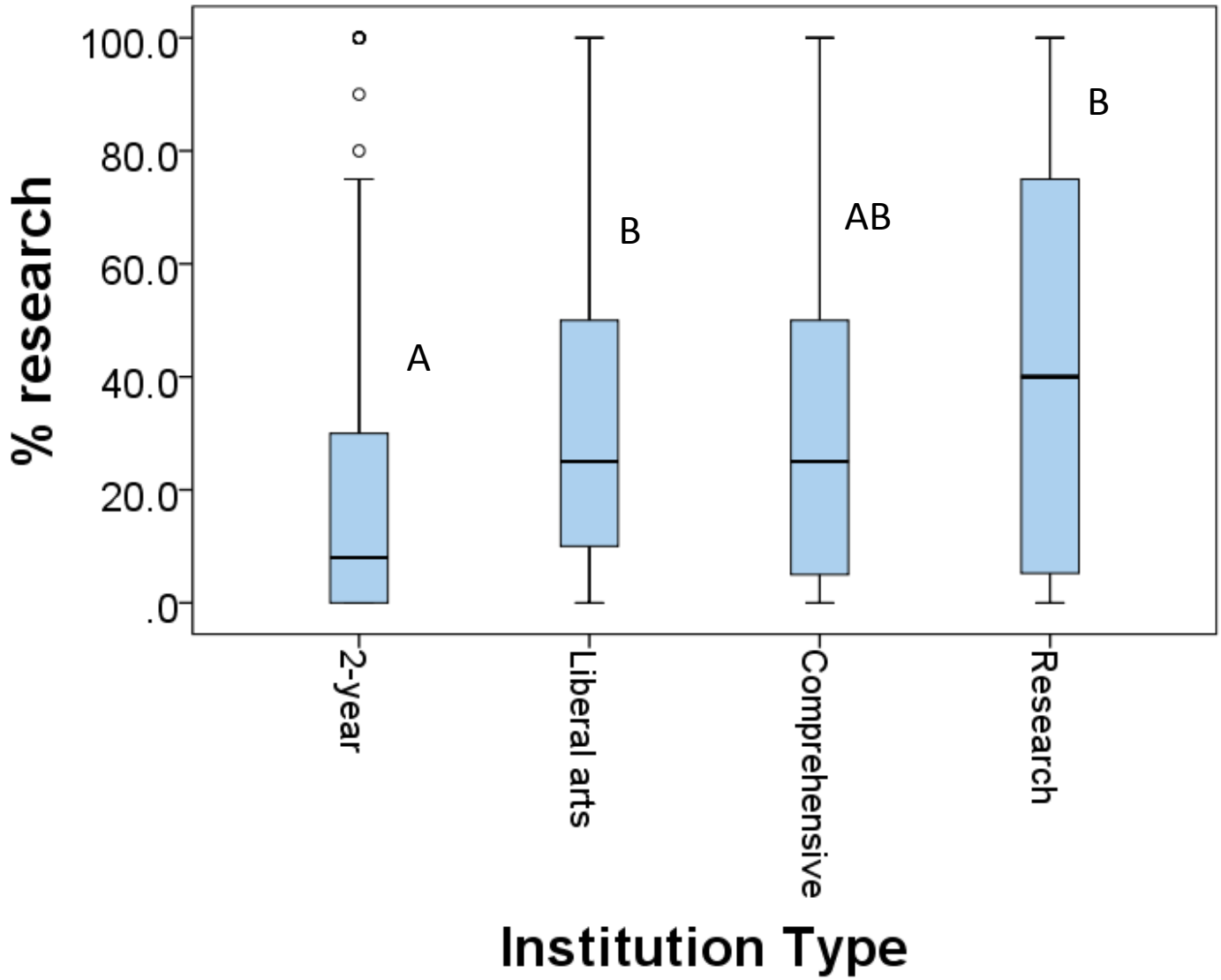
Research in intro lab courses



Effect of course type on research



