CADRE Meeting, June 2, 2016

Longitudinal studies of teacher development in elementary mathematics and science

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Model of Research-based Education (MORE) for Teachers

PIs: Dan Hanley, Matt Miller, Chris Ohana
Research Associates: Joe Brobst,
Phil Buly, Susan Kagel, Tammy Tasker

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Project ATOMS:
Accomplished Elementary Teachers of Mathematics & Science

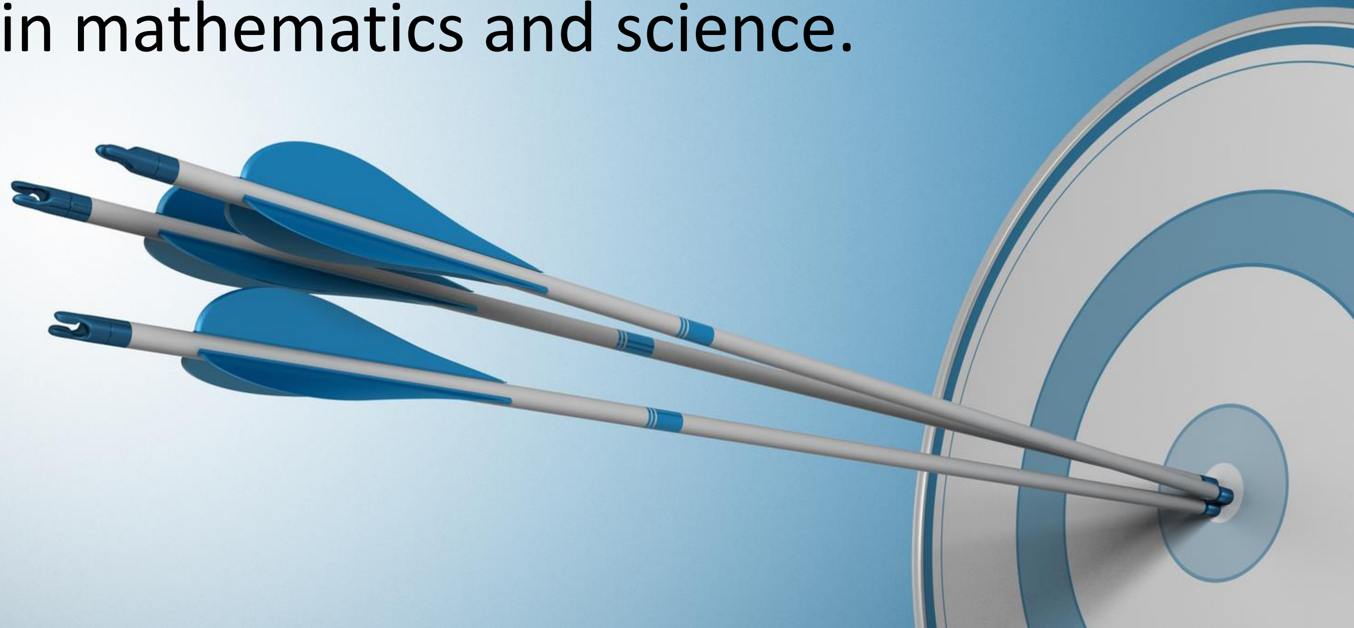
Supported by the
National Science Foundation,
DRK-12 Grant No. 1118894

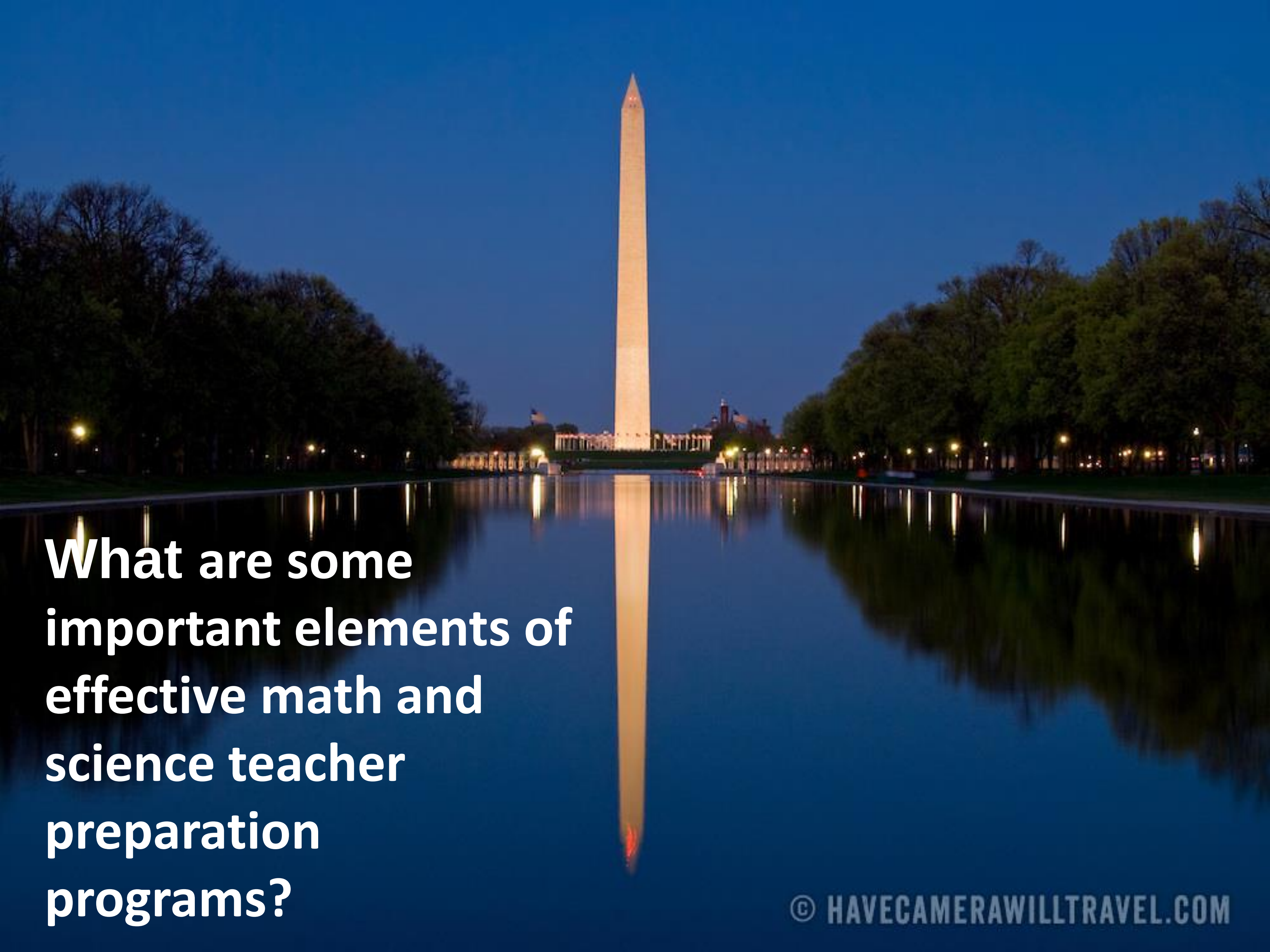
PI: Temple Walkowiak
Co-PIs: Sarah Carrier, Ellen McIntyre, Steve Porter, Margareta Thomson, Jayne Fleener
Senior Researchers: James Minogue, Andrew McEachin, Michael Maher

Goals for this Session

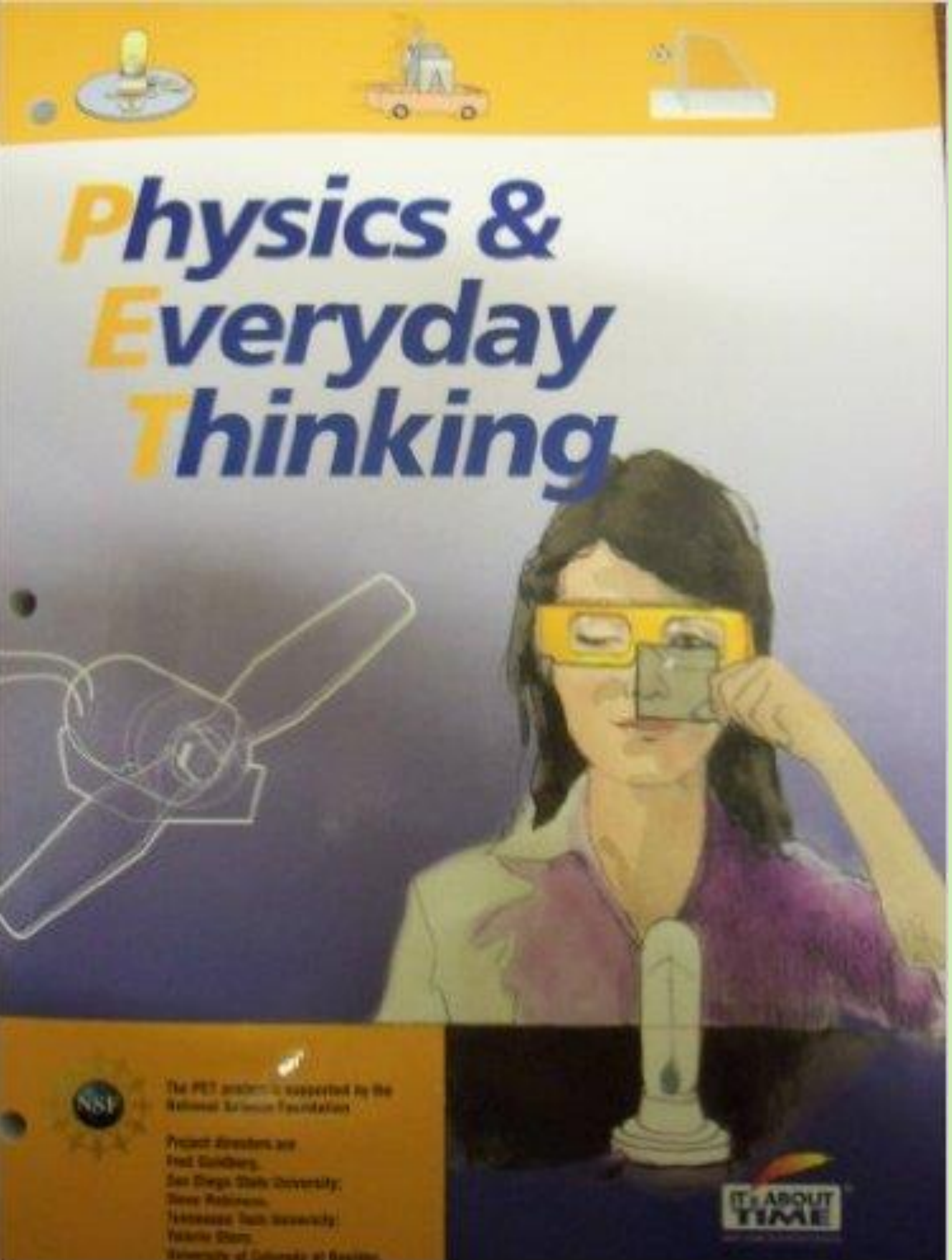
Participants will:

- learn about the two projects' research designs, frameworks, instruments, analyses, and key findings, and
- engage in discussions about elementary teacher preparation in mathematics and science.





What are some important elements of effective math and science teacher preparation programs?



Study 1: Impacts of new science content course for elementary PSTs (SCED 20X: Physics and Everyday Thinking).

