Research in Undergraduate STEM Education (Student Learning, Program Intervention, and Instructional Methodologies)

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Some Definitions

Research, according to Webster, is an "investigation or experimentation aimed at the discovery and interpretation of facts."

In education there are two major types of research: **basic research**, where the goal is a better understanding of learning and the educational process

applied research, which focuses on finding information that will improve current educational practice.

Evaluation, according to the web, is a "process of determining whether an item or activity meets specified criteria."

Some Things We Know Make A Difference In Undergraduate STEM Education

- High school preparation
- Undergraduate research experiences
- Use of familiar applications to explain/ demonstrate concepts
- Summer bridge experiences
- Supplemental instruction components: peer-facilitated, involve engaging students in cooperative work, focus on problems that supplement rather than remediate course material, and attempt to develop study skills.
- Students working in class in small groups.

Some Things We May Be Able to Generalize From PreCollege Research

- The effects of wait time on student participation
- The impact of inquiry based instruction on student science learning
- The role of praise in building (or tearing down confidence)
- The efficacy of different types of small group work/cooperative learning
- The impact of class size on student achievement
- The impact of peer tutoring on the tutors.

Thinking About Design: The Right Design for the Question

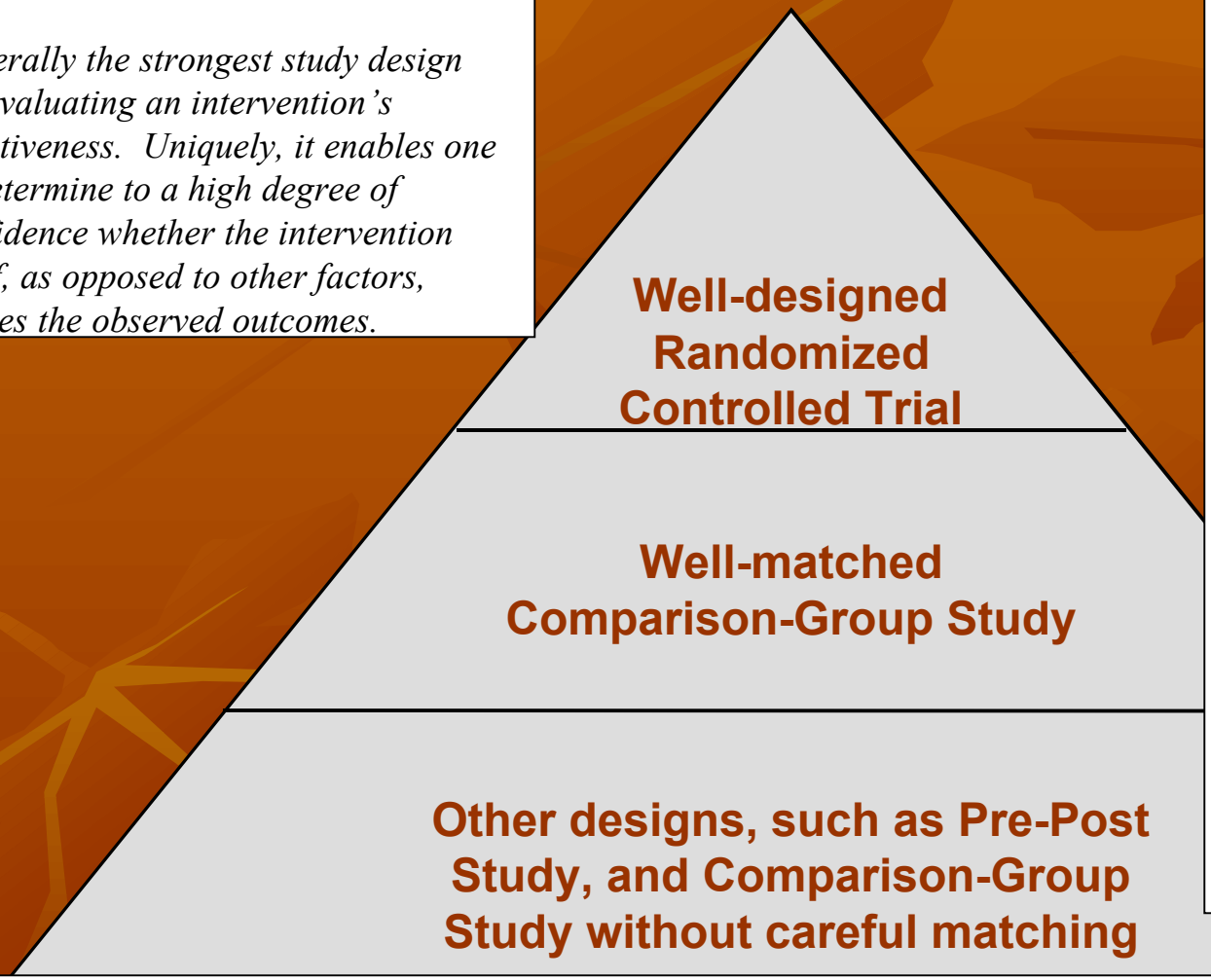
Study Type	Design	Representa-tion	Advantages	Disadvantages
Quantita-tive Case Study	One-shot Post-test only Design	X O	Takes fewer resources Can present a "snapshot" of a point in time	Doesn't look at change
Quasi-experiment al Study	One-shot Pre-test-Post-test Design	O_a X O_b	Looks at change over time	Other things besides treatment could be causing change
Quasi-experiment al Study	Post-test Only Intact Group Design	X O O	Compares to another group	Doesn't control for any initial differences in groups

