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Educating Highly-qualified Science Teachers

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Abstract for DBER Group Discussion on 2013-10-17

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Title:

Educating Highly-qualified Science Teachers

Abstract

Understanding what makes a highly-qualified science teacher requires careful research on teacher education programs. Existing research pertaining to secondary science preservice teachers (PSTs) is limited in the areas of: (a) mastery of subject matter knowledge; (b) evolving teaching self-efficacy, and (c) inquiry-based enacted curricular practices. We studied each issue over the course of an intensive, 14-month, graduate teacher certification program for practicing scientists and recent science graduates. First, we asked if there was a relationship between amount of content area undergraduate coursework and performance (GPA in core content courses) and found an expected, yet preliminary, connection between higher undergraduate GPA and fewer retained science misconceptions. Second, we surveyed pre- and post-program teaching self-efficacy beliefs in classroom management, instructional practices and student engagement; our analysis indicates a positive change over time on two of the three scales, and a reasonably large effect size. Finally, classroom inquiry-based instructional factors showed improvement as PSTs gained experience through student teaching and in their first year teaching science (fall and spring comparisons) over each 5-month period. We also present qualitative sub-studies of teacher self-efficacy and use of classroom discourse by PSTs as typical examples of issues faced by new science teachers.

Educating Highly-qualified Science Teachers

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Beth Lewis, Aaron Musson & Jia Lu

University of Nebraska-Lincoln

October 17, 2013

DBER Group



Research on Science Teacher Preparation

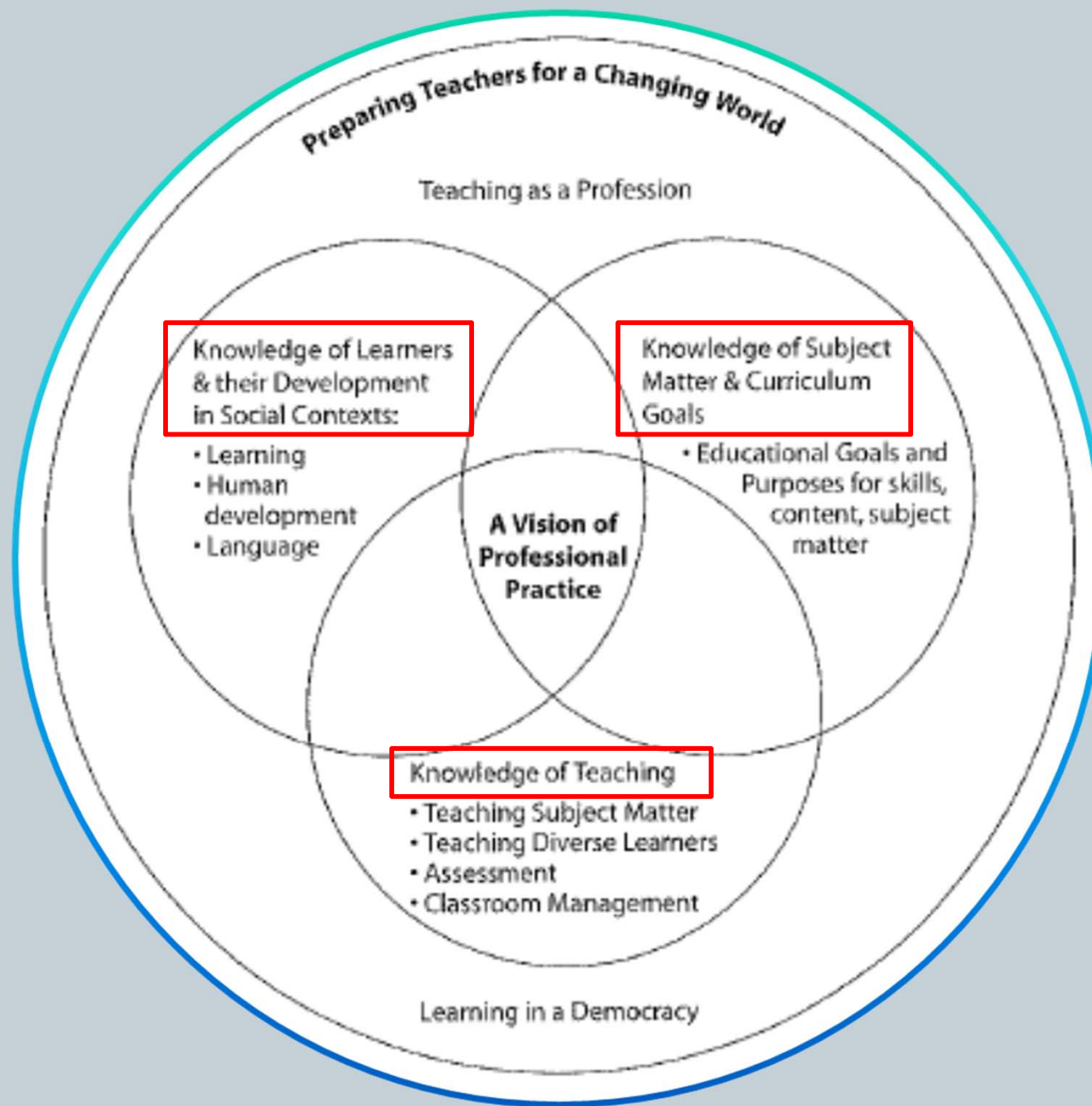
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- Research base in the United States provides little empirical evidence of what knowledge and skills science teachers need in order to be effective teachers (NRC, 2010; Cochran-Smith, 2005).
- Existing research pertaining to secondary science preservice teachers (PSTs) is limited in the areas of:
 - (a) mastery of subject matter knowledge (i.e., *how much is enough?*)
 - (b) evolving teaching self-efficacy
 - (c) curricular practices
 - (d) clinical experiences (NRC, 2010)