- Initial ideas
- Investigations
- Using evidence to make claims
- Sense-making

Study 3: Comparison of a learning-theory and a hands-on activity focus elementary science methods and practicum sequence

Bellingham

- Methods course (SCED 480) is a ten week course before internship
- Practicum course (SCED 490) places 2-3 students in B'ham classroom before internship for a quarter
- **Learning-theory focus**

TEOP

- 480 is a ten week course during their internship
- 490 currently during last quarter of internship and taught individually in their internship classroom
- **Hands-on activity focus**

STUDIES 1, 2 & 3

	Treatment Groups	SCED 480 – Elem Sci Methods	SCED 490 – Elem Sci Practicum	Internship
Study 1 **Science Course**	Taken 20X No 20X	Pre-survey Pre/post lesson critique	Study 2 (Mentoring) Post-survey Observation	
Study 3 **Methods/ Practicum**	Bellingham TEOP	Pre-survey Pre/post lesson critique	Post-survey	Observation

TBEST SURVEY (HRI, 2013)

- Learning Theory (LT)

  Lessons should elicit students' initial ideas, have students use evidence to evaluate claims and support conclusions, connect to related concepts, etc.

- Confirmatory Science (CS)

  Students should be told the outcome before an activity, which should serve to reinforce the intended outcome or concept.

- Hands on (HO)

  Students should do hands-on activities even if the activities don't provide relevant data, have students reflect on what they are learning, or are closely related to the intended science concept being examined.

LESSON CRITIQUE

PSTs rate the quality of a vignette of a 5th grade science lesson

- Hands-on
- High student engagement

- Lack of student learning

HRI AIM OBSERVATION PROTOCOL

Effective Science Instruction: What does research tell us

(Banilower et al., 2010)

- Accurate, developmentally appropriate **Content**,
- **Initial ideas** about the targeted idea,
- **Examples/phenomena** about the targeted idea,
- **Evidence** to draw conclusions and make claims,
- **Sense-making**: Students make sense of the targeted idea in light of their initial ideas, evidence about the phenomena, and other science ideas that they already know, and
- **Classroom culture** centered on students' collegial relationships, sharing of ideas, and taking intellectual risks.


FINDINGS
Study 1

- Do 20X students have more **sophisticated beliefs about Effective Science Instruction** than non-20X students at the start of the elementary science methods and practicum sequence?

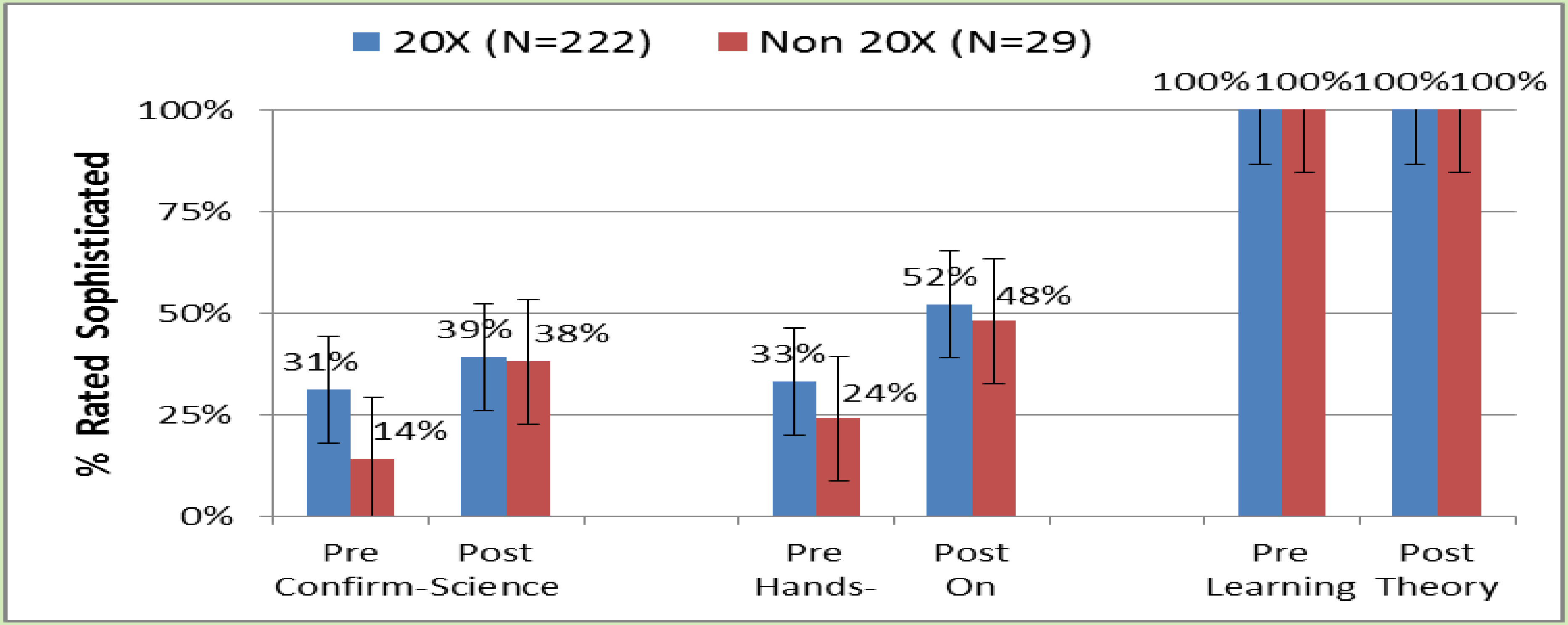
Yes for Confirmatory Science

Somewhat for Hands on

- Does the 20X course **“prime” students for learning, such that they have greater increases in the sophistication of their beliefs about Effective Science Instruction** over methods/practicum sequence than non-20X students?

No.

PRE and POST SURVEY

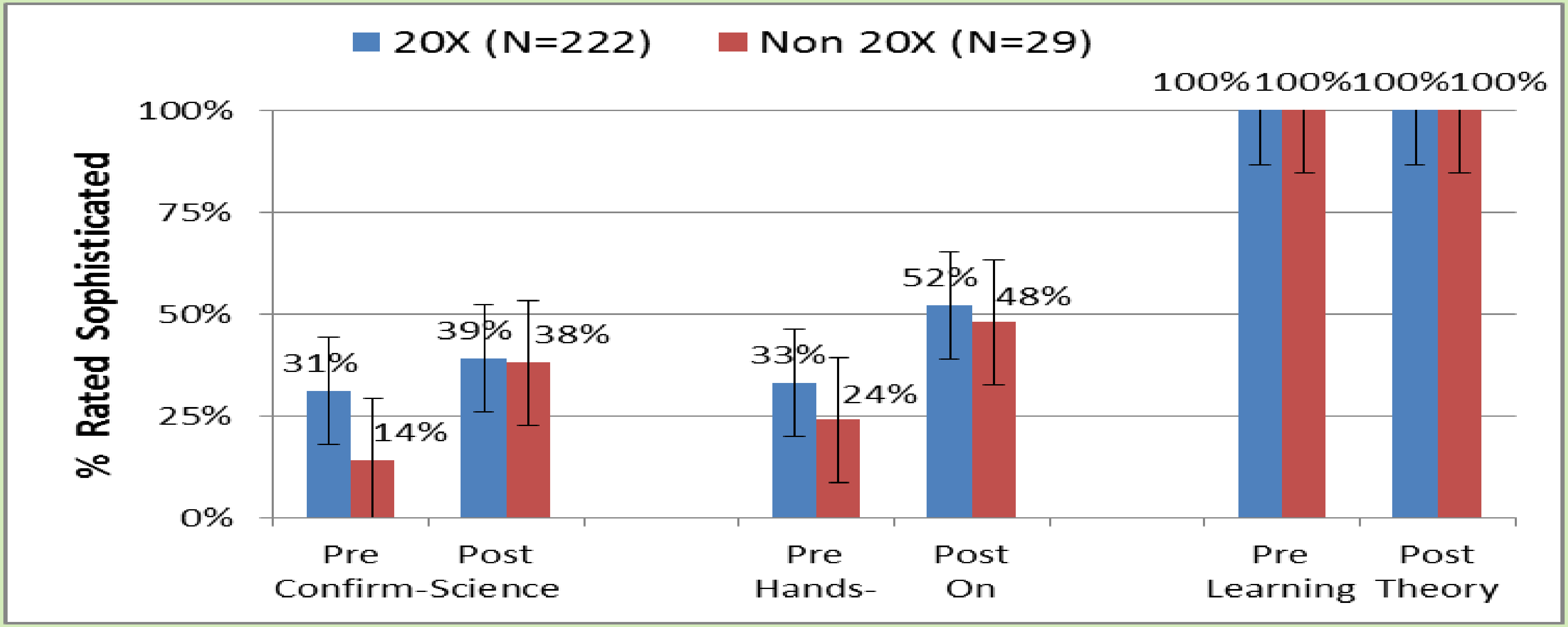


Confirmatory Science

Final estimation of fixed effects
(with robust standard errors)

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	3.158537	0.142092	22.229	310	0.000
YES_20X, G01	0.316331	0.149673	2.113	310	0.035
GPANO20X, G02	0.323874	0.165216	1.960	310	0.051
For POST slope, B1					
INTRCPT2, G10	0.454980	0.131834	3.451	264	0.001
YES_20X, G11	-0.371636	0.143935	-2.582	264	0.010
MENTEE, G12	0.197842	0.099591	1.987	264	0.048
GPANO20X, G13	0.106389	0.183924	0.578	264	0.563

PRE and POST SURVEY



Final estimation of fixed effects
(with robust standard errors)

