STEM Education Research: Evidence that Answers Research Questions vs Evaluation Questions

Sarah-Kathryn McDonald
Directorate for Education and Human Resources
May 15, 2018, 12:45-2:00pm

ITEST: Evidence that answers research questions

Synopsis of Program:

As the nation continues to expand the horizon of opportunities and possibilities through advances in science, technology, engineering and mathematics (STEM), the need for a more diverse and well-prepared STEM workforce is also expanding[1]. The challenge of preparing citizens for the expanding workforce and the changing workplace environments calls for new innovations in STEM education[2]. ITEST is a research and development program that supports projects to promote PreK-12 student interests and capacities to participate in the STEM and information and communications technology (ICT) workforce of the future. The ITEST program supports research on the design, development, implementation, and selective spread of innovative strategies for engaging students in technology-rich experiences that: (1) increase student awareness of STEM occupations; (2) motivate students to pursue appropriate education pathways to STEM occupations; or (3) develop disciplinary-based knowledge and practices, or promote critical thinking, reasoning skills, or communication skills needed for entering STEM workforce sectors. ITEST projects may adopt an interdisciplinary focus that includes multiple STEM disciplines, focus on a single discipline, or focus on one or more sub-disciplines. The ITEST program supports projects that provide evidence for factors, instructional designs, and practices in formal and informal learning environments that broaden participation of students from underrepresented groups in STEM fields and related education and workforce domains. Projects that actively engage business and industry partners to better ensure that PreK-12 experiences foster the knowledge and skill-sets needed for emerging STEM occupations are strongly encouraged.

Source: ITEST Program Solicitation, NSF 17-565, pp. 1-2 (https://www.nsf.gov/pubs/2017/nsf17565/nsf17565.pdf)

ITEST: Evidence that answers research questions

All ITEST projects are expected to: (1) be informed by relevant research (such as that on innovative pedagogical approaches, career education, in-school and out-of-school learning environments); and (2) contribute to the research knowledge base on strategies and program models for fostering student awareness of, interests in, and capacities to participate in STEM occupations or education pathways leading to those occupations. ITEST projects are expected to be grounded in professional literatures relating to career and technical education and technological literacy, in addition to the literature focusing on STEM education research and curriculum standards. ITEST projects are expected to generate data and provide evidence that furthers and deepens understandings of factors, designs and practices that encourage and motivate students to pursue and persist in education programs or pathways that prepare them for STEM occupations. ITEST projects must involve students and may focus on investigating: a) conceptual, epistemic, or social learning outcomes, b) the development of technological or computational practices, or c) learning environment conditions that enhance learner motivations, mindsets, identity, and interest in STEM learning and occupations. Within the focal contexts, ITEST projects are encouraged to examine the roles and influence of teachers, other education professionals, mentors, and caregivers working with students.

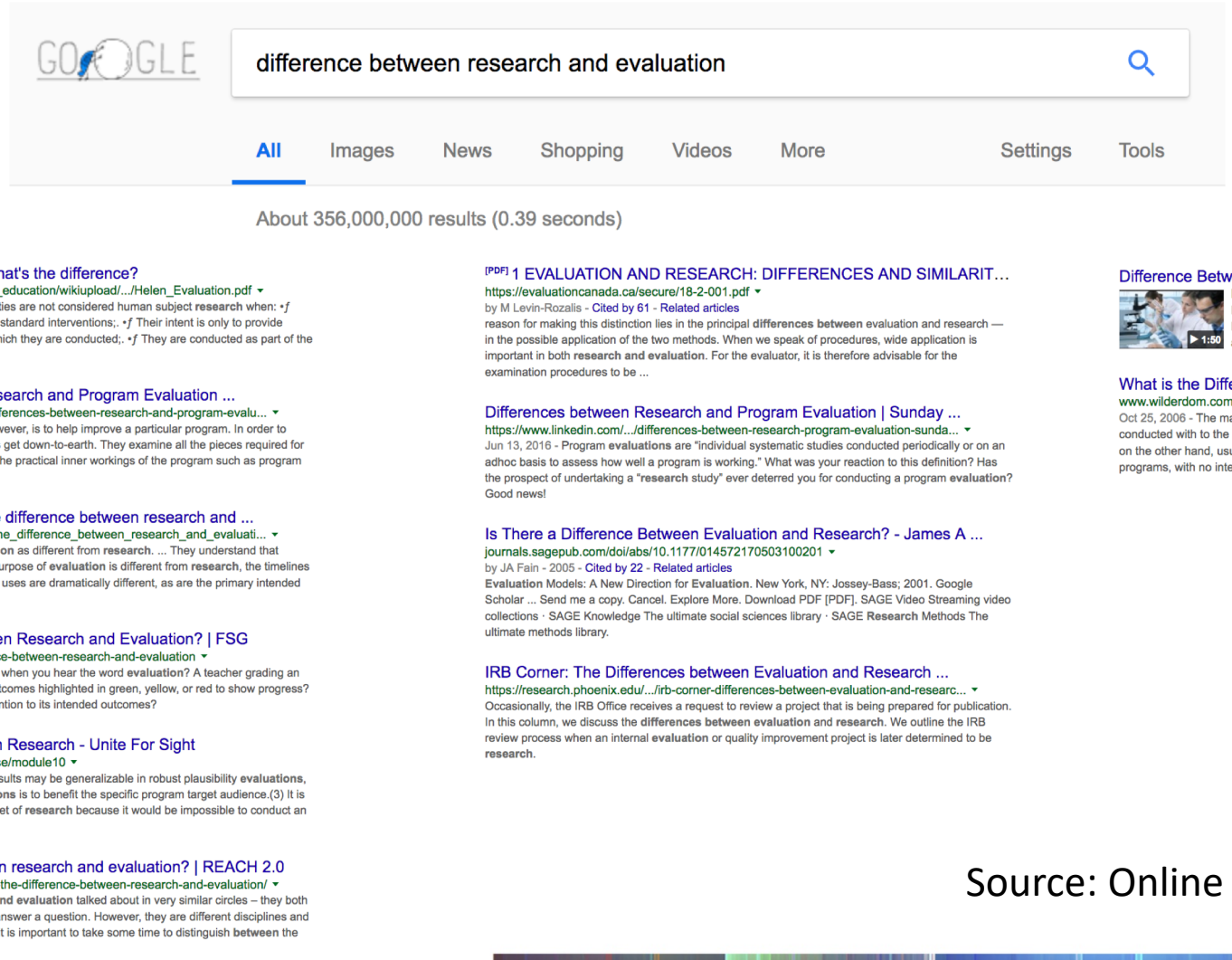
Source: ITEST Program Solicitation, NSF 17-565, p. 5
(https://www.nsf.gov/pubs/2017/nsf17565/nsf17565.pdf)