Teacher Preparation Framework

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- A comprehensive teacher knowledge framework has been offered (Darling-Hammond and Bransford, 2007) for educating a new generation of teachers.
- The three major intersecting areas that are important for any teacher to acquire are, knowledge of:
 1. **learners and their development in social contexts**
 2. **subject matter and curriculum goals**
 3. **teaching**



From Darling-Hammond and Bransford (2007)

Effective Teacher Preparation

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- Baker, Piburn & Clark's (2005) study of a graduate-level science teacher certification program (TEAMS) found that:
 - An analysis of 3rd year TEAMS teachers' teaching indicated that the TEAMS program had accelerated their professional growth
 - non-TEAMS teachers showed no gains
 - compared to non-TEAMS teachers, TEAMS teachers continued to grow professionally, becoming more student-centered and constructivist
- ❖ Our program at the University of Nebraska is similarly constructed and uses Darling-Hammond & Bransford's framework to educate PSTs
 - ❖ Our department designed a "cognitive map" of teacher education
 - ❖ Aligned student teaching evaluation (14 aspects of teaching)

Evolving Science Teachers' Vision

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- Academic coursework itself is an insufficient predictor of teachers' effectiveness,
- However, there are academic aspects of programs that can be adopted by science teachers (Adams & Krockover, 1997):
 - student-centered learning
 - cooperative learning
 - general pedagogical knowledge
 - PCK *

** Note: More recent consideration of the difficulties and persistent failures to measure PCK suggest that we should limit direct measurement attempts to SMK and PK only (Settleage, 2013)*