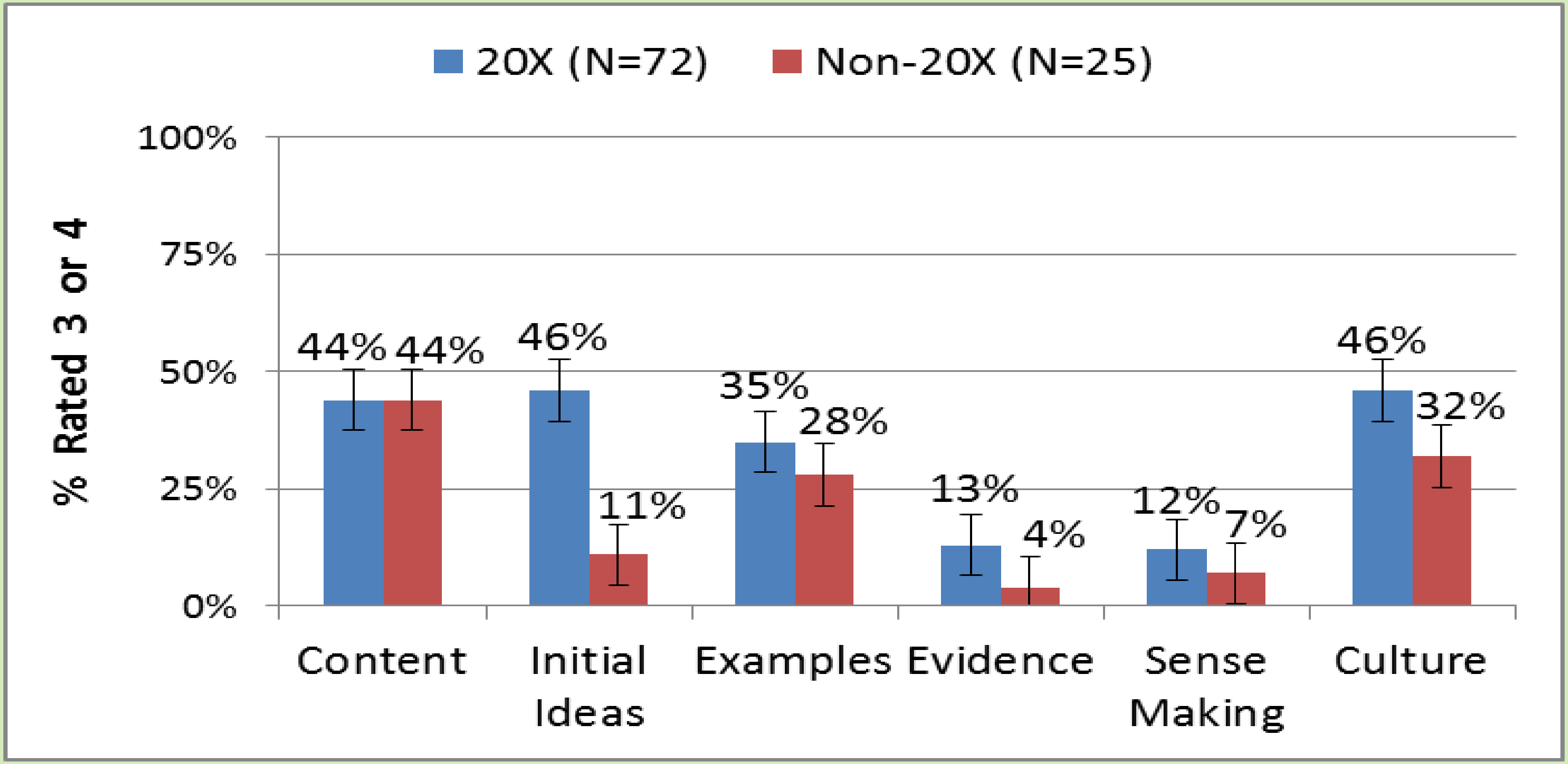
Hands-on

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	3.091178	0.182280	16.958	310	0.000
YES_20X, G01	0.308252	0.195060	1.580	310	0.115
GPANO20X, G02	0.604242	0.231054	2.615	310	0.009
For POST slope, B1					
INTRCPT2, G10	0.489187	0.230172	2.125	259	0.035
YES_20X, G11	-0.195052	0.253369	-0.770	259	0.442
MENTEE, G12	0.328555	0.160654	2.045	259	0.042
GPANO20X, G13	0.072998	0.283231	0.258	259	0.797

- Do 20X students **teach higher quality science lessons during their practicum** than non-20X students?

Yes.

490 CLASSROOM OBSERVATIONS



Linear Regression model, controlling for GPA and mentee status
Significant difference for:

- Initial Ideas, p value=. 036, effect size = .28
- Evidence, p value = .011, effect size = .26

FINDINGS

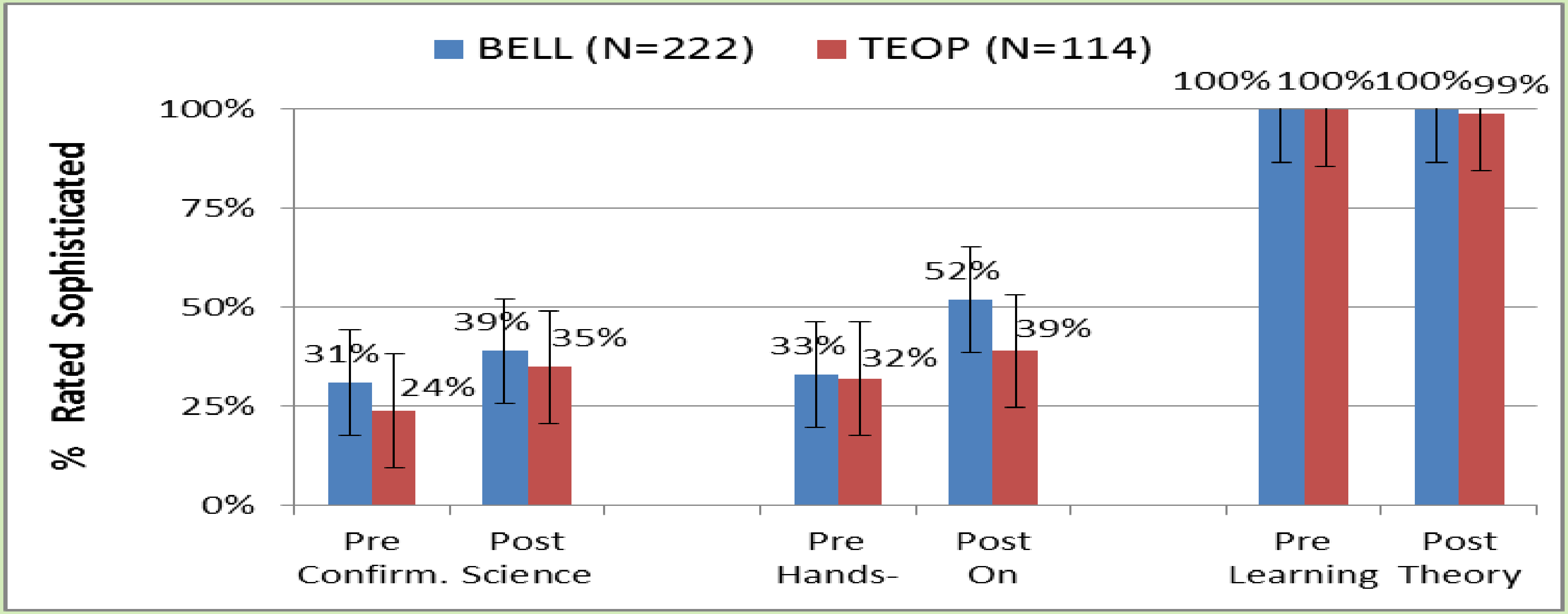
Study 3

- Do PSTs in a science methods/practicum sequence with a Learning-theory focus versus a Hands-on activity focus have ***greater gains in the sophistication of their beliefs about Effective Science Instruction***?

No for Confirmatory Science factor.

Yes for Hands On factor.

PRE and POST SURVEY

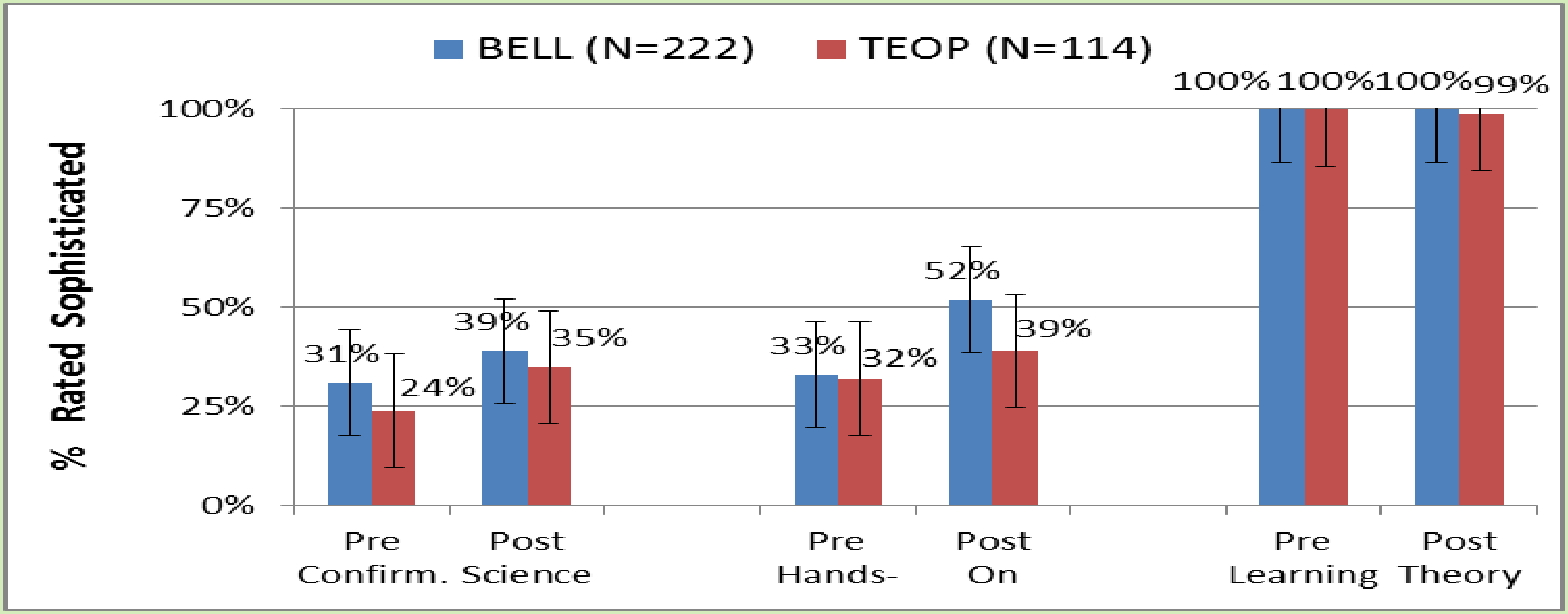


Final estimation of fixed effects
(with robust standard errors)

Confirmatory Science

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	3.356681	0.064548	52.003	445	0.000
BELL, G01	0.102921	0.081223	1.267	445	0.206
GPA_SCI, G02	0.152278	0.074679	2.039	445	0.042
For POST slope, B1					
INTRCPT2, G10	0.353376	0.078766	4.486	353	0.000
BELL, G11	-0.271069	0.105186	-2.577	353	0.010
MENTEE, G12	0.166195	0.105351	1.578	353	0.116
GPA_SCI, G13	0.092398	0.083853	1.102	353	0.271

PRE and POST SURVEY



Final estimation of fixed effects
(with robust standard errors)

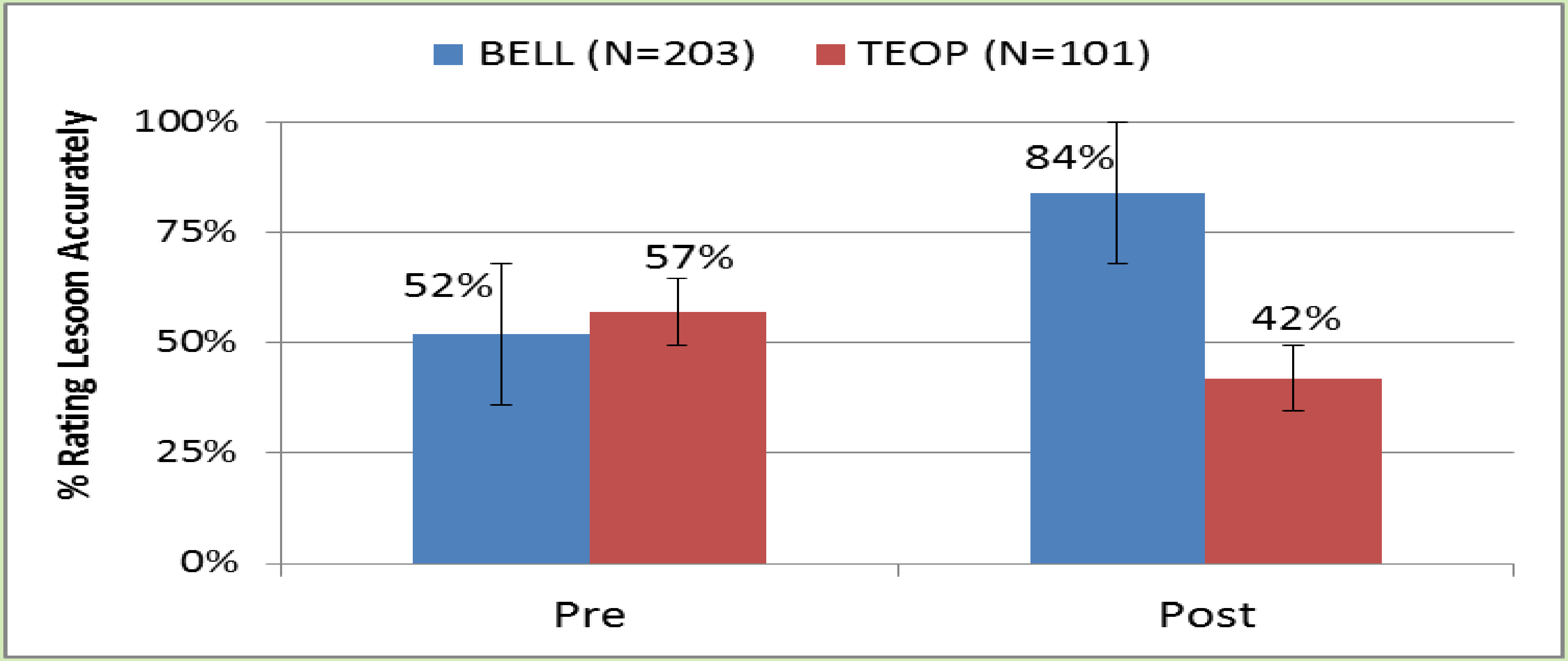
Hands-on

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	3.475221	0.087090	39.904	445	0.000
BELL, G01	-0.100888	0.112052	-0.900	445	0.368
GPA_SCI, G02	0.261064	0.103002	2.535	445	0.012
For POST slope, B1					
INTRCPT2, G10	0.025635	0.105718	0.242	347	0.809
BELL, G11	0.281784	0.148804	1.894	347	0.059
MENTEE, G12	0.276742	0.164602	1.681	347	0.094
GPA_SCI, G13	0.011575	0.134762	0.086	347	0.932

- Do PSTs in a science methods/practicum sequence with a Learning-theory focus versus a Hands-on activity focus have ***greater gains in their ability to recognize important elements of Effective Science Instruction in a lesson***?