ITEST: Evidence that addresses evaluation questions

Independent Review (Project Evaluation): All ITEST projects must include provisions for ongoing, independent, and critical reviews of their designs and activities, including reviews of their theoretical frameworks, data collection plans, analysis plans, and reporting plans. A proposal must describe appropriate mechanisms to assess success through project-specific external review and feedback processes. These might include an external review panel or advisory board proposed by the project or a third-party evaluator. The external critical review should be sufficiently independent and rigorous to influence the project's activities and improve the quality of its findings. The feedback processes should enable the project team to answer two overarching questions relating to the goals and objectives of both the research and development aspects of the project: (1) Is the project making sufficient progress toward meeting the goals and objectives? And (2) What are the intellectual merits and broader impacts of the project with respect to its intended outcomes? Successful proposals will: (1) describe the expertise of the external reviewer(s); (2) explain how that expertise relates to the goals and objectives of the proposal; and (3) specify how the PI will elicit, report, and use results of the project's external, critical review process.

Source: ITEST Program Solicitation, NSF 17-565, p. 9
(https://www.nsf.gov/pubs/2017/nsf17565/nsf17565.pdf)

Research & evaluation: What's the difference?



Source: Online search, February 2018

Different perspectives on the nature of the relationship

- Dichotomy

Source: Rogers (2014)
https://www.betterevaluation.org/en/blog/framing_the_difference_between_research_and_evaluation

Research vs. evaluation → Dichotomy

Research	Evaluation
Purpose is testing theory and producing generalizable findings.	Purpose is to determine the effectiveness of a specific program or model.
Questions originate with scholars in a discipline.	Questions originate with key stakeholders and primary intended users of evaluation findings.
Quality and importance judged by peer review in a discipline.	Quality and importance judged by those who will use the findings to take action and make decisions.
Ultimate test of value is contribution to knowledge.	Ultimate test of value is usefulness to improve effectiveness.

Source: Patton (2017)
http://www.dmeforpeace.org/wp-content/uploads/2017/06/OBF_flashcards_201402.pdf

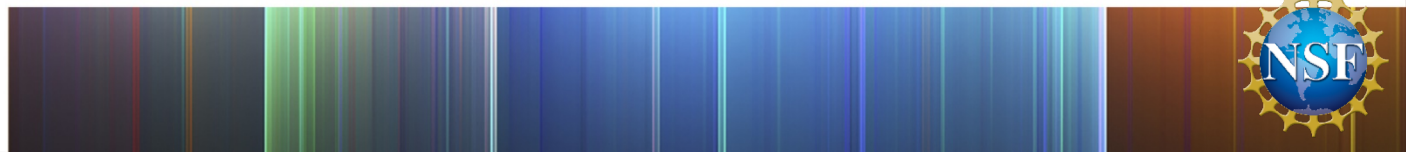


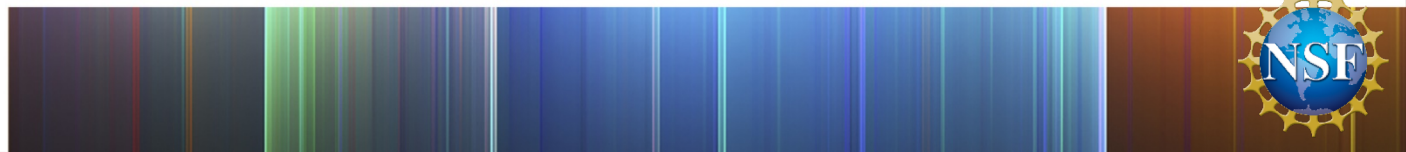
Table 1
Similarities and Differences in Evaluation and Research

	Evaluation	Research
Area of application	Application of the examination as wide as possible	Application of the examination as wide as possible
	Narrow application of findings focused in the project	Application of findings as wide as possible
	Aim of providing concrete feedback	Aim of increasing the body of scientific knowledge
Theory	Field-dependent: theory used to enlarge the understanding of findings	Theory-dependent: derived from or aspiring to theory
Methodology	Evaluation setting and data collection methods derived from the field	Research setting and data collection methods derived from theory
	The evaluator is reactive	The researcher is active
Generalization	Attempt to understand what is happening in a specific project	Attempt to formulate a general law; external validity is important
Relevance	Useful for the project	Increase of scientific knowledge
Causality	Stresses internal validity; that which is an artefact in research is seen as an internal variable in order to reach causality	Internal validity is important; stress is on a small number of causal variables in isolation from other variables

Source: Levin-Rozalis (2003: 5)

Research…some perspectives

- “The purpose of research is to enlarge the body of scientific knowledge…” (Levin-Rozalis, 2003: 1).
- “Research generates knowledge about how the world works and why it works as it does” (Patton, 2017: 7).
- “…the basic purpose of research is to observe and learn” (Endias, 1998 cited in Rogers, 2014).
- “*Research* means a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge. Activities which meet this definition constitute research for purposes of this policy, whether or not they are conducted or supported under a program which is considered research for other purposes” (45 CFR 46.102[d]).



Evaluation….some perspectives

- "…the purpose of evaluation is to provide useful feedback to program managers and entrepreneurs" (Levin-Rozalis, 2003: 1).
- "The purpose of evaluation is to improve, not prove" (Stufflebeam, 2001).
- "Evaluation generates improvements, judgments, and actionable learning about programs" (Patton, 2017: 7).
- "…the basic purpose of evaluation is to assess and decide" (Endias, 1998 cited in Rogers, 2014).