Rationale for Study

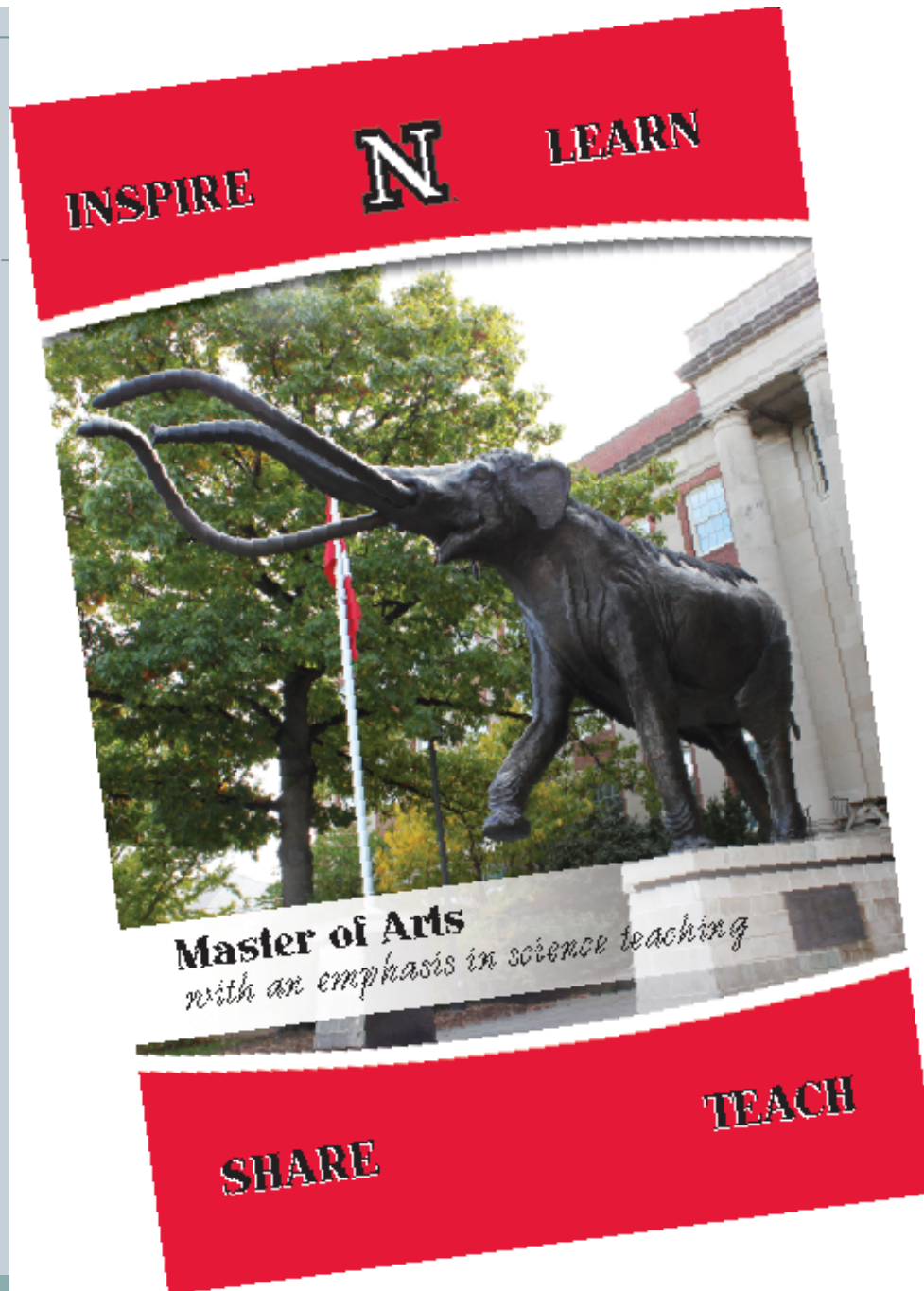
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- As researchers we are responsible for providing science teacher educators with:
 - more empirically-supported inferences
 - a clearly-defined range of effective teacher preparation approaches and strategies that can reliably produce highly-qualified science teachers
- A lack of understanding of teacher education confounds implementation of science education reform (e.g., *NGSS*) that demands a reliable supply of highly-qualified professionals.
- With carefully designed research of teacher education programs and their graduates, we can better understand the interaction between teachers' knowledge and enacted practices.

Purpose of Study

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- In our study of preservice and 1st year science teachers we focused on their evolving:
 - Adequate science content preparation and understanding of common science misconceptions
 - Teaching self-efficacy
 - Use of inquiry-based instruction
- This study is a base of a longitudinal study of our graduates as they move through their induction phase.
- Research informs iterative teacher education program design.