Yes.

LESSON CRITIQUE



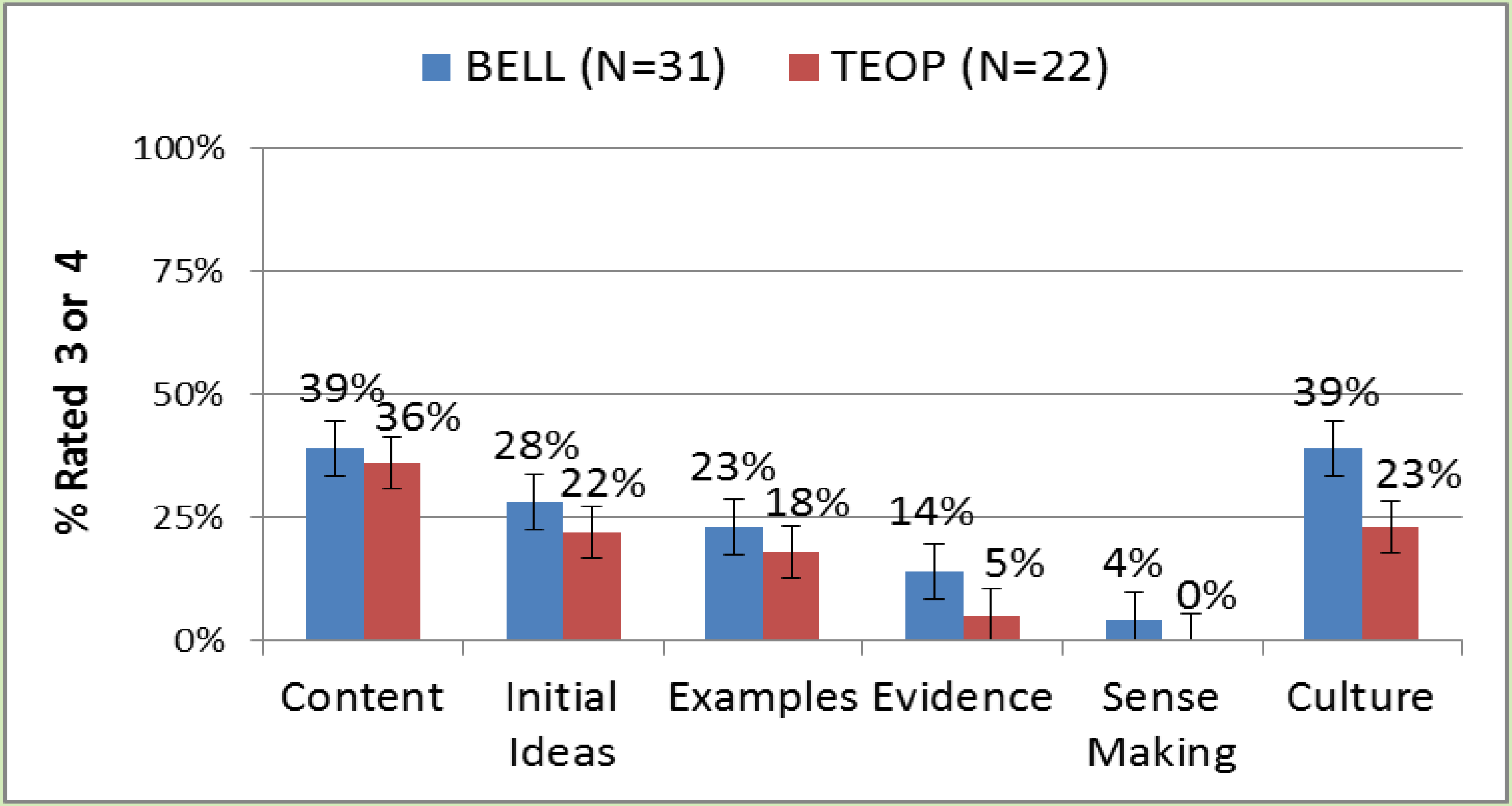
Final estimation of fixed effects
(with robust standard errors)

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0					
INTRCPT2, G00	1.378730	0.085074	16.206	339	0.000
BELL, G01	0.058969	0.102712	0.574	339	0.566
GPA_SCI, G02	-0.186738	0.085696	-2.179	339	0.030
For POST slope, B1					
INTRCPT2, G10	0.265994	0.091561	2.905	302	0.004
BELL, G11	-0.805173	0.112741	-7.142	302	0.000
GPA_SCI, G12	-0.102772	0.096613	-1.064	302	0.288

- Do PSTs in a science methods/practicum sequence with a Learning-theory focus versus a Hands-on activity focus ***teach higher quality science lessons during their internship***?

Trend is Yes, but not statistically significant.

INTERN CLASSROOM OBSERVATIONS



Linear Regression model, controlling for GPA and mentee status
No significant differences

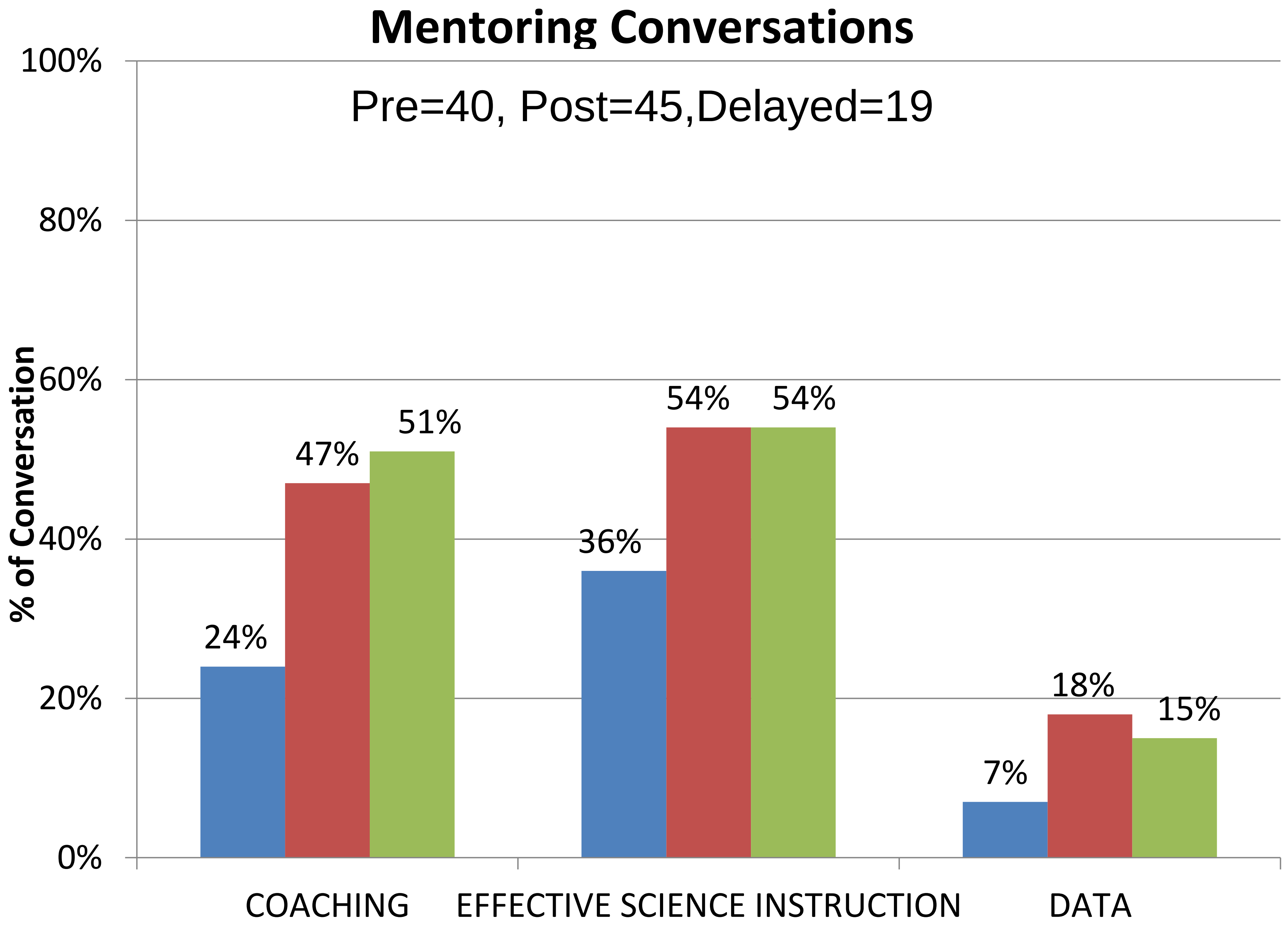
Study 2: Impacts of Mentoring on PSTs

WHAT TO TALK ABOUT

Effective Science Instruction (Banilower et al, 2010)

- Elements of ESI
- Shift from teacher-focused to student-focused
- Data as a Third Point


HOW TO TALK ABOUT IT
Coaching
Consulting
Flexibility in
Stance



Mentoring Conversations
Pre=40, Post=45,Delayed=19
% of Conversation
100%
80%
60%
40%
20%
0%
24%
47%
51%
36%
54%
54%
7%
18%
15%
COACHING
EFFECTIVE SCIENCE INSTRUCTION
DATA

Study 2: Impacts of high-quality mentoring

Initial mentoring conversations focused on classroom management from a consulting stance.

Subsequent mentoring conversations focused on student learning from a coaching stance.

Understanding of effective science instruction

Beliefs that mentoring improved their ability to collect observation data

IMPACTS ON MENTORS

Elementary science practicum students who were mentored (n=73) showed statistically greater gains in their understanding of ESI than their non-mentored peers (n=177).
Stat sig at $p=.019$ using a two-level HLM

Study 4: Newly inducted elementary science teachers' beliefs and practices

Conclusions

- Taking a science content course grounded in learning-theory develops elementary PSTs' beliefs about effective science instruction and their ability to incorporate these beliefs into their initial science teaching.
- Taking a methods/practicum sequence grounded in learning theory develops elementary PSTs' ability to understand and recognize the difference between hands-on and minds-on science lessons.
- Short mentoring conversations can significantly impact PSTs' beliefs about effective science instruction if they: 1) Focus on student thinking/learning, and 2) Model important, reflective questions.