Effect of institution type on research



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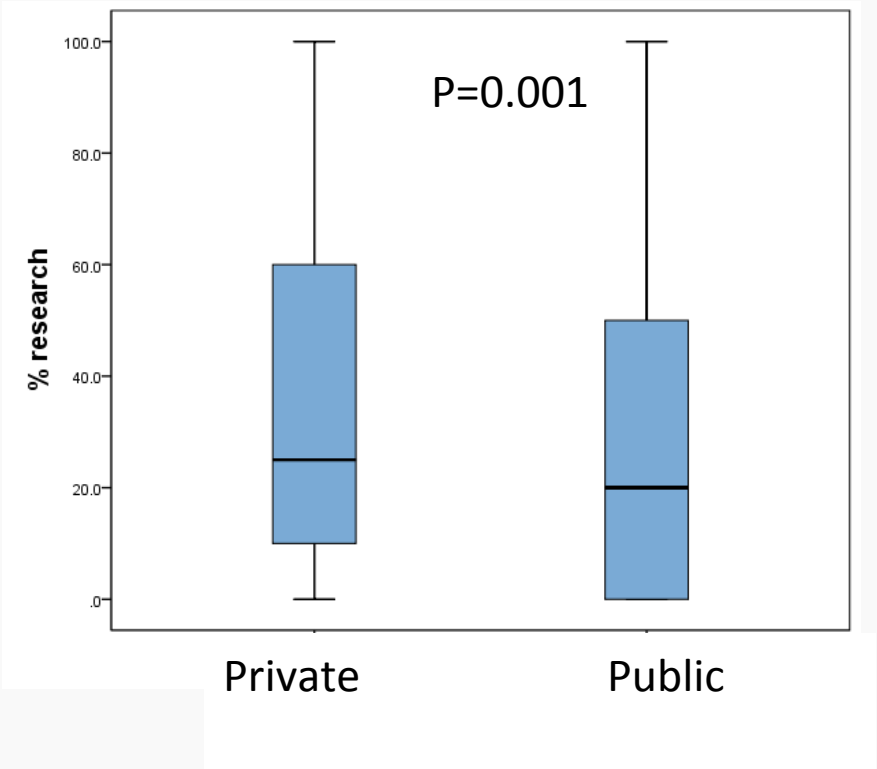
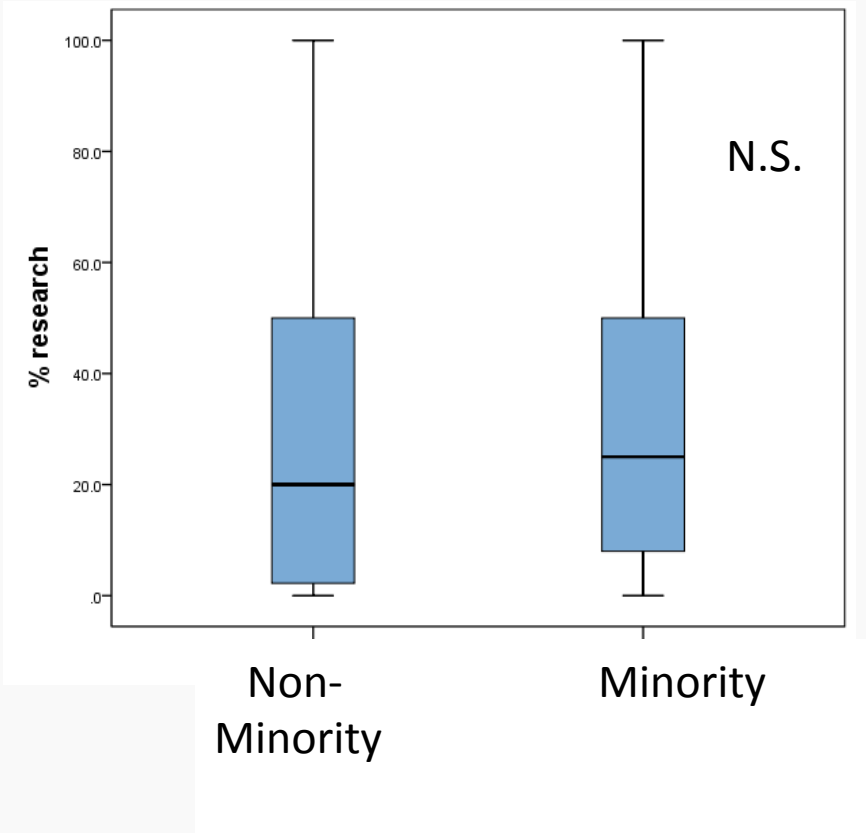
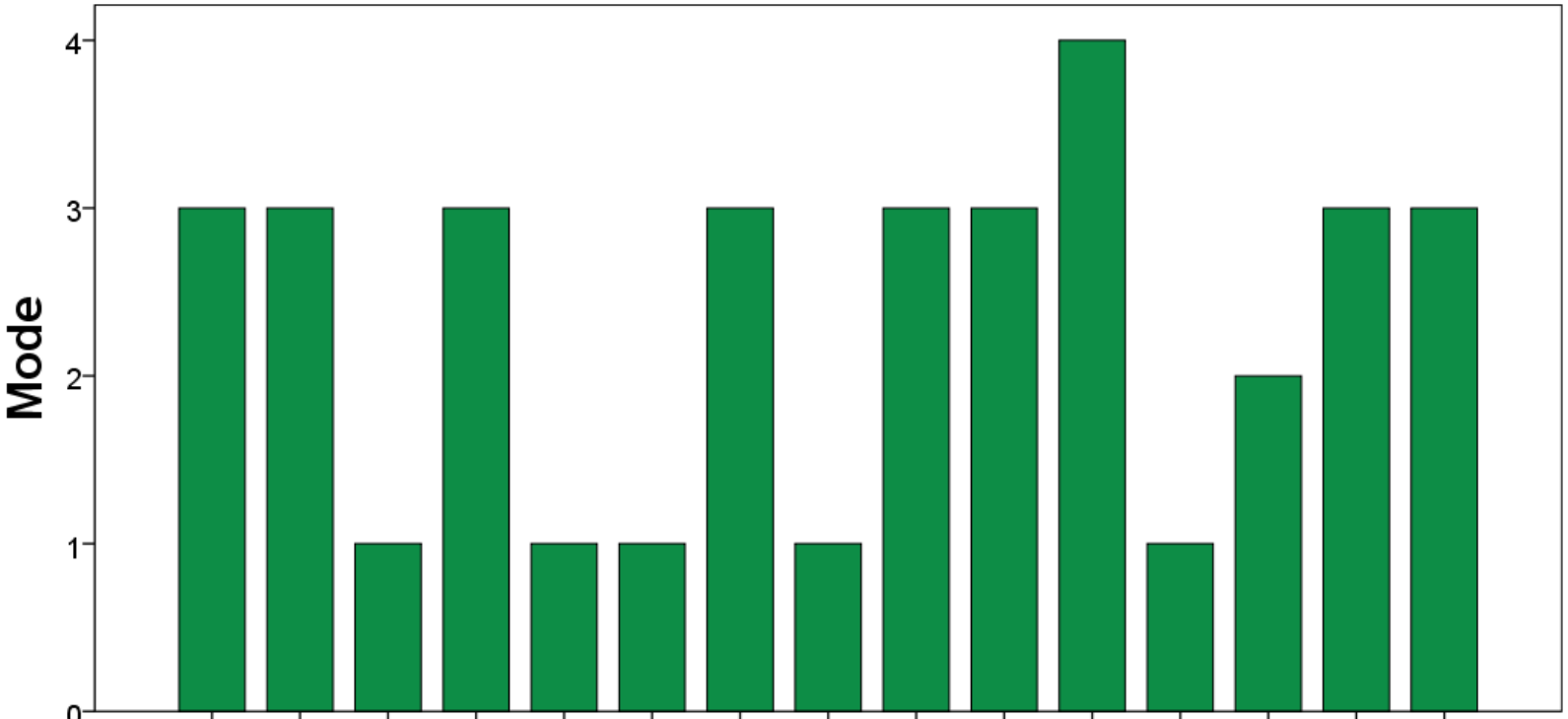




