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Beginning Science Teachers' Subject Matter Knowledge, Misconceptions, and Emerging Inquiry-based Teaching Practices (Poster)

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Introduction & Rationale

- The landscape of teacher preparation is complex and from a research perspective presents itself as a multilevel, multivariable puzzle.
- For decades, federal and state policy-makers, teacher education institutions, educational researchers, school districts, administrators, and other stakeholders have tried to determine and measure the key, malleable factors that result in effective teaching.
- While all U.S. states regulate science teacher certification, science education researchers have not produced research that unequivocally sets a minimum amount of science coursework, or mastery levels, for teachers.
- Thus, problematically ***even when minimal SMK state certification requirements are met teachers may still hold persistent misconceptions.***
- Determining teachers' minimum amount of science SMK is challenging as science is multidisciplinary.
  - A limitation of other studies is that only the number of subject area courses taken has been used to try to determine SMK mastery (NRC, 2010).
- Thus, we need studies that describe the relationship between: ***teachers' subject matter knowledge*** and ***enacted reformed-based teaching practices***

Our study addresses this gap...

Conceptual Framework

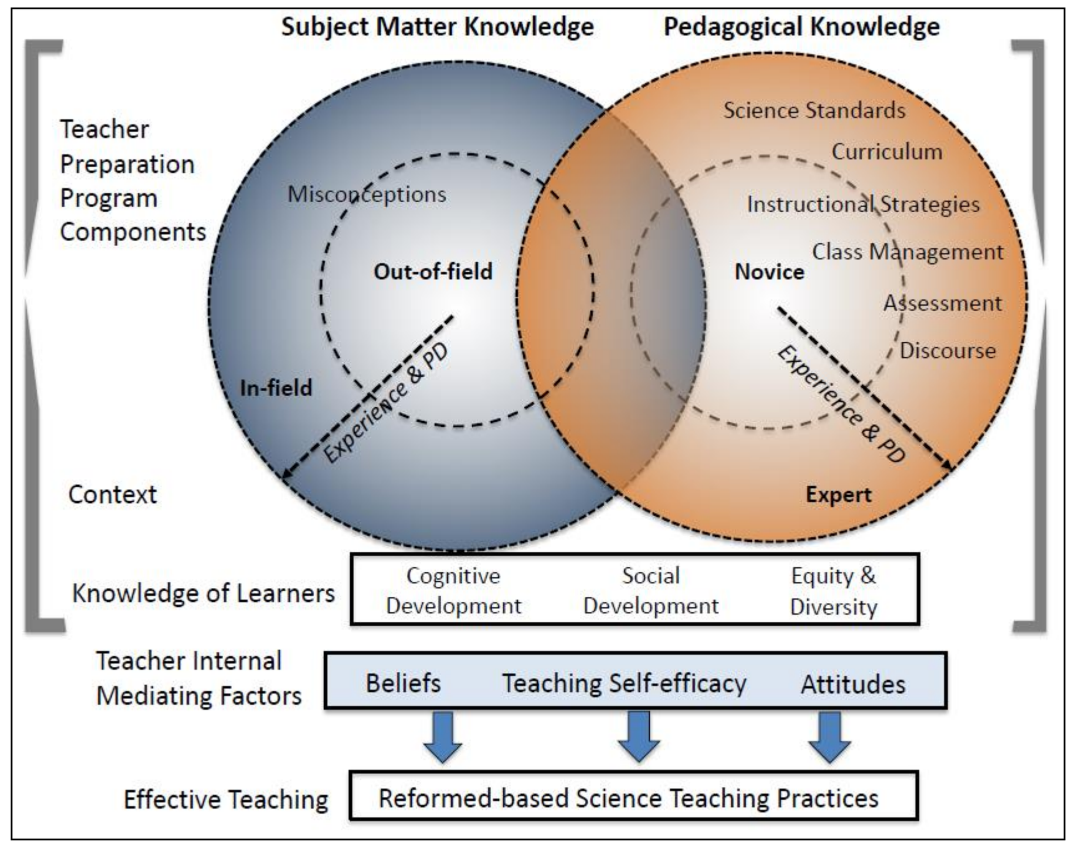

Figure 1. Conceptual framework of teacher preparation program and reformed-based science teaching practices.