Implications

- More intentional about making connections between PSTs’ science content courses and their methods/practicum courses to help develop their identity as a teacher of science, while they are in the role of a learner of science.
- In their science methods/practicum sequence, we want to draw on their experiences as a learner of science from the PET course to help them develop their skills and identity as a teacher of science.
- Develop systems to prepare teachers to mentor PSTs, and to place PSTs with trained mentors.

MORE FOR TEACHERS

Questions or Comments?

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NC STATE UNIVERSITY

Project ATOMS: Accomplished Elementary Teachers Of Mathematics and Science

Temple A. Walkowiak

CADRE NSF DRK-12 PI Meeting

Washington, DC

June 2, 2016

Goals

- Outline briefly the features of NC State University's STEM-focused elementary teacher preparation program

- Describe the research project → questions, design, measures, findings, and implications

Goals

Program Features

Research Project

Research Questions

Design

Measures & Data Collection

Findings

Next Steps & Implications

Contact Info & Acknowledgements: NC State Elementary Program

- Paola Sztajn, Professor and Department Head
- James Minogue, Director of Undergraduate Programs
- Ann Harrington, Program Coordinator
- Sarah Carrier, Valerie Faulkner, Joanna Koch, Beth Sondel, Jill Grifenhagen, Angela Wiseman, Laura Bottomley

- Temple Walkowiak, Assistant Professor

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Goals

Program Features

Research Project

Research Questions

Design

Measures & Data Collection

Findings

Next Steps & Implications

Contact Info & Acknowledgements: Research Project

- **Temple Walkowiak, Principal Investigator**
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- Co-PIs: Ellen McIntyre, **Sarah Carrier**, Steve Porter, Jayne Fleener, Margareta Pop Thomson
- Senior Researchers: **James Minogue**, Andrew McEachin, Michael Maher
- GRAs (current and former): Beth Adams, Carrie Lee, Ashley Whitehead, Daniell DiFrancesca
- Project Manager: Rebecca Lowe
- Study Coordinator: Terri Frasca

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Goals

Program Features

Research Project

Research Questions

Design

Measures & Data Collection

Findings

Next Steps & Implications

Program Features

- Approximately 50-60 graduates per year
- Two years of general studies courses followed by two years of program courses and field experiences (professional studies)
- Approximately 833 contact hours in K-5 field placements (approximately 15 partner schools)
- Cross-cutting course components → 7 Essential Teaching Practices & Routines (e.g., attend to equity, align tasks with learning goals)

Goals

Program Features

Research Project

Research Questions

Design

Measures & Data Collection

Findings

Next Steps & Implications

Program Features: General Studies
(Freshman and Sophomore Years)

- A minimum of 27 credit hours (9 courses) of STEM content
  - 4 mathematics content courses that includes Calculus for Elementary Teachers (two-semester, 6-credit course)
  - 4 science content courses that includes Conceptual Physics for Elementary Teachers
  - 1 engineering design course (e.g., Design Thinking, Materials in Engineering)
- Four education/child-focused courses
  - Intro to Education
  - Child Development
  - Educational Psychology
  - Intro to Elementary Education (15 hours in K-5 classroom)

Goals
Program Features
Research Project
Research Questions
Design
Measures & Data Collection
Findings
Next Steps & Implications

Program Features: Professional Studies (Junior Year)

Fall Semester	Spring Semester
Mathematics Methods (K-2)	Mathematics Methods (3-5)
Science Methods (K-2)	Science Methods (3-5)
Engineering Methods (K-5)	Assessment
Reading Methods (K-2)	Reading Methods (3-5)
Classroom Management Seminar	Diversity Seminar
Field Placement in K-2 classroom (86 contact hours → 3 hours per week plus two full-time weeks)	Field Placement in 3-5 classroom (86 contact hours → 3 hours per week plus two full-time weeks)

Program Features: Professional Studies (Senior Year)

Fall Semester	Spring Semester
Arts in Elementary School	
Special Education	
Language Arts Methods	
Social Studies Methods	
Instructional Design Seminar (K-5)	

Yearlong Field Placement in K-5 classroom

FALL: 121 contact hours → 3 hours per week plus three full-time weeks
SPRING: Student Teaching = 525 contact hours

Project ATOMS

Project ATOMS: **A**ccomplished Elementary **T**eachers **O**f **M**athematics and **S**cience

5-year grant project funded by NSF

Goals

Program Features

Research Project

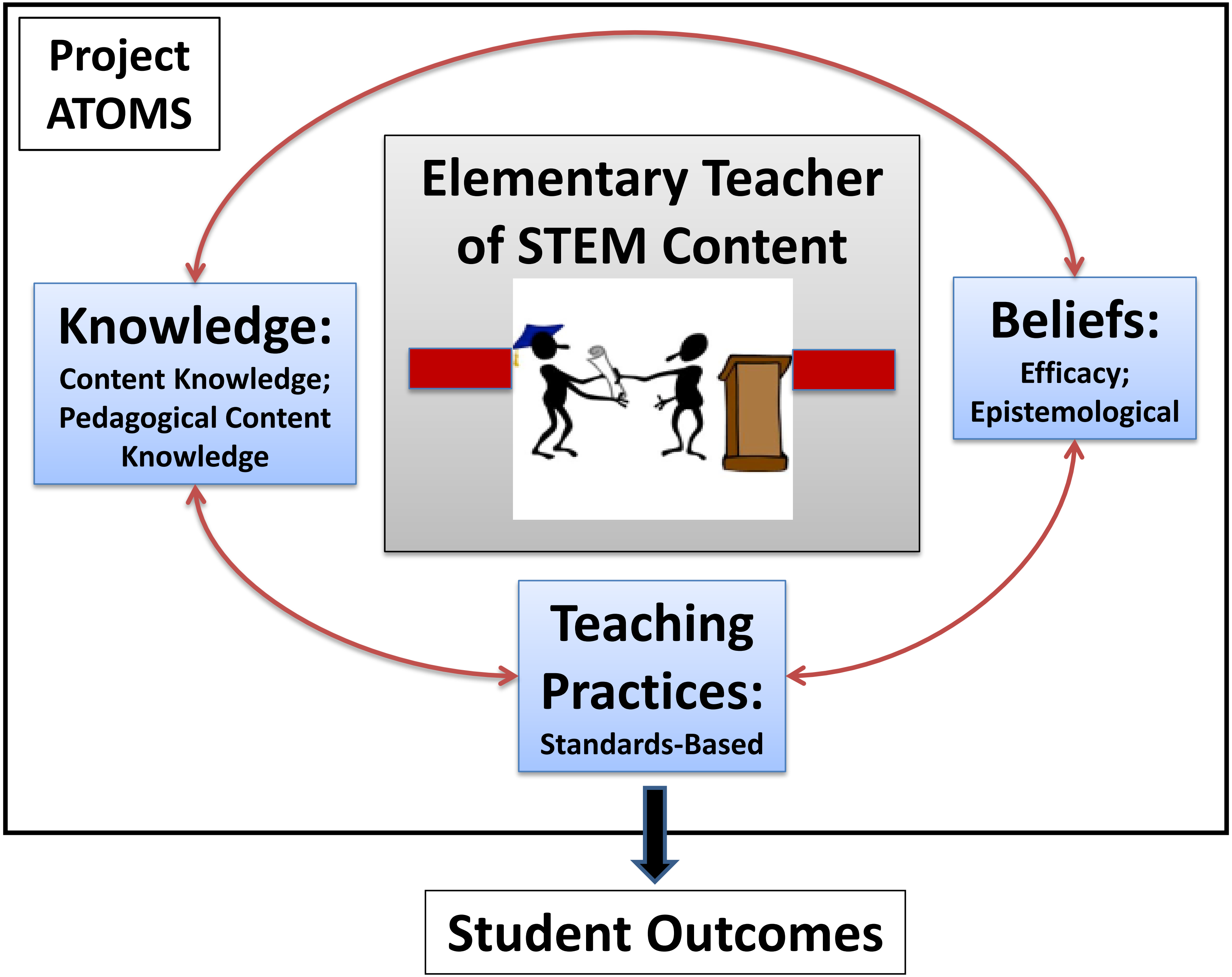
Research Questions

Design

Measures & Data Collection

Findings

Next Steps & Implications


Project ATOMS
Elementary Teacher of STEM Content
Knowledge:
Content Knowledge; Pedagogical Content Knowledge
Beliefs:
Efficacy; Epistemological
Teaching Practices:
Standards-Based
Student Outcomes

Research Questions

- DEVELOPMENTAL study component:
  - How do pre-service teachers develop in the dimensions of mathematics and science content knowledge, pedagogical content knowledge, teaching practices, and beliefs (i.e., self-efficacy and epistemological) through the ATOMS program and into their first two years of teaching?
- COMPARATIVE study component:
  - How do ATOMS teachers compare to non-ATOMS teachers on knowledge, beliefs, and instructional practices after one and two years of teaching?
  - After matching on demographic and school characteristics, how does student achievement in classrooms served by ATOMS beginning teachers compare to student achievement in classrooms served by other beginning teachers?

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Design:
Developmental Study Component

	Study Year 1	Study Year 2	Study Year 3	Study Year 4	Study Year 5
G-Cohort	1st Year	2nd Year			
S-Cohort n=59	Senior	1st Year	2nd Year		
J-Cohort n=56	Junior	Senior	1st Year	2nd Year	
P-Cohort n=56	Sophomore	Junior	Senior	1st Year	2nd Year
F-Cohort n=56	Freshman	Sophomore	Junior	Senior	1st Year