Genres of research, types of evaluation

- Foundational
- Early stage or exploratory
- Design & development
- Efficacy
- Effectiveness
- Scale-up

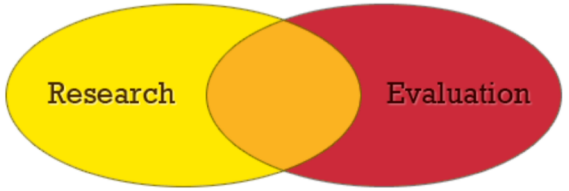
- Evaluability assessment
- Formative
- Developmental
- Process / implementation
- Outcome / effectiveness
- Impact

Source: IES & NSF (2013). *Common Guidelines for Education Research and Development* (NSF 13-126).

Different perspectives on the nature of the relationship

- Dichotomy

- Different…but *not* mutually exclusive



Source: Rogers (2014)

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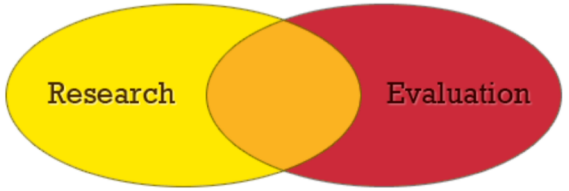

- Evaluation as a subset of research

Source: Rogers (2014)

Different perspectives on the nature of the relationship

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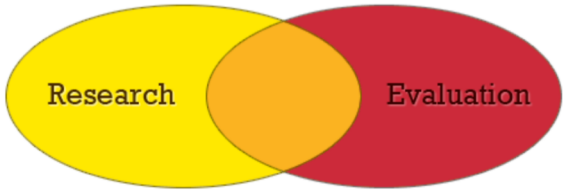


- Evaluation as a subset of research

- Research as a subset of evaluation

Source: Rogers (2014)

Research & evaluation: Similarities & differences

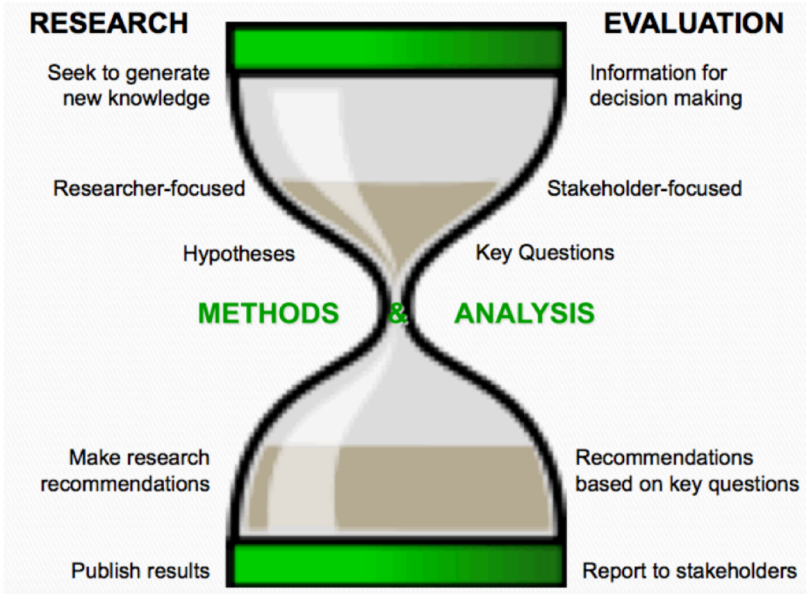
(somewhat) Different…

- Goals
- Audiences
- Domain(s) of application
- Level of abstraction

Same…

- Methods
- Designs
- Analytic tools, plans

Hot Tip: Visualize the relationship like an hourglass. I tend to be a visual person, and so I developed a picture of an hourglass with research on one side and evaluation on the other. This picture illustrates how evaluation and research begin at different points and funnel to using the same methods to answer questions and analyze data. They diverge again when it comes time to report on the outcomes (or processes) under study.



Source: LaVelle (2010)
http://aea365.org/blog/john-lavelle-on-describing-evaluation/

Research & evaluation: Similarities & differences

"…there are, of course, many points where research and evaluation overlap; otherwise there would be no confusion and, indeed, where this occurs, the similarities are greater than the differences" (Levin-Rozalis, 2003: 3).

"Evaluation and research are closely related and should be synergistic" (Fain, 2005: 150).

Clarifying, aligning goals; addressing challenges

- How would you characterize the nature of the relationships among your ITEST projects' research and evaluation goals?
- When are the same data sufficient—when are different data required—to address these goals?
- What challenges (if any) do projects share in their efforts to …
  - Monitor progress?
  - Inform project management?
  - Take corrective action?
  - Be accountable?
  - Provide evidence for program-level evaluation?

What important insights can your ITEST colleagues, POs, and prospective applicants glean from your experiences as researchers and evaluators?

VT PEERS

Partnering with Educators and Engineers in Rural Schools

<u>School Systems:</u> Bedford, Giles, and Smyth Counties

<u>Industry Partners:</u> fostek CORPORATION Celanese UNIVERSAL FIBERS

<u>Award:</u> Community-Engaged Engineering Interventions with Appalachian Youth

$1,077,035, 6/1/2017-5/31/2018 from the Division of Research on Learning, #165726

<u>Year 1 Program/Outreach By the Numbers:</u>

9 partnering 6th grade science teachers across 7 schools

6 workshops (1/month) with 757 students project-wide

At these schools, <u>every</u> 6th grader will participate

1+ volunteering engineer from industry per day

8 full days per month, VT PEERS is in schools

<u>Year 1 Research By the Numbers:</u>

Interviews (teachers, admins, industry reps, ourselves)

Student Data (pre/post instruments, ongoing reflections)

Observations (each activity, multiple per teacher/site)

Sharing -- Giles County FOCUS, Central Appalachia STEM Summit, VT Science Festival, VT President's Box; 2 ASEE papers accepted

<u>Principal Investigators:</u> Jacob Grohs, Holly Matusovich, Gary Kirk, Liesl Baum

<u>Project Team:</u> Cheryl Carrico, Andrew Gillen, Holly Lesko, Veronica van Montfrans, Tawni Paradise

Research vs. Evaluation?