14-month Master of Arts with emphasis in science teaching (MAst) program

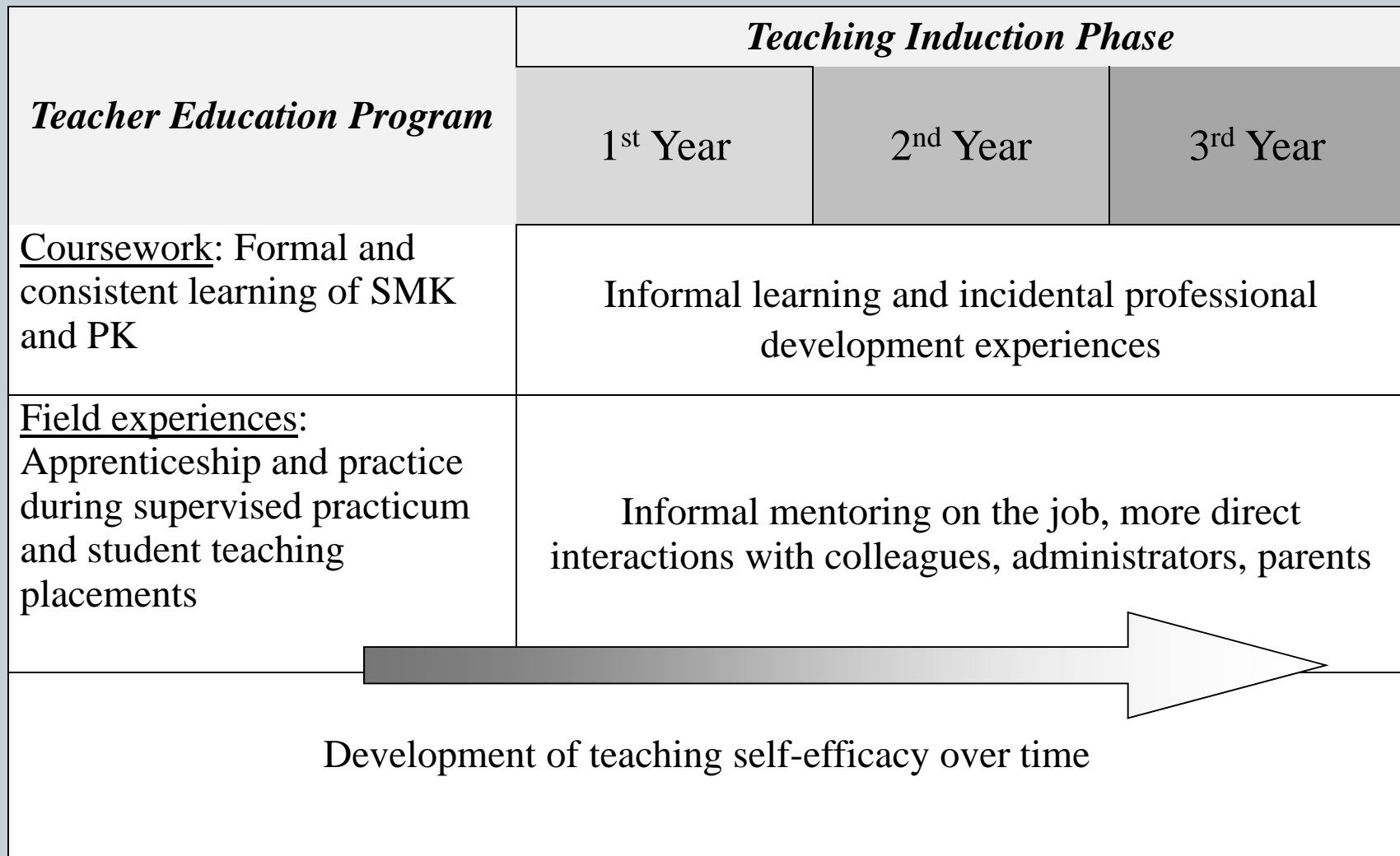
Supported by a National Science Foundation Robert Noyce Teacher Scholarship grant

Research Context: The MAst Program

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- Required teacher certification courses (e.g., students with special needs, pluralistic society, human cognition & development)
- Two science methods courses
- Supporting courses in nature of science and teaching English language learners (ELL)
- An extensive (600+ hours), three-phase teaching internship with local cooperating teachers
- Courses on types of educational research, curriculum theory
- A final teacher action research study during student teaching (MA degree capstone project)

Conceptual Research Framework



Research Participants

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Participants had been practicing scientists or recent science majors (BS) graduates before entering the MAst program.

Table 1. Overview of MAst Cohorts

Cohort	Median age (range) years	Time between degrees years	Endorsements*			
			Biology	Chem	Earth	Physics
MAst-1 (<i>n</i> =14)	27.8 (22-46)	5.3	8	4	0	3
MAst-2 (<i>n</i> =17)	24.3 (22-53)	3	16	6	1	0

** PSTs may have been eligible for multiple endorsements*

Research Questions

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1. How well do PSTs perform on a test of misconceptions (MOSART test) in their core certification areas?
2. What were the changes, if any, of the teachers' instructional practices from student teaching to 1st year teaching?

Data Sources & Methods of Analysis

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Q1: MOSART science tests (*Misconceptions-Oriented Standards-based Assessment Resources for Teachers*, Sadler, et al., 2010) were used to evaluate the PSTs' understanding of their main subject-specific content

- Administered at conclusion of program
- Measure of PSTs' content-area knowledge in endorsement areas
 - Tests aligned with national 9-12 science standards
 - A HS-level biology test was not available, middle school life science test was used (possible issue of maxing out and not capturing full range of competency).
- Results analyzed by percent correct, inspected for trends in incorrect answers.