Total n = 227

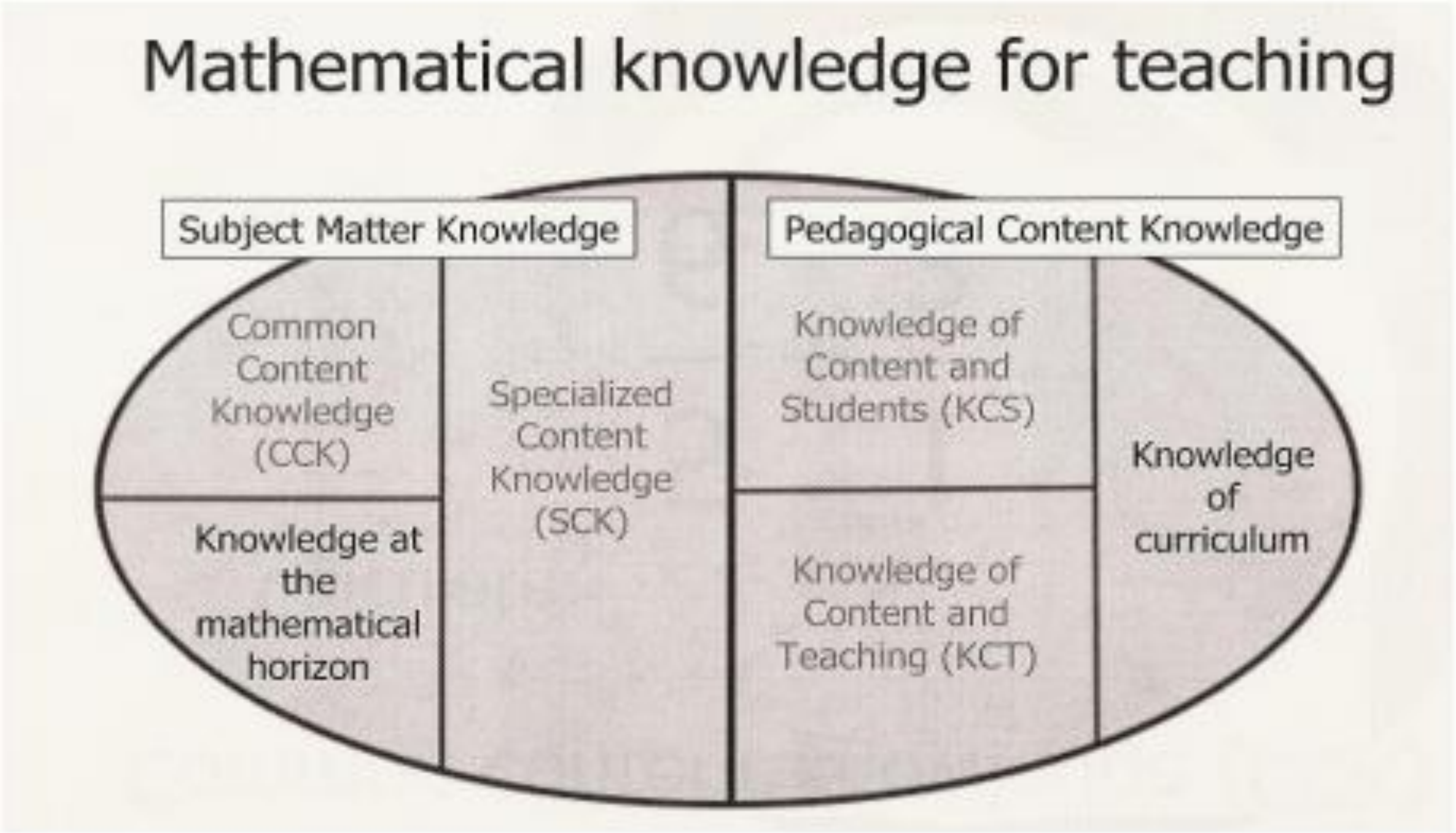
Yellow → 19 Case Studies

Measures & Data Collection: Developmental Component

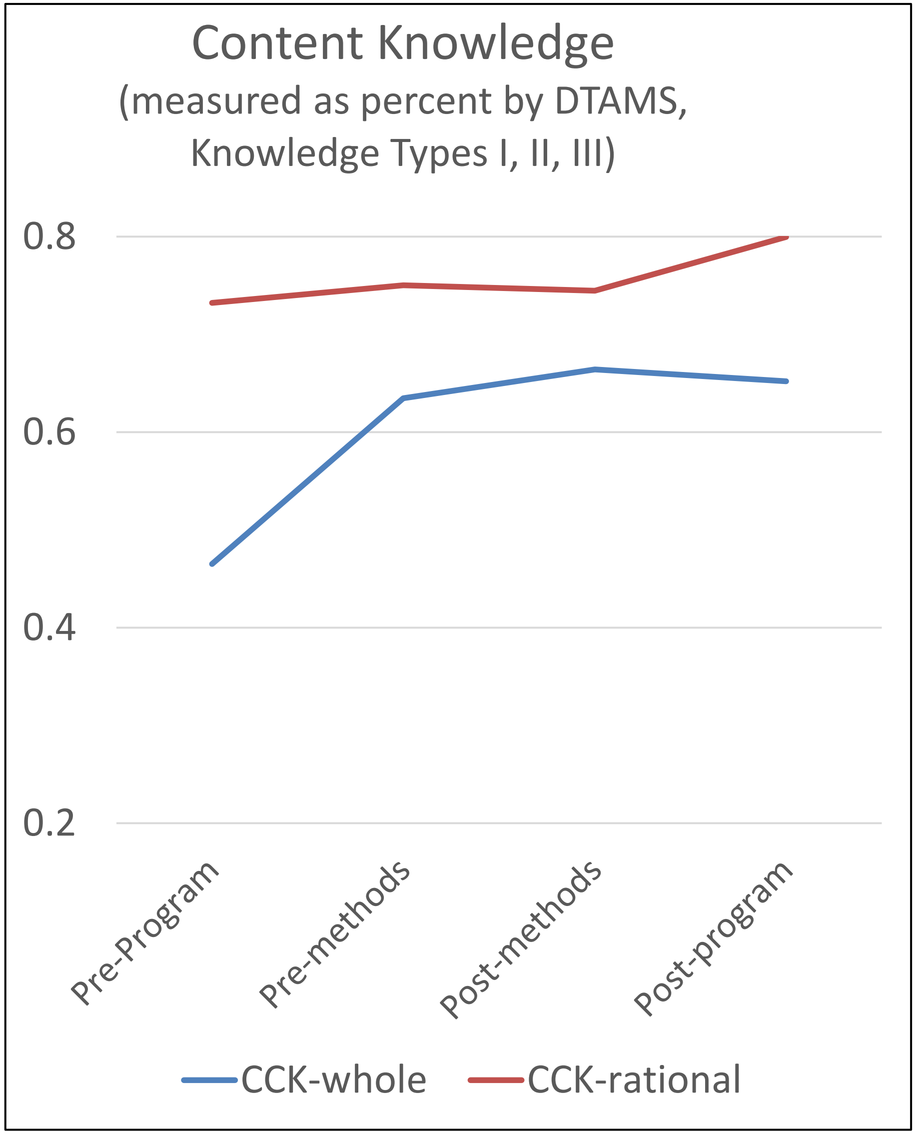
- Knowledge
  - DTAMS → Whole Numbers, Rational Numbers, Life Sciences, Physical Sciences (CRiMSTeD, 2008)
  - LMT-MKT → Number and Operations (LMT, 2004)
- Beliefs
  - MECS → Mathematics Experiences and Conceptions (Jong, Hodges, & Welder, 2012)
  - MTEBI → Efficacy (Enochs, Smith, & Huinker, 2000)
  - TBEST → Effective Science Instruction (Horizon Research, 2014)
- Case Studies
  - 22 Interviews and 12 video-recorded lessons
    - Junior Year: 7 interviews (4 focused on lessons/course projects)
    - Senior Year: 6 interviews (3 focused on implemented lessons)
    - First Year of Teaching: 9 interviews (6 focused on implemented lessons)

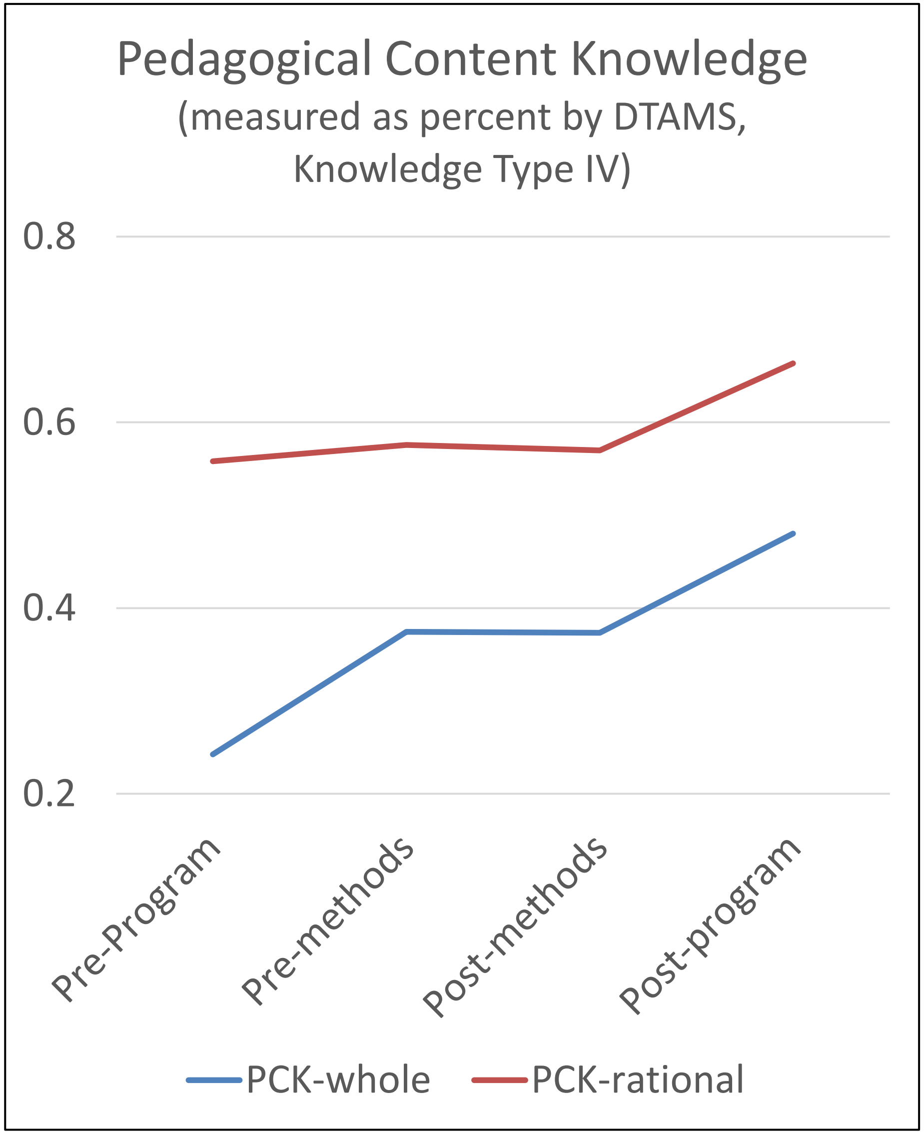
Theoretical Underpinnings: Knowledge, Mathematics

(Ball, Thames, & Phelps, 2008)