Disclaimer: This is how we conceptualize them - take it or leave it as you see fit.

Some Key Similarities:

- Both are enhanced when guided by clear overarching goals and focused questions or objectives.
- Done well, both draw on rich traditions of data collection and analysis in social science.
  Thus, frameworks, reliability, validity, psychometrically validated instruments, apply in both efforts.
- Existing literature serves as a valuable guide to both efforts.
- Research and evaluation both may use the same data and may even analyze the data similarly.

Some Key Differences:

- Research prioritizes generating knowledge, ideally with broader generalizability or transferability across contexts.
- Research contributions must be built upon/interwoven with "existing knowledge in the field"
- Great (or poor) research may be independent of how well (or poorly) the project meets programmatic objectives
- In contrast, evaluation is necessarily more pragmatic and aimed at formally assessing project work via stated goals and objectives. Evaluation serves the direct purposes of informing current practice, determining quality, and making recommendations for improvement.

Operationalized?: Goals & RQs

Goal 1: Increase Youth Awareness of, Interest in, and Readiness for Diverse Engineering Related Careers and Educational Pathways

- *RQ 1: How do participants conceptualize engineering careers? How and why do such perceptions shift throughout the project?*
- *RQ 2: What elements of the targeted intervention affect student motivation towards engineering careers specifically with regard to developing competencies and ability beliefs regarding engineering?*

Goal 2: Build Capacity for Schools to Sustainably Integrate Engineering Skills and Knowledge of Diverse Engineering-Related Careers and Educational Pathways

- *RQ 3: How can strategic collaboration between K12 and industry promote a shift in teacher's conceptions of engineers and increased self-efficacy in building and delivering engineering curriculum?*
- *RQ 4: How do stakeholder characteristics, perceptions, and dynamics affect the likelihood of sustainability in strategic collaborations between K12 and industry stakeholders? How do prevailing institutional and collaborative conditions mediate sustainability?*

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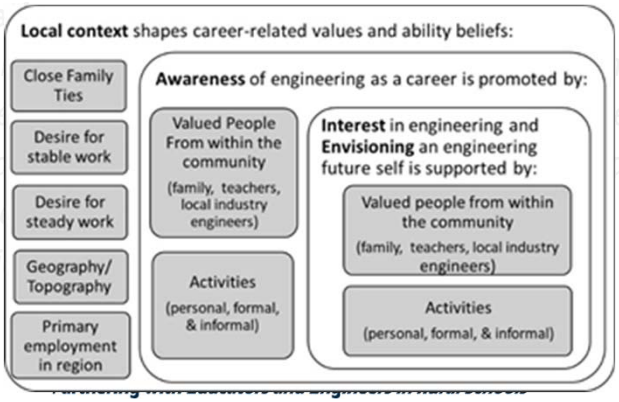
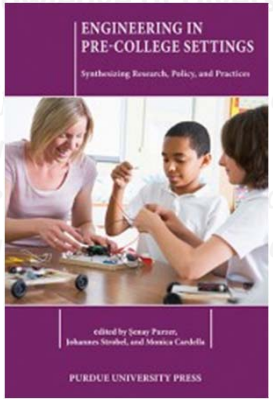
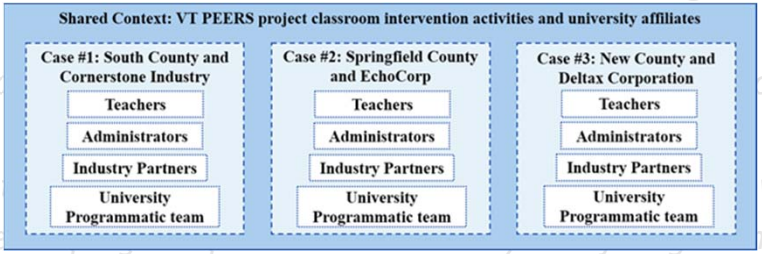
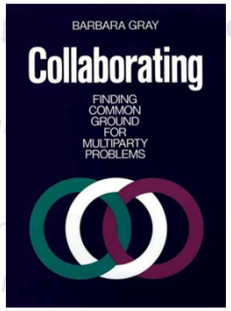




Operationalized?: Goals & RQs





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Operationalized?: Goals & Objectives

Goal 1: Increase Youth Awareness of, Interest in, and Readiness for Diverse Engineering Related Careers and Educational Pathways

This goal hinges on a collaboratively designed and facilitated set of monthly interventions in a curricular setting that specifically prioritize the following measurable objectives:

- *Objective 1.1: Broaden youth conceptions of engineering in a culturally relevant way*
  Evidence: Annual pre/post intervention artifact collection, class observations, focus group activities
- *Objective 1.2: Foster engineering identity development in participating youth*
  Evidence: Annual Engineering Identity Development instrument for pre-adolescent learners
- *Objective 1.3: Develop high-value engineering competencies such as systematic problem-solving*
  Evidence: Artifact collection from intervention activities looking for qualitative change over time
- *Objective 1.4: Increase knowledge of and potential interest in engineering-related career opportunities across a range of education levels*
  Evidence: Yearly pre/post intervention survey, artifact collection, observations, focus groups

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Operationalized?: Goals & Objectives

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Research | Evaluation | Both Research & Evaluation

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Evaluation Considerations

Disclaimer: This is how we conceptualize them - take it or leave it as you see fit.

Outputs: For our purposes, we consider outputs to be easily quantified with no specific justification of the benefit (e.g., number of students participating).

Outcomes: Outcomes relate specifically to the objectives mentioned, are measurable, but require documented evidence to justify benefit (e.g., improved student awareness about engineering careers).

Impacts: Impacts are on a longer time-scale than the duration of the project, can be quantified/qualified but evidence and/or causation during the timeframe of the project may be difficult to claim (e.g., participating student choosing an engineer career).