Barriers to Authentic Research

Barriers to Authentic Research



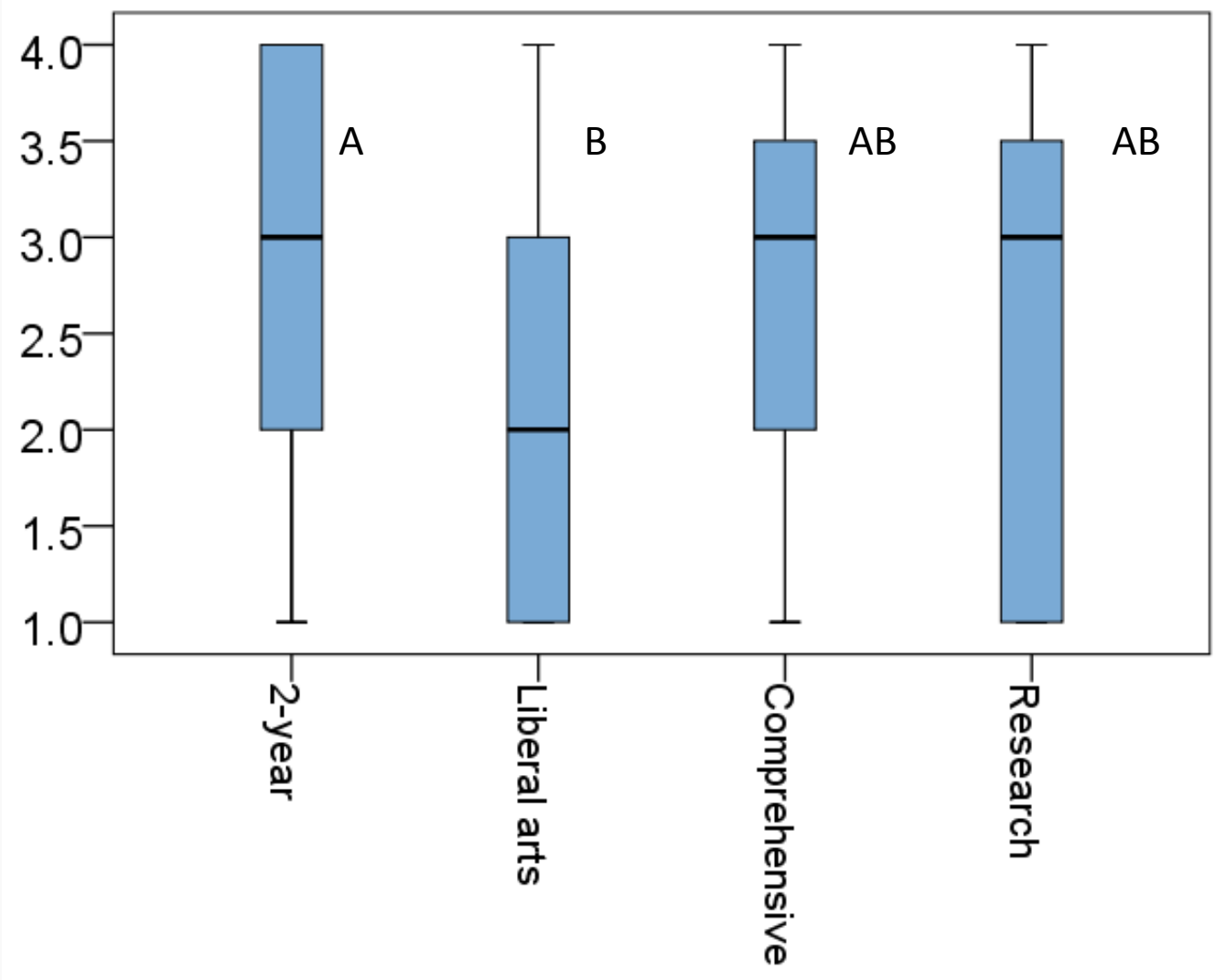
Conclusions of Barriers

TIME

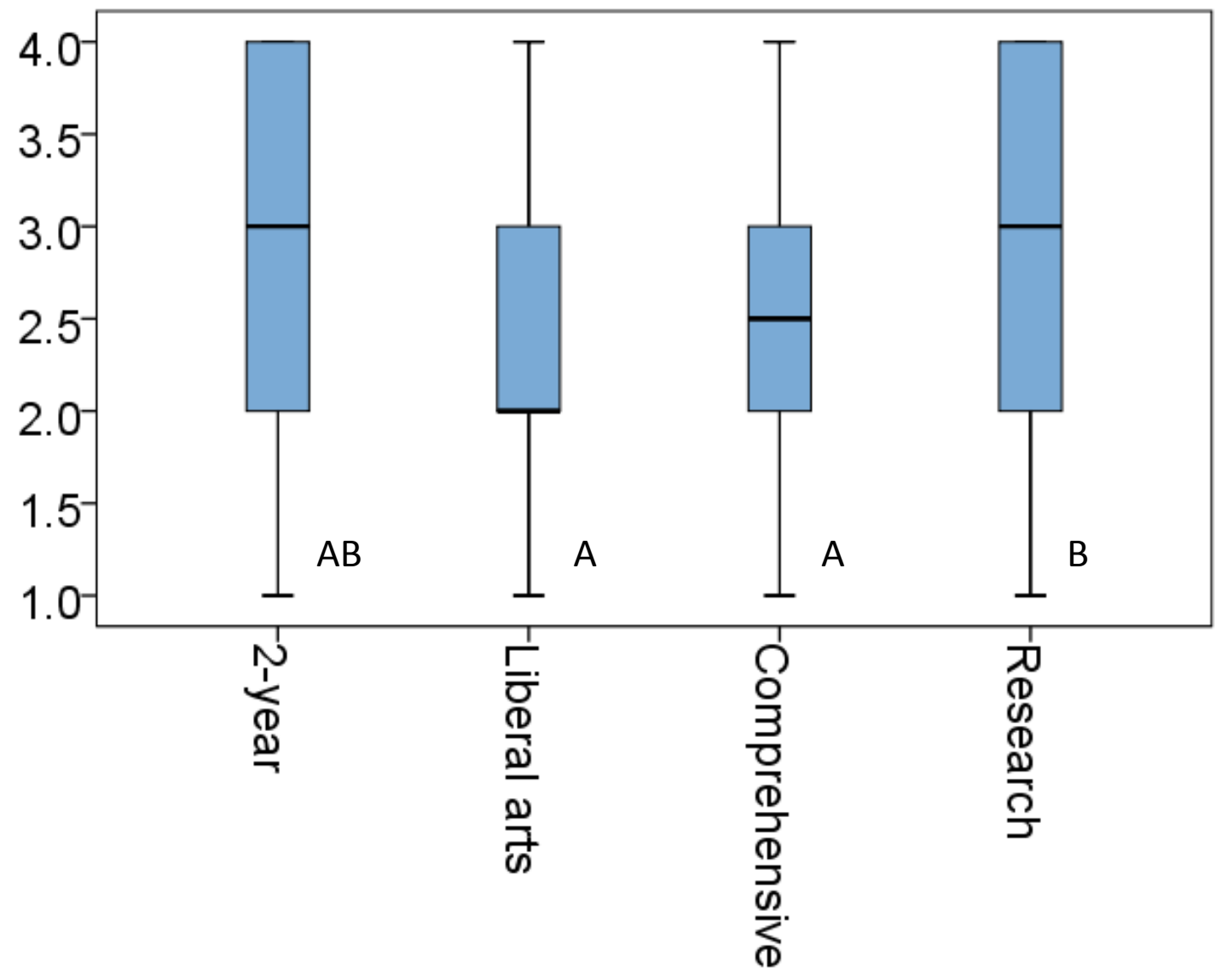
Not significant barriers, generally

- class size
- section numbers
- facilities

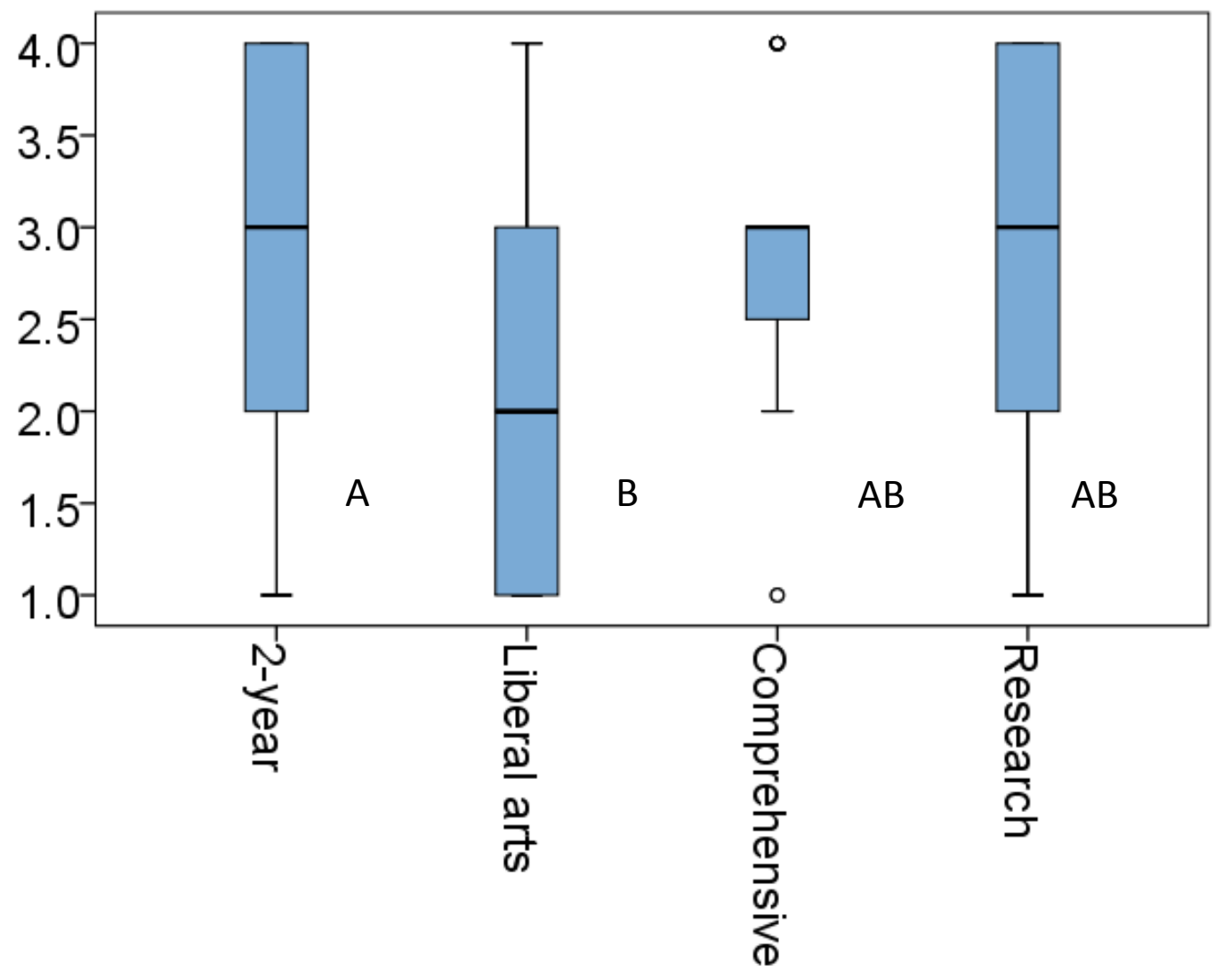
Effect of Institution Type on Barriers: Lack of Equipment



Effect of Institution Type on Barriers: Class Size



Effect of Institution Type on Barriers: Student Preparation



Barriers to Authentic Research at Minority-serving Institutions

- Lack of administrator support
- Lack of facilities
- Lack of time for faculty to develop new research experiences
- Effects on student evaluation of instructors

Barriers to Authentic Research at Public Institutions

- Cost
- Lack of equipment
- Lack of student preparation
- Effects on student evaluation of instructors