Results: Research Question #1, Misconceptions

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- **Claim:** PSTs with more science coursework and professional work experiences scored higher on the science content tests.

Table 2. *MOSART Test Results for MAst-1*

Certification Area	Mean % (SD)	% of scores above 90%
Biology ($n = 8$)	94.5 (6.0)	75
Chemistry ($n = 4$)	89.8 (14.5)	75
Physics ($n = 2$)	92.0 (11.3)	50
All ($n= 14$)	92.8 (9.1)	71

Data Sources & Methods of Analysis

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Q2: Observations of science lessons during multiple phases.

- Used EQUIP instrument (Marshall, Smart & Horton, 2010) to code observations of teachers ($n= 62$).
- EQUIP instrument is designed to measure quality of K-12 science inquiry instruction; aligned with (U.S.) national science education standards.
- Analysis of the degree to which teachers used inquiry-based instruction, score 1 (non-inquiry) to 4 (proficient inquiry)
- Four scales with 5-6 items on each scale: (a) instruction, (b) discourse, (c) assessment, and (d) curriculum.

Results: Research Question #2, Inquiry-based Instructional Practices

Table 4. EQUIP scale scores on observations of science lessons ($n = 72$)

EQUIP Scale Factors (each item scores 1- 4 pts)	Cohort 2	Cohort 1	
	Student Teaching Spring 2013	1st Year Winter (Oct 2012- Jan 2013)	1st Year Spring (Feb - April 2013)
# of Lessons	($n= 27$)	($n= 26$)	($n= 19$)
<i>Instructional</i>			
Mean	1.96	2.06	2.37
<i>Discourse</i>			
Mean	1.86	1.93	2.09
<i>Assessment</i>			
Mean	1.55	1.61	1.86
<i>Curriculum</i>			
Mean	1.77	2.00	2.26

From Apprenticeship toward MAstery:
First-year Teachers' Reflections on Key Student
Teaching Experiences and How They Shaped Their
Beliefs and Practices.

Importance of Teaching Self-efficacy

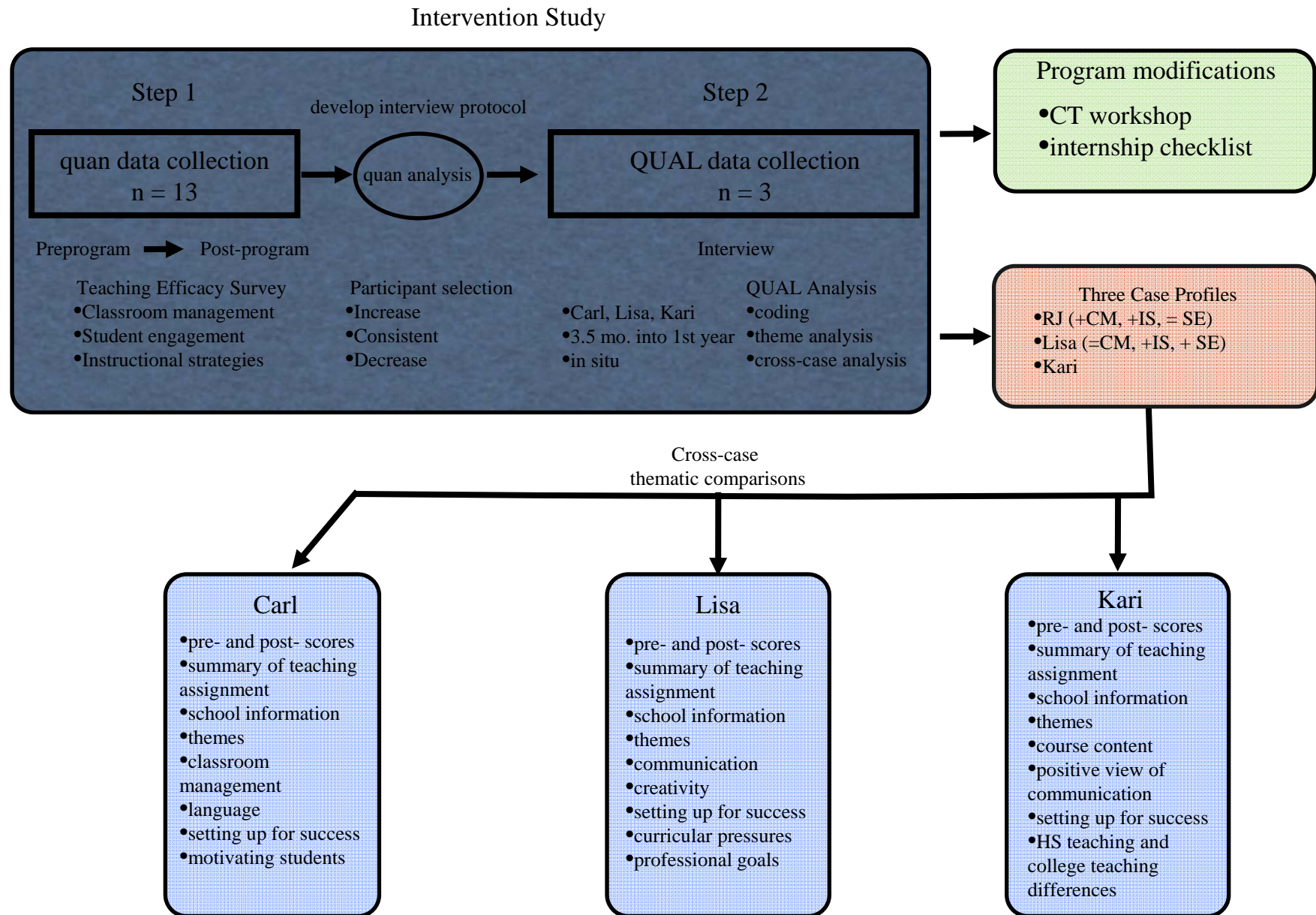
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- Measuring teaching self-efficacy and beliefs in shaping teaching practice
- Dual purposed: educative & evaluative
 - ❖ “...helping teachers develop strong efficacy beliefs early in their career will pay lasting dividends” (Tschannen-Moran, Hoy, and Hoy, 1998, p.234)
 - ❖ Our research agendas must attend to PSTs’ beliefs as a means for informing educational practice (Pajares, 1992)