Challenges We Have Faced with R&E

Pedagogical and Practical Costs of Data: Our day-to-day experiences in classrooms has led us to believe that nothing ever goes the same way twice. Some days, data collection (e.g., artifacts, surveys) is seamlessly integrated into the activities while on other days it must be rushed, feels forced, or sometimes even gets pushed to another day.

This creates a productive tension to carefully align and prioritize to suit multiple needs.

Data Quality: With so many different partners, there have been seemingly inevitable surprises related to "contaminated" data (e.g., a well-intentioned teacher coaching student responses) or missed opportunities to formally capture data (e.g., between-class chats).

We have learned to listen carefully, analyze, reflect, and revise our plans often.

VT PEERS
Partnering with Educators and Engineers in Rural Schools

Tufts University School of Medicine

CTSE Center for Translational Science Education

Providing practical solutions to bring benchtop and bedside to desktop

Research and Evaluation:

Finding Synergies

Berri Jacque

Berri.jacque@tufts.edu

Outline

- **Brief overview of project goals**
- **Research and evaluation**
  - **Research aims**
  - **Evaluation goals**
  - **Synergies**
- **Lessons learned and challenges**

The BIG Goals

1. **Capture student interest**

2. **Build career awareness**

3. **Build critical skills and student perceptions**

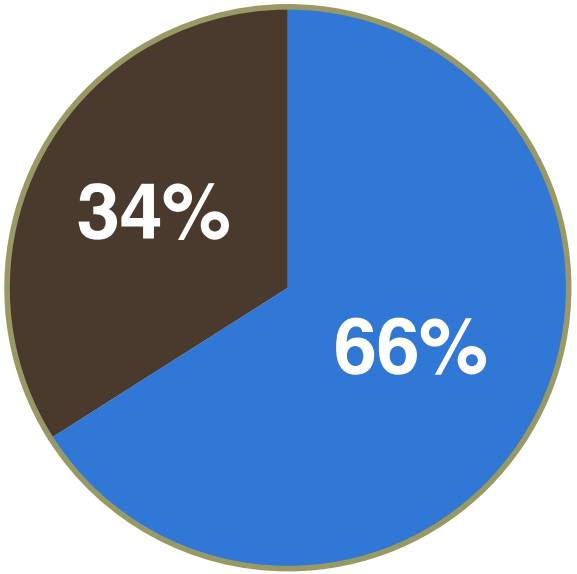
Your average science classroom...

(iStockphoto)

Data from PISA 2007

Your average science classroom...

(iStockphoto)

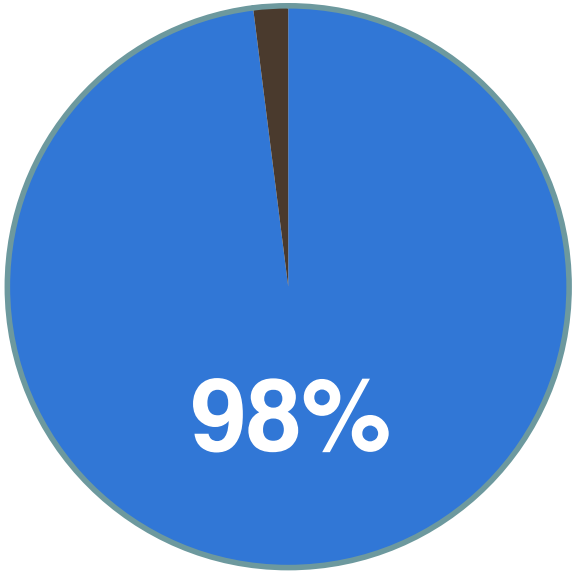


66% of students value learning about science

Data from PISA 2007

How interested are high school students in learning about health?

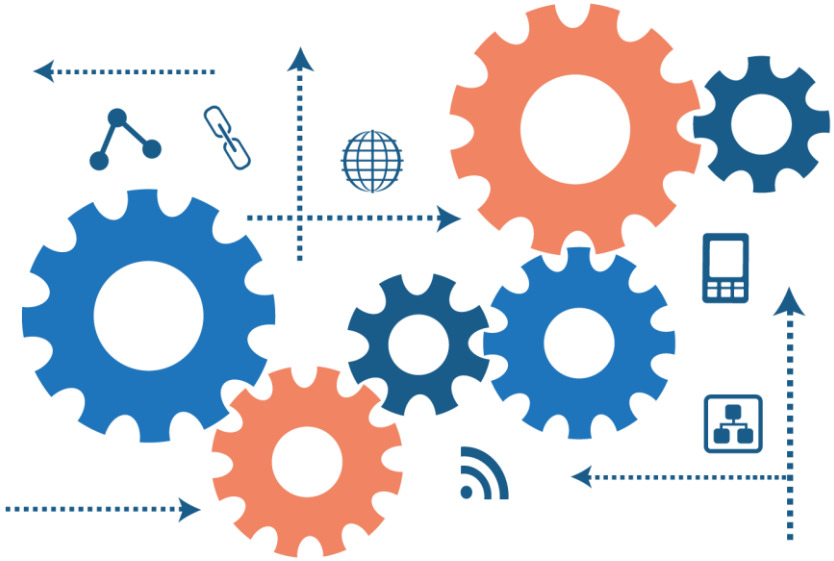
How interested are high school students in learning about health?



98% of students value learning about health

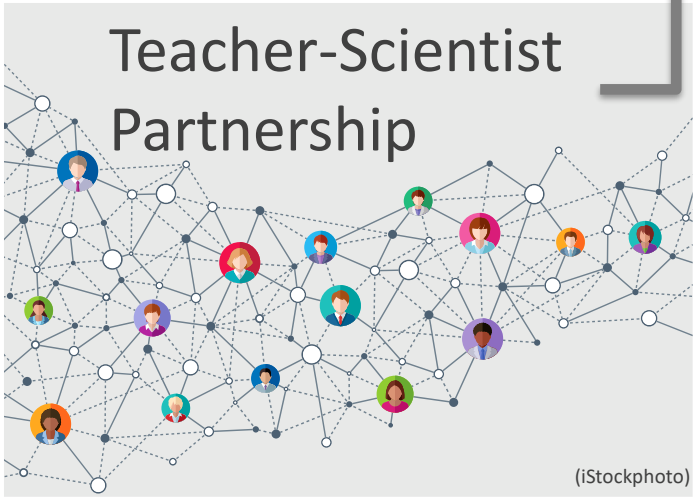
Our approach

Integrate STEM literacy and career awareness



Do something real and meaningful from the perspective of a career role!