List of Network Member Modules of Research in the Curriculum

by institution type

2 Year College

Name	Institution	Course	Module	Type of course-
Nitya Jacob	Oxford College (liberal arts intensive 2 year college)	Intro Bio for majors	Arabia Mountain	Student-generated question and hypothesis, guided inquiry
Joanna Vondrasek	Piedmont Virginia Community College community college	Required research course for science majors	Semester-long independent research	Student-generated question
Joanna Vondrasek	Piedmont Virginia Community College community college	Non-majors biology	bean beetle labs	Semester-long, guided inquiry
Joanna Vondrasek	Piedmont Virginia Community College community college	sophomore level Cell Bio and Genetics courses	fairly open-ended multi-week labs	

Liberal Arts

Name	Institution	Course	Module	Type of course-
Lawrence Blumer	Morehouse College (private liberal arts, HBCU)	Freshman Course	HHMI Phage Hunters	Novel question
Lawrence Blumer	Morehouse College (private liberal arts, HBCU	majors introductory laboratory	bean beetle guided-inquiry	Student-generated questions and expt design?

Liberal Arts

Name	Institution	Course	Module	Type of course-
Sibdas Ghosh	Dominican University of California (liberal arts college)	Undergraduate Research Sequence, starting 2nd semester		Research methodology
Lonnie Guralnick	Roger Williams University (public college)	Intro Bio lab at Western Oregon	Ecology module for majors intro	Directed inquiry, term-long project
Pam Hanson	Birmingham-Southern College (liberal arts college)	Upper level genetics course and intro honors cell and molecular biology,	KP1019	Semester long novel research project

Liberal Arts

Name	Institution	Course	Module	Type of course-
Mary Miller	Rhodes College (liberal arts college)	Intro Bio Sequence	Student-designed experiment, focus on scientific communication	
Jen Rhode Ward	UNC-Asheville (public liberal arts college, with ~250 majors)	Freshman and sophomore courses	Plant ecology, physiology, and genetics	authentic research-based lab work
Kathy Winnett-Murray	Hope College (liberal arts college)	non-majors	investigation of the impacts of invasive plant species in ecological communities	month-long group research project, jigsaw approach

Comprehensive Universities

Name	Institution	Course	Module	Type of course-
Barbara J Abraham	Hampton University (HBCU)	majors Intro Bio sequence	Analyses of chemistry and animals in soil samples	3-4 week module with student-generated question, presentation and paper
Judy Guinan	Radford University (comprehensive)	Introductory majors		Guided inquiry, then student-designed question and experimental design, analysis and presentation
Larry Wimmers	Towson University (comprehensive)	Intro labs		guided inquiry with student generated hypothesis and design

Research Universities

Name	Institution	Course	Module	Type of course-
Kristen Miller	UGA (public university)	Introductory Biology for majors, for majors		Student-designed experiments,
Craig Ogilvie	Iowa State University	Multiple courses, approximately 1000 students per year courses	5-6 week research projects in 9 science lab courses	learning communities of faculty and graduate student TAs
Elisabeth Schussler	University of Tennessee (public university)	Second semester introductory biology for majors (cell biology)	Four 2-week guided laboratories	Guided inquiry based on research by UT faculty members
Rachelle Spell	Emory University (research university)	Research Methods Course	Semester-long novel research	Entry level (freshman and up)

Example Module: Investigating Arabia Mountain: A Molecular Approach

Introductory Biology Laboratory

by Nitya Jacob

Oxford College

Investigating Arabia Mountain: A Molecular Approach

1) Literature Research – Proposal

"Thinking Time"

(Student ownership)

2) Sample collection

3) Laboratory bench work

4) Data analysis

"Thinking Time"

(Student ownership)

5) Communicating Evidence

Connection to Biology 141

Building the foundation of a research-rich curriculum

Gary Reiness

Department of Biology, Lewis & Clark College, Portland, OR

Lewis & Clark

We want our graduates to:

- understand the process of scientific inquiry
- be independent learners
- recognize that 'facts' are hypotheses well-supported by evidence
- be able to draw appropriate conclusions from experimental data
- understand what kinds of issues are amenable to scientific inquiry and what kinds are not
- be able to collaborate effectively

Like many of you, we try to achieve those goals by emphasizing student-designed, inquiry-driven laboratories

Use lecture time to teach experimental design and data analysis

Experimental Design

Two options

Manipulative: where the investigator actually does something to the system and measures the effects of these manipulations on variables of interest.