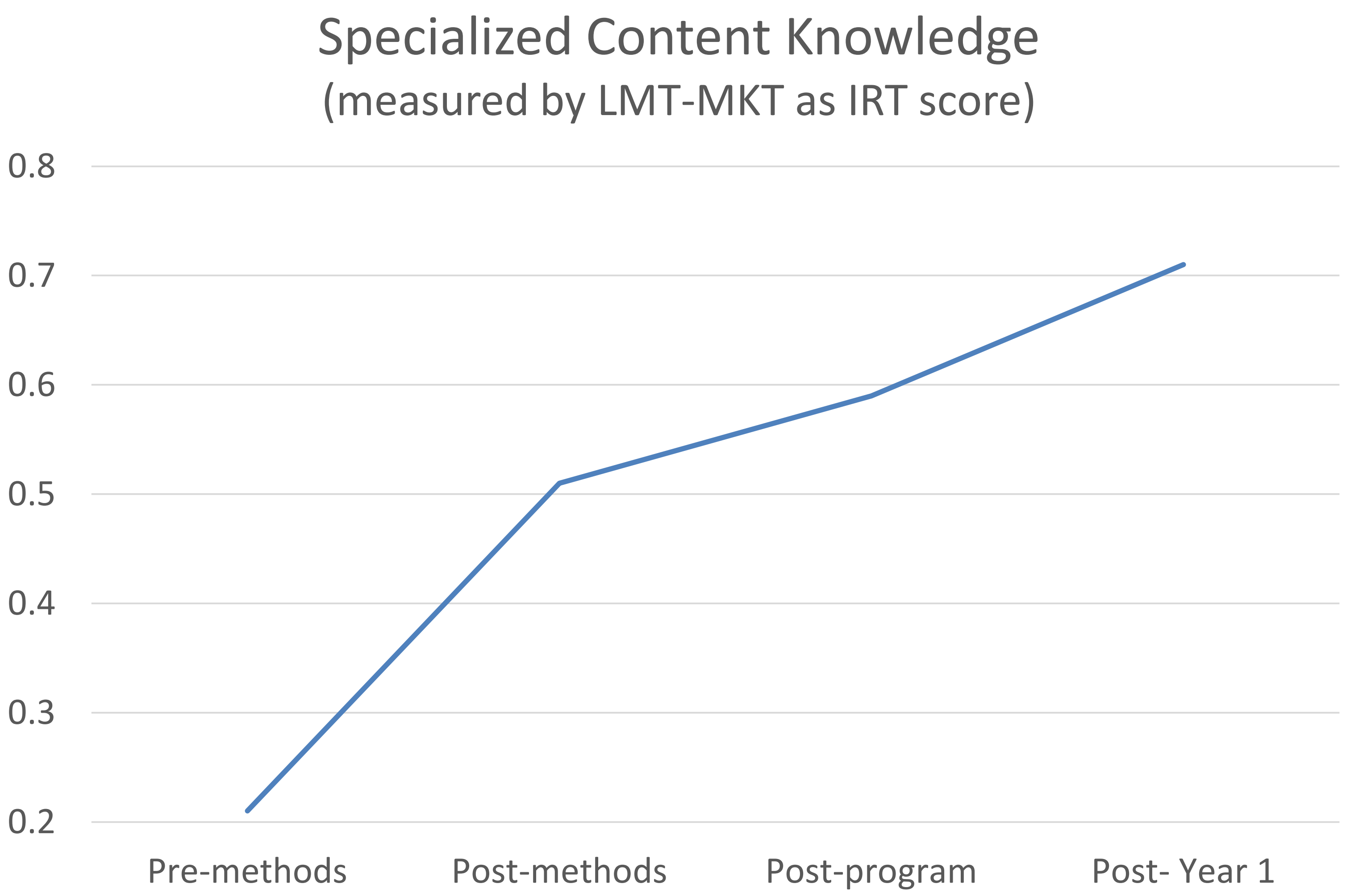


Findings, Developmental Study: Knowledge, Mathematics





Findings, Developmental Study: Knowledge, Mathematics



Goals

Program Features

Research Project

Research Questions

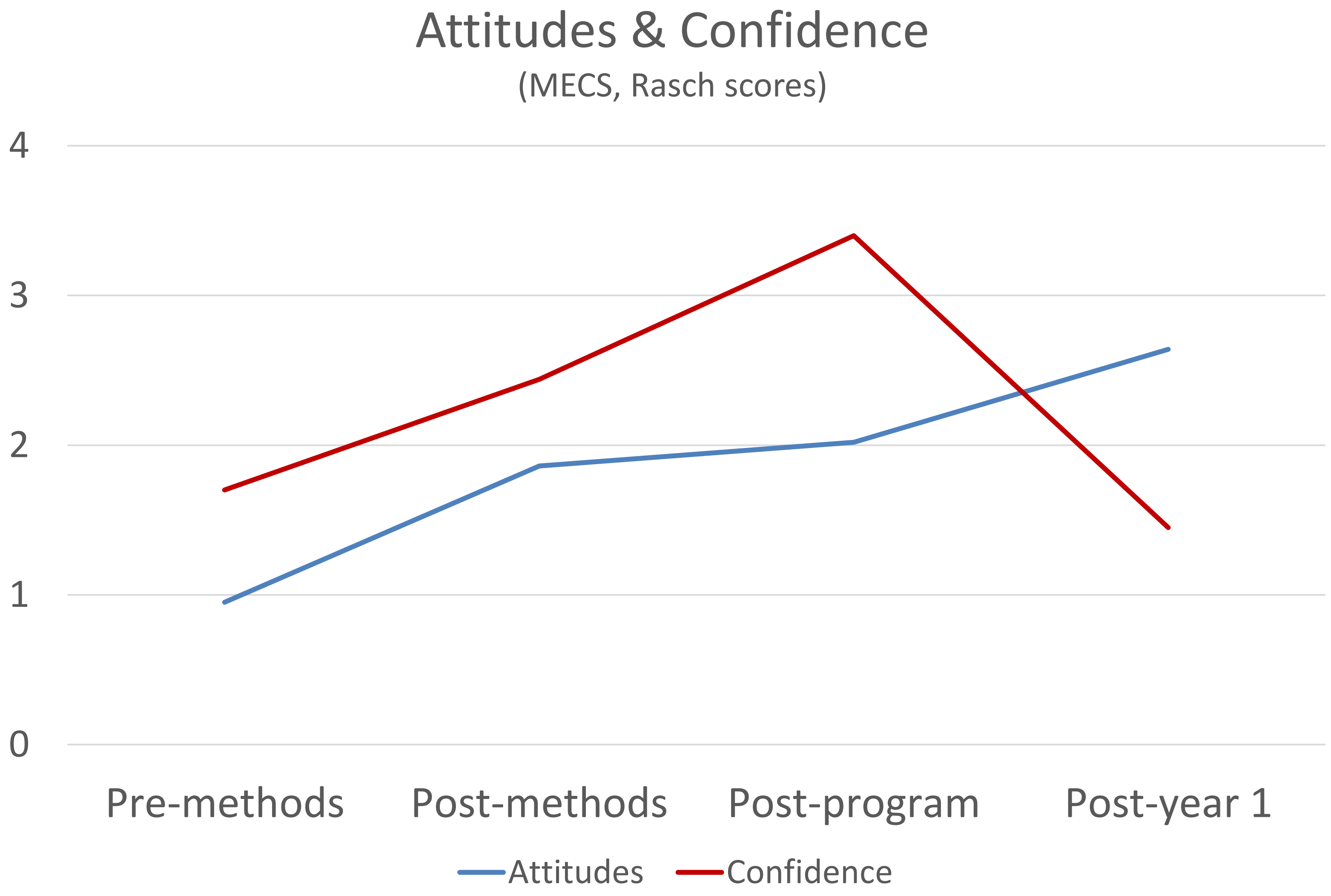
Design

Measures & Data Collection

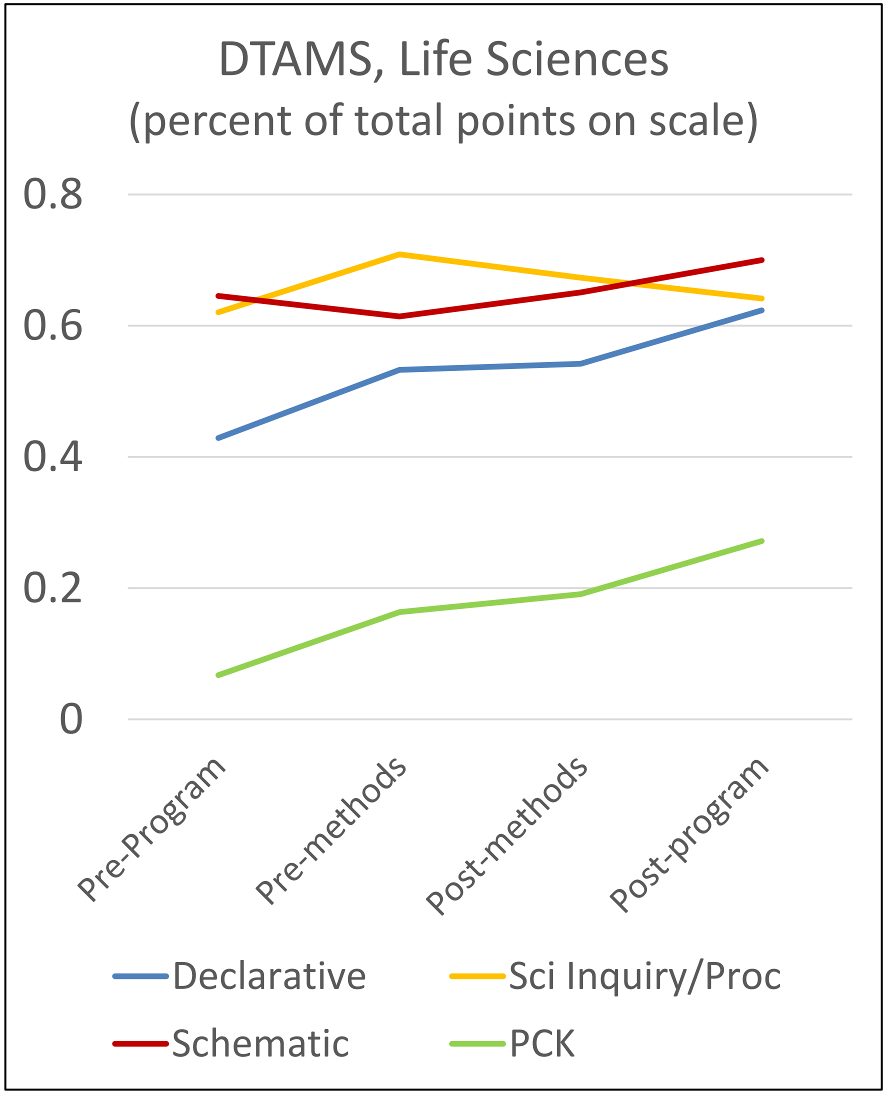
Findings

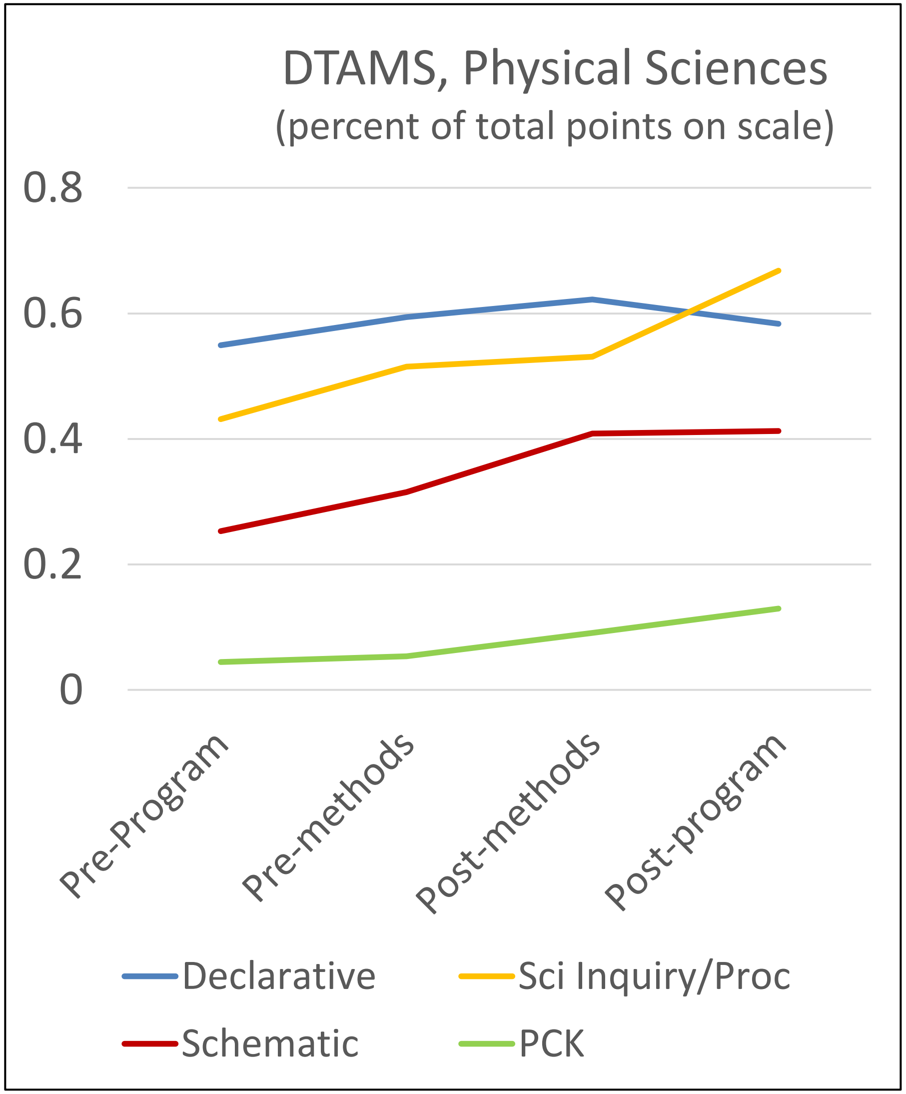
Next Steps & Implications

Findings, Developmental Study:
Attitudes & Confidence, Mathematics (MECS)