Problem

- ✿ Allen (2003) identified eight areas of teacher research. This project addresses one of the areas: “To what extent does high-quality field experience ... contribute to a teacher’s effectiveness?”
- ✿ “We have little basis on which to offer specific findings about what sorts of instructional experiences teachers need” (NRC, 2010)

Explanatory Sequential Intervention Study of Three Pre-service/First-year Science Teachers



Purpose

- ✿ Identify potential modifications to the internship program in order to provide a more educative and practical internship experience for successive groups of pre-service teachers
- ✿ Provide a deeper understanding of how teaching experiences shape beliefs during teachers' early careers

Research Questions

RQ3: What was the PSTs' self-efficacy concerning classroom management, student engagement, and instructional decisions change over time?

- ✿ **Quan:** How do pre-service teacher (PST) beliefs about their ability to engage students, manage classroom environment and use instructional strategies change from the beginning of a teacher preparation program to the end of their teaching internship?
- ✿ **QUAL:** How do PSTs explain the change or consistency of their beliefs? How do PSTs (now as first-year teachers) relate the change or consistency of their beliefs to their internship experiences?

Data Sources & Methods of Analysis

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Teaching self-efficacy survey developed by Tschannan-Moran and Hoy (2001) was used to record pre- and post- program beliefs in 3 areas:

- instructional strategies
 - classroom management
 - student engagement
- Each category was assessed using eight, five-point Likert-type questions (total of 24 items)
 - Change scores within the 3 categories for PSTs were calculated.
 - Pre-post program efficacy changes were used to select participants for the qualitative (in-depth interview) portion of the study.

Results: Research Question #3, Self-Efficacy

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- Claim: An overall increase in efficacy scores from pre-to post-program in Cohort 1 responses in each of the three categories; suggests that PSTs gained confidence in their teaching skills.

Table 3. *PSTs' Teaching self-efficacy changes*

Self-efficacy category	MAst-1 (<i>n</i> = 14) Pre-program mean (SD)	MAst-1 (<i>n</i> = 13) Post-program mean (SD)	MAst-1 Pre-Post Gain	MAst-2 (<i>n</i> = 17) Pre-Program mean (SD)
Student engagement	24.9 (3.9)	29.5 (4.1)	4.6	30.2 (4.4)
Classroom management	24.7 (6.0)	31.8 (4.5)	7.1	32.6 (3.8)
Instructional strategies	26.1 (6.1)	32.1 (4.1)	6.0	31.5 (4.7)

Results: Research Question #3, Self-Efficacy

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- Post-program PSTs' self-efficacy in:
 - **engaging students** increased significantly, $F(1,26) = 228.77, p < 0.01$
 - use of **instructional strategies** did not, $F(1,26) = 102.19, p = 0.10$
 - **classroom management** abilities changed significant over the course of the MAst program, $F(1,26) = 265.45, p < 0.01$
- Within change over time in self-efficacy of student engagement and classroom management, much of the variance at the end of the year was accounted for scores at the beginning of the year (i.e., $R^2 = 0.59, R^2 = 0.53$, respectively).
- While this analysis indicates a positive change over time on two scales, and a reasonably large effect size, more participants and data points are necessary to better characterize the change over time.