Correlational: makes use of natural variation to look for the effect of one factor on another.

Bird Tail Feather Example

http://identify.whatbird.com/img/4/4800/Image.aspx

Hypothesis:

Long tail feathers seen in many species of birds have evolved to make males more attractive to females.

Correlational approach

See which bird gets the most mates during the breeding season.

Manipulative approach

Shorten feathers | Extend feathers | Manipulation control

Group 1 | Group 2 | Group 3

Manipulate tail length, band birds, and monitor the number of matings.

Courtesy of Peter Kennedy

Introduce Primary Literature

- Even first semester students can read carefully chosen papers
- Class discussions are used to develop ability to critically evaluate experiments
- Students develop "taste" from comparing good and flawed work
- Good experiments provide models for students designing their own

Provide feedback on projects prior to execution

- Student groups present research proposals to peers
- Proposals are critiqued by peers and course staff
- Students receive feedback on their experimental plan, and
- Learn from the strengths and weaknesses of other proposals

Monitor progress of experiments

- Obtain regular reports on progress of experiments (or make site visits to field studies)
- Helps students stay on task and assists in troubleshooting or modifying experiment
- Helps reduce last-minute scrambles for data or failed studies

Assign written reports to be drafted in stages, with revision

- For multi-week projects, students write Introduction and Methods before obtaining Results.
- Instructor critiques these and students revise them
- Student groups outline Introduction, Results, and Discussion sections in lab (with instructor feedback) to assure common understanding, enrich collaborative interpretation, and reduce "you write section A and I'll write B" discontinuities.

Assign oral presentations of results, with emphasis on "research lessons learned"

- Students must describe what they would do differently if repeating their experiment
- The lab manual provides a grading rubric

These are the criteria by which your group's oral report will be graded. When you rehearse it, make sure that you can answer "yes" to each of the following questions.

CHECKLIST FOR ORAL REPORTS

_____Was the question or hypothesis clearly described, early in the presentation? Was it clear why the group thought this was an interesting question, what they expected to see, and why?

_____Was the design of the study clearly described?

_____Were the study's results presented in a way that was easy to understand? Were important trends described? Were visual aids used when appropriate? Were they clear and well explained?

_____Were the conclusions described and explained/justified?

_____Did the presentation include a description of what the group would do differently if they repeated the study, and why?

_____ Did all members of the group contribute to the presentation? Was the presentation well-coordinated? Well-rehearsed? Did everyone play their

Infusing faculty research into an introductory biology laboratory

Elisabeth Schussler, University of Tennessee, Division of Biology

Course: Organization and Function of the Cell
Second semester majors' course
>900 students per academic year

Previous lab: cookbook, techniques

In 2011, identified research of four <u>UTK faculty</u> members to be the basis of new guided inquiry laboratories

Infusing faculty research into an introductory biology laboratory

Elisabeth Schussler, University of Tennessee, Division of Biology

Each lab,
Week 1: background and techniques, collect and analyze preliminary data, brainstorm hypothesis and experimental design for another experiment given supplies available

Week 2: collect data, analyze data, compile and present an oral communication

Follow-up: Written lab communication

End of semester: Group presentation on how they would continue experimentation on one of the systems they worked with that semester

Example Module: Novel Research Lab Course

Bio285 Biology Laboratory

Rachelle Spell

Emory University

Biol285 Research Course

Collaboration with Pamela Hansen (Birmingham-Southern College) and Mary Miller (Rhodes College)

- novel question: effect of a new metallo-compound chemotherapy agent KP1019 on yeast
- given experimental design
- scientific communication: paper and poster presentation
- designed for freshman

Breakout

Please share

- factors that contribute/d to your success
- barriers that limit/ed your success
- interest in joining our network

Next Steps for REIL-BIology

- disseminate findings
  - presentations
  - publications
- submit full grant proposal
  - identify best practices
  - recruit more network members
  - gather real-life examples
  - address barriers to increase implementation

Thank you

Please join our network activities