Thinking About Design: The Right Design for the Question

Study Type	Design	Advantages	Disadvantages
Ethno-graphy	Observer examination of group behaviors and patterns	Explores complex effects over time	Resource intensive Story telling approach may limit audience Potential observer bias
Case Study	Exploration of a case (or multiple cases) over time	Provides an in-depth view	Limited generalizability
Content Analysis	Systematic identification of properties of large amounts of textual information	Allows for quantitative and qualitative analysis	Tends too often to simply consist of word counts Can disregard the context that produced the text
Mixed Methods Study	Use of more than one of the above designs	Can counteract the disadvantages of any one design	None

Hierarchy of Study Designs For Evaluating a STEM Educational Intervention

Generally the strongest study design for evaluating an intervention's effectiveness. Uniquely, it enables one to determine to a high degree of confidence whether the intervention itself, as opposed to other factors, causes the observed outcomes.



A second-best alternative when a randomized controlled trial is not feasible. The evidence suggests that if the intervention and comparison groups are very closely matched in key characteristics (e.g., pre-intervention educational achievement, demographics), the study in many cases yields the correct overall conclusion about whether the intervention is effective, ineffective, or harmful. However, its estimate of the size of the intervention's effect is often inaccurate, possibly resulting in misleading conclusions about the intervention's policy or practical significance.

Can be useful in generating hypotheses about what works that merit confirmation in more rigorous studies, but should not be relied upon to inform policy decisions, as they often produce erroneous conclusions about an intervention's effectiveness. This is true even when statistical techniques (such as regression adjustment) are used to correct for factors other than the intervention that may affect the study participants' outcomes.

Academic Competitive Council: Federal Undergraduate STEM Education Goals and Metrics

Number and percent:

- declaring or completing at STEM major/program
- attending a STEM graduate program
- taking a STEM job
- non STEM majors completing STEM courses

Scores on standardized tests, where appropriate

Employer satisfaction.

Some Directions For Future Research: Expanding The Unit of Analysis

- The Student
- The Pedagogy
- The Curriculum
- Assessment
- The Professor
- The Department
- The Institution.

Some Directions For Future Research: Looking At Institutional Impact

Ok I'm still working on this one:

What are institutional predictors of student success in STEM? Do these vary for different students?

What are first year predictors of STEM undergraduate college success? Do these vary for different students?

What is the value added of the institution (assessing the quality of the student leaving the institution rather than the quality of the entering student)?

Some Directions for Future Reserch: Testing A Trilogy for Student Success

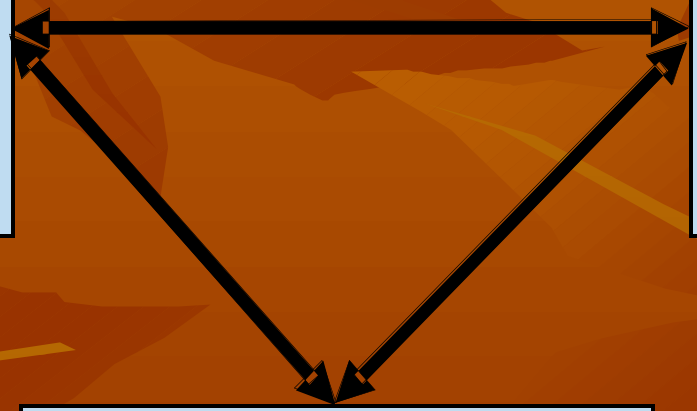
The ECC Trilogy

Engagement

Having an orientation to the sciences and/or quantitative disciplines that includes such qualities as awareness, interest and motivation.

Capacity

Possessing the acquired knowledge and skills needed to advance to increasingly rigorous content in the sciences and quantitative disciplines.



Continuity

Institutional and programmatic opportunities, material resources and guidance that support advancement to increasingly rigorous content in the sciences and quantitative disciplines.

Some Directions For Future Research: Three Fundamental Questions Related To Encouraging Minorities To Pursue Research Careers

What are the probabilities that an individual with a given set of characteristics will make the transition from one stage to another in a career in research?

Why do people with different characteristics make the decisions that they do?

How can these probabilities be changed?

Jeremy Berg, Director NIGMS

Some Directions For Future Research: Using Existing Data

NCES

Baccalaureate and Beyond
Beginning Postsecondary Students
High School and Beyond
Integrated Postsecondary Educational Data Systems
National Study of Postsecondary Faculty.

NSF

National Survey of Recent College Graduates
Science and Engineering Indicators.

Some Web-based Sources of Measures

OERL, the Online Evaluation Resource Library.
http://oerl.sri.com/home.html

ETS Test Link (a library of more than 25,000 measures).
http://www.ets.org/portal/site/ets/menuitem.1488512ecfd5b8849a77b13bc3921509/?vgnextoid=ed462d3631df4010VgnVCM10000022f95190RCRD&vgnextchannel=85af197a484f4010VgnVCM10000022f95190RCRD

OERL, the Online Evaluation Resource Library. http://oerl.sri.com/home.html

Includes NSF project evaluation plans, instruments, reports and professional development modules on

- Designing an Evaluation
- Developing Written Questionnaires
- Developing Interviews
- Developing Observation Instruments
- Data Collection
- Instrument Triangulation and Adaptation.