Collaborative co-design team



BioScann Curricula
and Technology

bioScann
Navigating Biosciences Careers and Networks

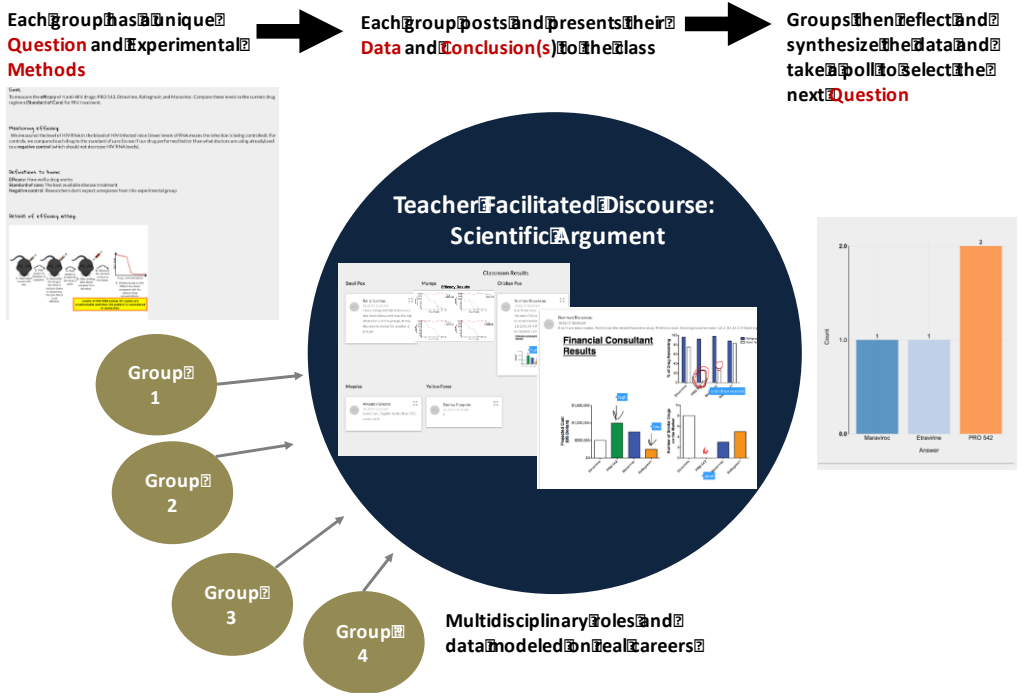
Technology enhanced multi-role interrupted case studies (ICS)

Context - Students work together to design a new drug to combat HIV.

Roles - Students are each given a distinct role as a member of a drug discovery team.

Instructional approach - Interrupted case study

- Team based problem solving
- Deliberation / collaborations
- Data analysis (skill)
- Communication



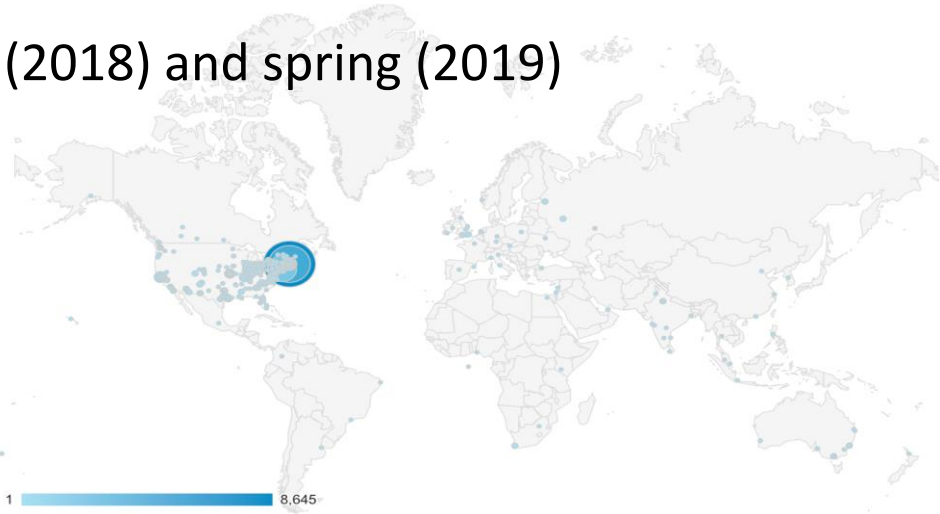
Teacher training and dissemination

- New teacher training summer 2018
  - Boston and Maine (40 students and teachers)

- Mentored support and pilots fall (2018) and spring (2019) (250-500 students)

- Open access to our

teacher network (2019+)



Outline

- Brief overview of project goals

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  - **Synergies**

- **Lessons learned and challenges**

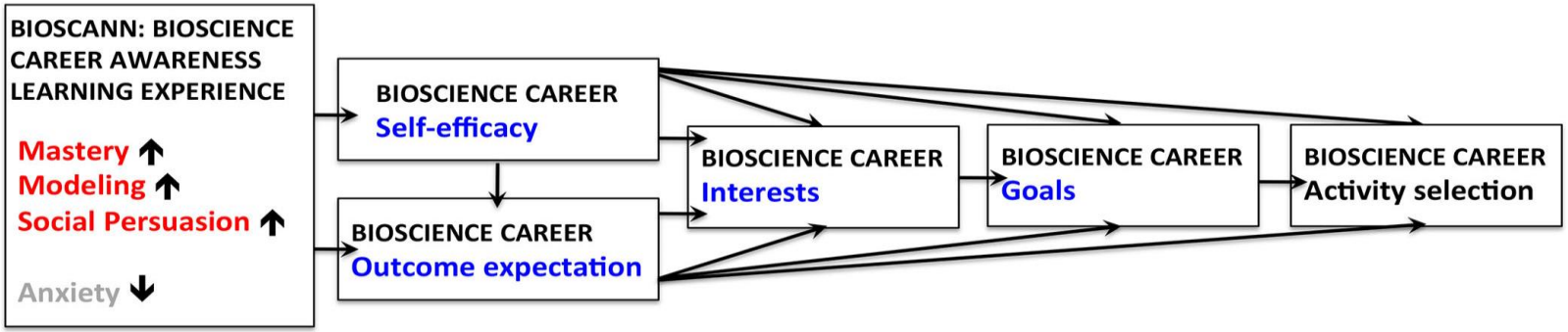
Does integrating STEM literacy and career awareness via multi-role ICS:

1. Capture student interest

2. Build career awareness

3. Build critical skills and student perceptions

Social Cognitive Career Theory (SCCT): A framework for building and measuring STEM career selection



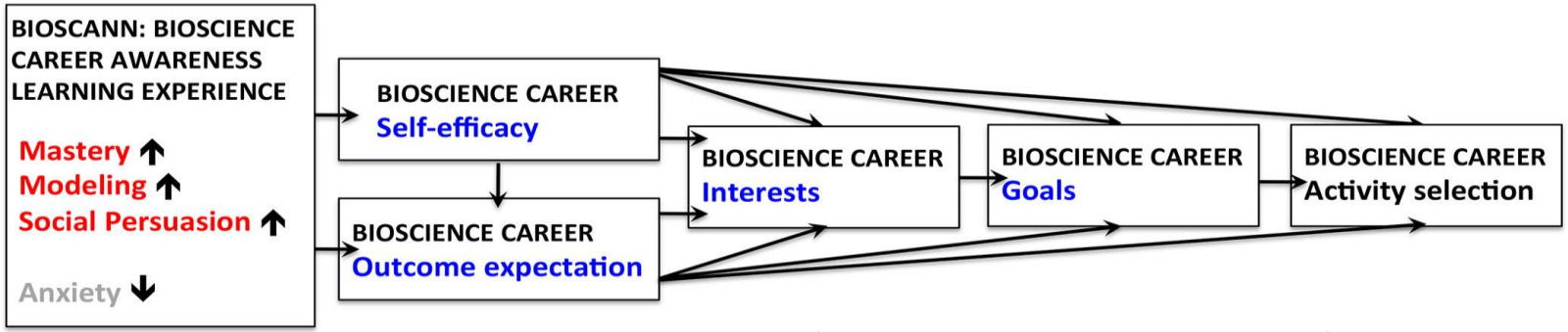
Social Cognitive Career Theory (SCCT) as a framework for building and measuring STEM career selection: *This model is adapted from Lent et al., 2013.*

Social Cognitive Career Theory (SCCT): A framework for building and measuring STEM career selection

Does student mastery of scientific content and practices increase?
Data Analysis and data based decision making

Does BioScann foster student Career Awareness, Self Efficacy, Outcome Expectations, Interests, and Career Goals?

What are the relationships between the factors?



Does BioScann and accompanying supports and trainings prepare teachers to for implementation?

Does the training promote positive mindsets towards perceived student capacity to pursue STEM careers?

Social Cognitive Career Theory (SCCT) as a framework for building and measuring STEM career selection: *This model is adapted from Lent et al., 2013.*

Evaluation

"The program evaluation will help monitor the alignment between the research activities and the implementation plan to insure evolving outcomes are captured, analyzed and necessary modifications are made to best meet the project goals."

- The primary questions:
  - To what extent are the research questions being answered?
  - What is the value of the research questions to the field?
  - How do different teachers and classrooms respond?
  - What is the sustainability, depth and quality of the program implementation?

- From a research perspective - evaluator provides:
  - Independent and unbiased perspectives on findings, data collection, analysis, interpretation, and instrument development through regular feedback
  - Collect data complementary to the research effort with a focus on teacher response.

Research and evaluation synergies:

Research Questions	*Researchers*	*Evaluator*
Student Level		
Does BioSCANN promote student mastery of scientific content and practices? Data Analysis, data based decision making	• Mastery of Content Test • Qualitative analysis of student work	
Does BioScann foster student Career Awareness, Self Efficacy, Outcome Expectations, Interests, and Career Goals?	• SCCT Survey • Qualitative analysis of student work	• Classroom observations • Student interviews • SCCT Survey psychometrics
What are the relationships between Mastery, Career Awareness, Self Efficacy, Outcome Expectations, Interests, and Career Goals?	• Mastery of Content Test • SCCT Survey	
Teacher Level		
Does BioScann and accompanying supports and trainings prepare teachers to for implementation?		• Qualitative analysis of co-design, training and classroom observations • Teacher interviews • Teacher SCCT Survey
Does the training promote positive mindsets towards perceived student capacity to pursue STEM careers.		• Teacher interviews • Teacher SCCT Survey

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- **Lessons learned and challenges**

Lessons learned and challenges

- Relationship with evaluator is critical!
- Aligned and complimentary tasks/goals are needed.
  - Highly structured but also allowing flexibility based on observation.
- Meeting research goals while allowing for modifications / iterations can be a challenge.
  - Example: pilots revealed need for increased adaptability of teacher strand.

CodeQueens!

AKA

"INSPIRING COMMITMENT FOR STEM CAREER PATH THROUGH EXTENDED WOMEN'S HACKATHONS"

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After School Program That Is More Than Interest, Awareness & Skills

Computer Science Identity
"I belong here?"
"Computer Scientists are Like me?"

Self Efficacy
"I can do this!"

Goals and Values
"A career in computer science allow me to reach my goals?

The Path To Sustained Commitment To CS

Research And Evaluation Approach

Evaluation

Establishment of intervention infrastructure

Integration and sustainability

Participant and stakeholder perspectives

Improving the intervention

Research

Individuals' change across time

Foster and sustain computer science self-efficacy, identity?

Align perceptions of computer science with goals and values?

Increase participants' commitment to a computing career path?