Participant Selection (quan)

☼ Purposive sampling based on large or small changes in category scores and availability of participants for follow-up interviews

- Three physical science teachers
- All career-changers with either advanced (MS) degrees or significant graduate-level science coursework
- Each taught in the same metropolitan area in demographically different schools

☼ Questions from the survey were used to guide the interview topics for each interview participant.

Interview participant efficacy changes

Teaching Efficacy Category	Pre-Program		Post-Program		Change	
	Kari	Carl	Kari	Carl	Kari	Carl
Student engagement	19	27	27	28	+8**	+1*
Classroom management	27	20	28	34	+1*	+14**
Instructional strategies	23	27	31	33	+6	+6

* Selected as a “non-changer” in the category.

** Selected as a “changer” in the category.

Data Collection (QUAL)

- ✿ Follow-up interview with Carl and Kari, interview with Lisa
- ✿ Pre- Post program survey results identified “changers” and “non-changers”
 - ✿ Carl identified as a “changer” in classroom management and a “non-changer” in student engagement
 - ✿ Kari identified as a “changer” in student engagement and a “non-changer” in classroom management

Results (QUAL)

	Carl	Kari	Lisa
Classroom Management	a variety of teaching styles modeled positive interactions / relationships with students		
Instructional Strategies		balancing rigor of course with student interest	CT encouraged student creativity using art projects implemented a student-led investigation of environmental toxins
Student Engagement	communication with families not modeled during internship, but communicates often with families during 1st year	communication with families modeled during internship, extended into 1st year teaching with positive results	communication with families not modeled during internship, and did not initiate contact with families during 1st semester

Significance of Project

- ✿ Program quality is improved through continual evaluation of program components, especially field experiences.
- ✿ Identify key experiences for teaching interns which will help prepare them for their first year of teaching.

Limitations

- ☼ Small n in whole sample
- ☼ Availability of participants for second phase of study
 - Location of participants
 - Employment status
- ☼ Interview questions are specific to each participant's area of greatest change. We should not extend individual reasons for efficacy changes to the entire group.

Extensions of current study

- ✿ Conduct focus group discussions with “changers” and “non-changers” from each efficacy category as an “exit interview” prior to graduation.
- ✿ Survey and interview cooperating teachers and PSTs about their mentoring and internship experiences. Use results to inform focus group questions.

**DISCOURSE FACTORS IN
INQUIRY-BASED SCIENCE
INSTRUCTION:
A DESCRIPTIVE STUDY OF
TWO PSTS**



Background: Inquiry-based science education



- ❑ The practice of inquiry-based instruction often takes on different forms (Crawford, 2007).
- ❑ Students do not develop understandings of inquiry or NOS as a result of having experienced scientific inquiry or inquiry-oriented classroom climates (Abd-El-Khalic et al., 2004).

Background: Classroom discourse



- ❑ “fluent speaker of science” (Lemke, 1990).
- ❑ A productive marriage of science and language is key to scientific literacy (Mercer et al., 2004; Lewis et al., 2008; Hackling et al., 2010)
- ❑ Mostly controlled by teachers and little of it is used for reasoning or developing ideas (Blanchard et al., 2008; Hackling et al., 2010)

Research Questions



1. What does inquiry-based science teaching mean to beginning science teachers ?
2. How do beginning science teachers view the role of discourse in inquiry-based science instruction ?
3. How do beginning science teachers structure a classroom discourse that supports teaching scientific inquiry ?