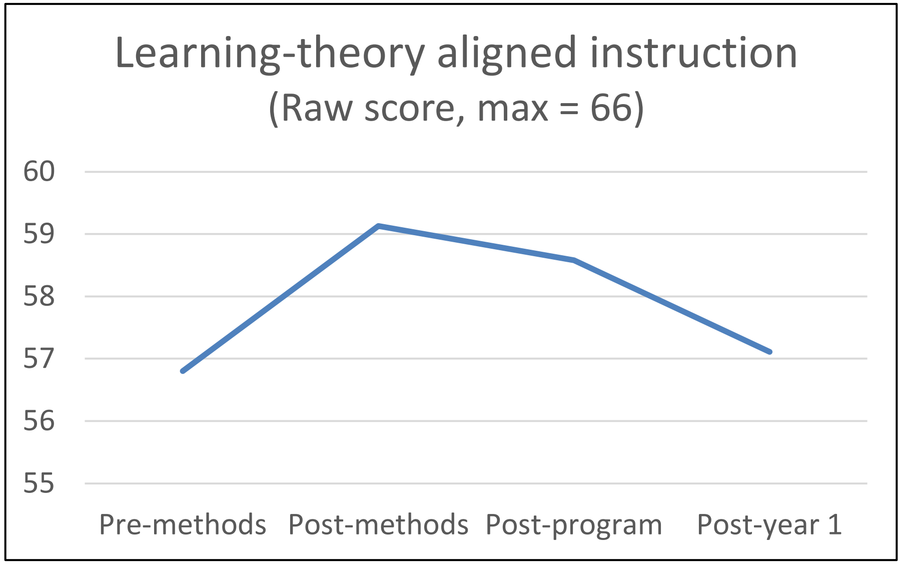
Findings, Developmental Study: Knowledge, Science

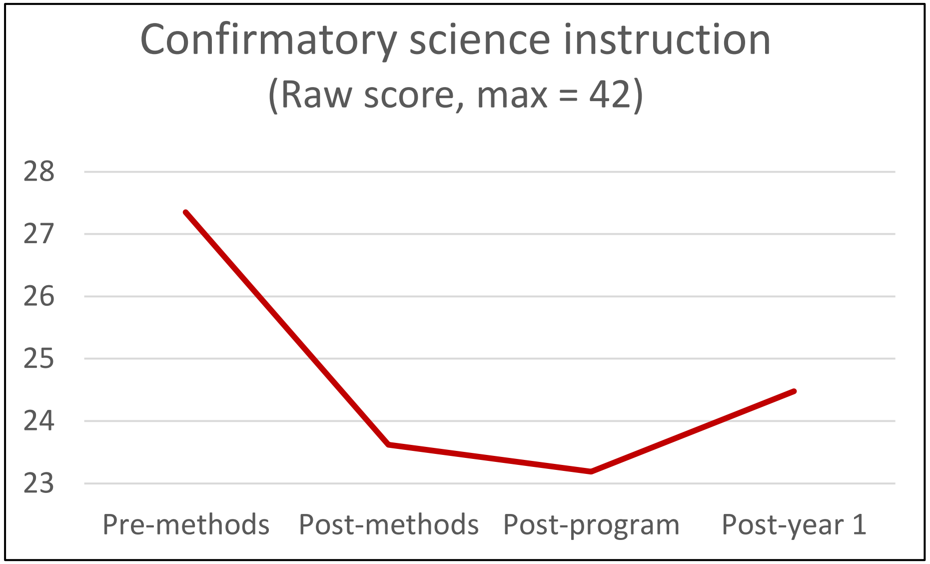


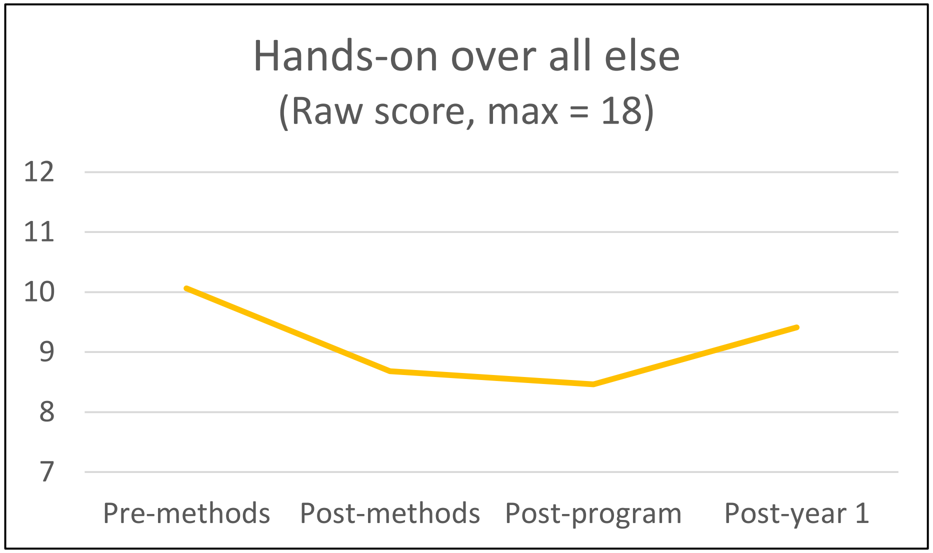


NC STATE UNIVERSITY

Findings, Developmental Study:
Beliefs about Effective Science Instruction (TBEST)







Findings, Developmental Study: Visions of Mathematics Instruction

(Walkowiak, Lee, & Whitehead, in process)

- Visions of Instruction (Munter, 2014; Hammerness, 2001)
- 18 participants
  - Describe effective elementary math lesson.
  - What should the teacher be doing during math instruction? What should the students be doing?
- VHQMI Rubric (Visions of High-Quality Mathematics Instruction; Munter, 2014)
- Pre-Methods (PRE-M), Post-Methods (POST-M), and End of Program (EOP)
- 12 of 18 participants' visions shifted to be more standards-based, but 14 participants remained same or declined in vision from POST-M to EOP.

Findings, Developmental Study: Identities as Teachers of Science

(Carrier, Whitehead, Walkowiak, Luginbuhl, & Thomson, under review)

- In-depth examination of three purposefully selected cases (based upon past experiences in science)
- Teacher preparation program influenced their identities as teachers of science.
- However, past experiences and school contextual factors played a key role in the development of their identities and how they implemented what they had learned in teacher preparation program.

Research Questions

- DEVELOPMENTAL study component:
  - How do pre-service teachers develop in the dimensions of mathematics and science content knowledge, pedagogical content knowledge, teaching practices, and beliefs (i.e., self-efficacy and epistemological) through the ATOMS program and into their first two years of teaching?

- **COMPARATIVE study component:**
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Design:
Comparative Study Component

	Study Year 1	Study Year 2	Study Year 3	Study Year 4	Study Year 5
G-Cohort	1st Year	2nd Year			
S-Cohort N=59	Senior	1st Year	2nd Year		
J-Cohort n=56	Junior	Senior	1st Year	2nd Year	
P-Cohort n=56	Sophomore	Junior	Senior	1st Year	2nd Year
F-Cohort n=56	Freshman	Sophomore	Junior	Senior	1st Year

Measures & Data Collection:

- Knowledge
  - LMT-MKT → Number and Operations (LMT, 2004)
  - AIM → Ecosystems; Matter (Horizon Research, 2013)
- Beliefs
  - MECS → Mathematics Experiences and Conceptions (Jong, Hodges, & Welder, 2012)
  - MTEBI → Efficacy (Enochs, Smith, & Huinker, 2000)
  - TBEST → Effective Science Instruction (Horizon Research, 2014)
- Instructional Practices
  - Instructional Practices Log in Mathematics (IPL-M)
  - Instructional Practices Log in Science (IPL-S)
  - At least three video-recorded mathematics lessons
  - At least three video-recorded science lessonns

Findings: Comparative Study Component, Post-1st Year of teaching

	ATOMS (n = 49) Mean (SE)	Non-ATOMS (n =96) Mean (SE)	t-statistic
LMT-MKT	**.63 (.12)**	**.29 (.07)**	**2.57***
AIM Ecosystems	15.14 (.69)	15.21 (.46)	-.08
AIM Matter	16.82 (.58)	16.47 (.48)	.66
Attitudes (MECS)	2.62 (.23)	2.13 (.21)	1.50
Confidence (MECS)	1.27 (.11)	1.06 (.10)	1.31
TBEST (LT-aligned)	56.88 (.61)	56.45 (.63)	0.49
TBEST (Confirm Sci)	25.69 (.82)	25.22 (.78)	0.42
TBEST (Hands-on)	**9.53 (.40)**	**10.82 (.42)**	**2.24***
Efficacy – STOE	**1.12 (.13)**	**0.79 (.09)**	**2.12***

*$p < .05$

Results are based on two-sample mean comparison t-tests with equal variances. Results were consistent with results of t-tests with unequal variances.

Measures: IPL-M and IPL-S

Scale (IPL-M)	Cronbach's Alpha	Item Loading Range	Range of ICCs
Problem Solving	.903	.62 - .87	.22 - .41
Connections	.811	.40 - .84	.20 - .36
Procedural instruction	.843	.35 - .82	.20 - .43
Math Talk	.928	.60 - .91	.24 - .46
Use of Representations	.802	.61 - .83	.32 - .51

Scale (IPL-S)	Cronbach's Alpha	Item Loading Range	Range of ICCs
Low-level Sense-making	.756	.51 - .86	.17 - .30
High-level Sense-making	.913	.53 - .89	.17 - .28
Communication	.880	.57 - .87	.16 - .27
Basic Practices	.896	.50 - .78	.11 - .28
Integrated Practices	.925	.63 - .93	.11 - .19

Next Steps

COMPARATIVE

- Log Data
  - Compare two groups on scales
  - Instructional Profiles
- Student Outcomes
  - Compare two samples

DEVELOPMENTAL

- General Linear Models – developmental trajectories
- Qualitative Data – case study participants

Goals

Program Features

Research Project

Research Questions

Design

Measures & Data Collection

Findings

Next Steps & Implications

Implications

- Programmatic Improvement
  - General studies courses → coherence with methods courses in pedagogy, scientific/mathematical practices?
  - Field placements – structure, quality
- Field of Elementary Teacher Education in Mathematics & Science
  - Role of field placements
  - School contextual factors
    - field placements and first jobs
  - Induction/support for novice teachers
- Potential of IPL-M and IPL-S
  - Research tool
  - Professional development tool

Goals

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Research Questions

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Measures & Data Collection

Findings

Next Steps & Implications

Contact Info & Acknowledgements: Research Project

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- Project Manager: Rebecca Lowe
- Study Coordinator: Terri Frasca

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Across-Project Themes

- Math and science content courses that model effective pedagogy and provide opportunities for students to reflect on attributes of the learning environment (the facilitation, the materials, the interactions with peers, etc.) and how those contribute to, or interfere with, their learning.
- Importance of support for novice teachers (preservice and induction years) by classroom teachers who have a shared vision of effective instruction and skills to facilitate mentoring conversations focused on student learning and those elements of effective instruction.
- What is developmentally appropriate knowledge and skills for novice teachers?

In what ways did today's session reinforce, or make you think differently, about important elements of effective math and science teacher preparation programs?

What are some effective strategies for evaluating the quality and impacts of teacher preparation programs?

CADRE Meeting, June 2, 2016

Longitudinal studies of teacher development in elementary mathematics and science

Dan Hanley, Western Washington University
Temple Walkowiak, North Carolina State University