Data That Converges And Complements

Empirical data to test hypotheses of program effect on students

Longitudinal data gathered at critical points

- During implementation
- Beyond the program

Gain deeper insight into the survey results

Exploration of critical stakeholder perspectives

Surfacing of potentially unexpected impacts – good or bad

Formative feedback to project PI regarding progress towards outcomes

Research & Evaluation Methodology

Evaluation

- High school site observations
- Mid-year focus group with the undergraduate CS mentors
- Mid-year interviews with the high school teachers
- End-of-year focus group with high school teachers
- Focus group with industry Showcase judges

Research

- Longitudinal research design
- Pre – Mid – Post program
- Beyond program
- Explicit and implicit measures of identity
- Comparison group of non-program students to come

Successes: Insightful Results

Very high response rate to data collection

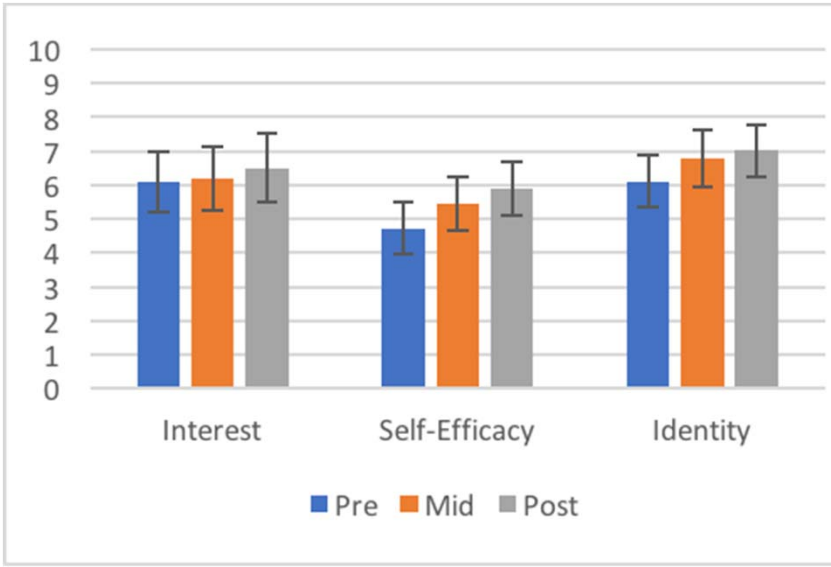
Baseline interest in coding and coding experience was very low

Learned about each high school's unique cultural context

Discovered the individualized recruitment strategies used by teachers

Realized the mentors were expecting too much of themselves

Engaged in an internal conversation about competition



Challenges: Revealed and Explored

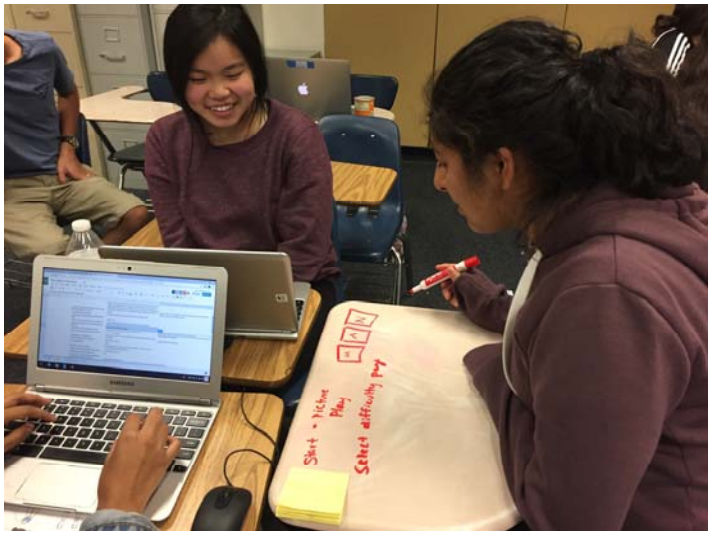
Longitudinal data collection and program implementation hindered by inconsistent attendance by participants'

- Research data identified the problem
- Evaluation data explored the causes of the problem and informed culturally appropriate solutions

Showcase event not well attended by participants' family and friends

- Research data on identity informed personalized invitations
- Evaluation explored the efficacy of the approach

Questions?



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EXTRA SLIDES FOLLOW THIS

Research

Data was collected 3 times

1. Before the 10-week program (Feb. 11, 2017)
2. At the mid point (March 28, 2018)
3. After the club ended (May 15 - May 25)

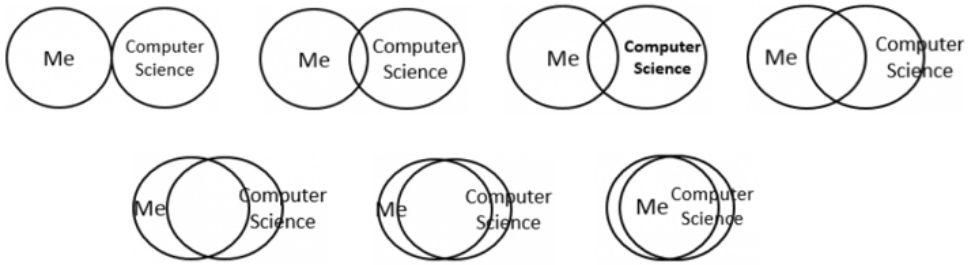
WELCOME!

CSUSM Extended Hackathon Codequeens Study

This is one of three very important surveys the Code Queens will complete this year. We are checking in to see how things are going and changing for you during the year.

California State University SAN MARCOS

Please indicate which **ONE** picture below best describes your relationship with computer science.



On a scale of 0 to 10, how interested are you in **being a computer scientist someday?**

Not at all interested 0	1	2	3	4	5	6	7	8	9	Very interested 10
○	○	○	○	○	○	○	○	○	○	○

On a scale of 0 to 10, how **good do you think you are at coding?**

Not good at all 0	1	2	3	4	5	6	7	8	9	Excellent 10
○	○	○	○	○	○	○	○	○	○	○

On a scale of 0 to 10, how much do you think that a **computer scientist is someone like you?**

Not at all 0	1	2	3	4	5	6	7	8	9	Completely 10
○	○	○	○	○	○	○	○	○	○	○