Methodology



- Purpose: to investigate PSTs' use of discourse in the classroom
- Participants
 - Mary, 8th grade biology
 - Jane, 12th grade anatomy & 10th grade biology, block
- Data
 - 1 class video (45 min)
 - 1 semi-structured interview (45-60 min) with each participant

Theme 1: Teaching scientific inquiry



- Hands-on activities
- The nature of science (NOS)
- Scientific literacy

Theme 2: Limited role of classroom discourse – Discourse type

Table 2. Video lesson descriptions

Teacher	Topic	Class activities	Discourse type	Instructional purpose	Duration (minute)
Mary	arthropod	graphic organizer	small group	review	7
		arthropod quiz game	whole class	concepts/application	20
		graphic organizer/drawing	individual	summary/review	10
Jane	skeletal system	board game	small group	prior knowledge	5
		sharing questions	whole class	prior knowledge	10
		mini-lecture	whole class	explanation	20
		labeling the manikin	small group	concepts/review	10

Theme 2: Limited role of classroom discourse – Questioning

Table 3. Questions captured from the video lessons

Teacher-generated questions: Type, count¹ and examples

	Mary	Jane	
short-answer	16	11	Where is the <u>zygomatic</u> bone? What type of arthropod is this?
explanation	2	3	Why does it (sternum) have 3 parts? How did you know it's a centipede?
open-ended	3		Has anybody ever seen an insect molting?

Student-generated questions: Type, count² and examples

clarification	2	4	Is sacrum the tailbone? Do we need to draw all the legs of the centipede?
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Theme 3: Challenges in inquiry-based science education



- Cooperating teacher
- Timeframe
- Standardized tests
- Student factors

Results: Research Question #2, Inquiry-based Instructional Practices

Table 4.

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Discussion



- Gap between beliefs and practices
- IRE model
- Limitations
 - video
 - data size
 - discourse: written ?

Conclusions & Implications

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- *Advanced and rigorous* preservice science teacher preparation can positively affect:
 - teaching self-efficacy
 - inquiry-based instructional practices teachers develop over time during the induction phase of their careers
- We need to structure teacher education programs that:
 - are consistent and predictable
 - apply rigorous recruiting and selection criteria
 - incorporate carefully constructed internship experiences that are aligned with national standards

Current Activities & Next Steps...

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- Comparison with traditional (4-year) undergraduate program
 - Students only take 24 credit hours in one area of science (+ another 12 ancillary) rather than earn an undergraduate degree.
 - Science content courses taken at the same time as initial certification coursework in education
 - Less advanced coursework in both science and education
- Following graduates of MAst program in their 2nd and 3rd years
 - Annual self-efficacy survey
 - Regular observations to measure inquiry-based practices
 - Interviews about program experience (e.g., mentor teacher/student teaching)
 - Documentation of professional development activities
 - Effects of school policy & culture on curricular decision-making
- Build a model (HML) of teacher change with multiple measures

References

- Adams, P.E., and Krockover, G.H. (1997). Beginning science teacher cognition and its original in the preservice secondary science teacher program. *Journal of Research in Science Teaching*, 34 (6), 633-653.
- Allen, M. (2003). *Eight Questions on Teacher Preparation: What Does the Research Say?* Denver, CO: Education Commission of the States.
- Baker, D., Piburn, M., and Clark, D. (2005). TEAMS: Working together to improve teacher education. In R.E. Yager (Ed.), *Exemplary science: Best practices in professional development* (pp. 35-44). Arlington, VA: NSTA Press.
- Cochran-Smith, M. (2005). Studying teacher education: What we know and need to know. *Journal of Teacher Education*, 56 (4), 301-306.
- Darling-Hammond, L., & Bransford, J. (Eds.). (2007). *Preparing teachers for a changing world: What teachers should learn and be able to do*. San Francisco, CA: Jossey-Bass, A Wiley Imprint.
- Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research*, 76(4), 607-651.
- Laughram, J. J. (2007). Science teacher as learner. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 1043-1065). New York, Y: Routledge Taylor & Francis Group.

References (con't)

48

- National Research Council (2010). Preparing teachers: Building evidence for sound policy. Committee on the Study of Teacher Preparation Programs in the United States, Center for Education. Washington, DC: National Academies Press.
- Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research*, 62(3), 307-332.
- Sadler, P.M., Coyle, H., Miller, J., Cook-Smith, N., Dussault, M., & Gould, R. (2010). The Astronomy and Space Science Concept Inventory: Development and validation of assessment instruments aligned with the K–12 National Science Standards. *Astronomy Education Review*, 8 (1).
- Tschannen-Moran, M., & Hoy, A. W. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education*, 17, 783-805.
- Tschannen-Moran, M., Hoy, A.W., Hoy, W.K. (1998). Teacher Efficacy: Its Meaning and Measure. *Review of Educational Research*, 68 (2), 202-248.