***Context:** State Teacher Certification*.

- A single-subject endorsement requires 24 credit hours minimum in one of four core science areas (biology, chemistry, physics, or ESS) with 12 credit hours among the other 3 subject areas..
- Broad field endorsement allows teachers to teach any area of science, but only requires a minimum of 8-12* credit hours (less than a minor in the subject) in each of the 4 areas to do so. (* effective 2013)

Federal Definition of Highly-qualified Teacher

- Federal guidelines define highly-qualified teachers as having a major in the content area they teach.

Research Questions, Methodology, & Context

Research Questions

1. *What is the performance of newly certified science teachers with a range of SMK on tests of science misconceptions?*
2. *To what degree are these teachers' practices reform-based (i.e., inquiry-based)?*

Approach & Methods

- Longitudinal (4 years), multi-method approach to investigating beginning science teachers' SMK, science misconceptions, and instructional practices of undergraduate and master's level science TPP graduates (Lewis, Rivero, Musson, Lu, & Lucas, 2016).
- Teachers' SMK was examined through an analysis of Misconceptions-Oriented Standards-Based Assessment Resources for Teachers (MOSART) test scores and transcript analysis.
- We coded and analyzed science lessons using the *EQUIP* instrument (Marshall, Horton, Smart, & Llewellyn, 2008).

Table 1. *Comparison of undergraduate and MAT teacher education programs.*

	Undergraduate	Master of Arts
Science Coursework	Prior and concurrent to acceptance: Sufficient science coursework for Nebraska secondary science teaching endorsement (~24 credit hours in one area with another 12 hours among the other 3 areas).	Prior to Acceptance: Undergraduate major in one area of science; some MA students have graduate-level science coursework or advanced degree.
Education Coursework	Pre-professional Education Coursework (including the common coursework with *): Foundations of Education; Adolescent Development & Practicum (13 credit hours)	MAT Coursework: History and Nature of Science (Cohorts 1-2); Reading in the Content Areas (Cohort 3-7); Teaching ELLs in the Content Area; Intro to Educational Research; Curriculum Theory; Teacher Action Research Project
Common Coursework	Accommodating Exceptional Learners Adolescent Development* Science Teaching Methods (two classes, each with a practicum experience) Multicultural Education* or Pluralistic Society	
Resulting Degree	BA Secondary Science Education	MA with emphasis in science teaching

NSF Noyce Grant Overview

NSF Track I, Phase II

Longitudinal Evaluation of Noyce Science Teachers to Determine Sources of Effective Teaching

- Four-year NSF grant (September 2015 – August 2019)
- 60% of grant is required to be dedicated to the Noyce stipends (30 stipends at $16,000 each) in MAT program.
  Supporting diverse learners. Noyce recipients must complete 2 years of teaching at high-needs school districts.
- Remainder of grant is used to investigate two models of science teacher preparation.
- Our NSF Noyce Phase II grant has enabled us to add a comparison group to our previous study of MAT graduates started with our Noyce Track I, Phase I grant.

Conclusions & Future Research

Our research of our two teacher preparation programs contributes a reliable design for producing highly-qualified teachers who can provide active, engaging, constructivist learning opportunities for diverse students while addressing rigorous national science education standards.

Implications: ***Meeting the Need for High Quality Science Education***

- Findings may be **transferable to other similar programs** in terms of which science courses and at what level of mastery support strong SMK.
- Science teacher educators and professional development providers may find our results useful in considering **teacher preparation priorities** and **induction phase teachers' professional development needs.**
- While **strong science content knowledge** ensures that teachers are able to recognize their students' misconceptions, SMK is insufficient in of itself to teach effectively using **inquiry-based instruction**.
  - Other possible contributing factors include pedagogical knowledge, teaching self-efficacy, beliefs about reform-based science education.

Future Research: Comprehensive Model Building

Fall 2017- Spring 2018 Activities

- We generated about 250 more classroom observations.
- Each with a week's worth of lessons documented for a total of 1,250 class periods.(Follow-up interviews also served as coaching sessions for the teachers)

Summer – Fall 2018 Activities

- Building a **comprehensive HLM** that includes other variables (i.e., teaching self-efficacy, beliefs about reformed-based science teaching, and school-level data).

Study Findings: Subject Matter Knowledge & Misconceptions

- Linear and logistic regression were used to predict **MOSART chemistry (grades 9-12)** test scores.
- For each **+0.10 change in GPA teachers were 1.22 times more likely to pass test at 80%** (e^{β} = 7.47)

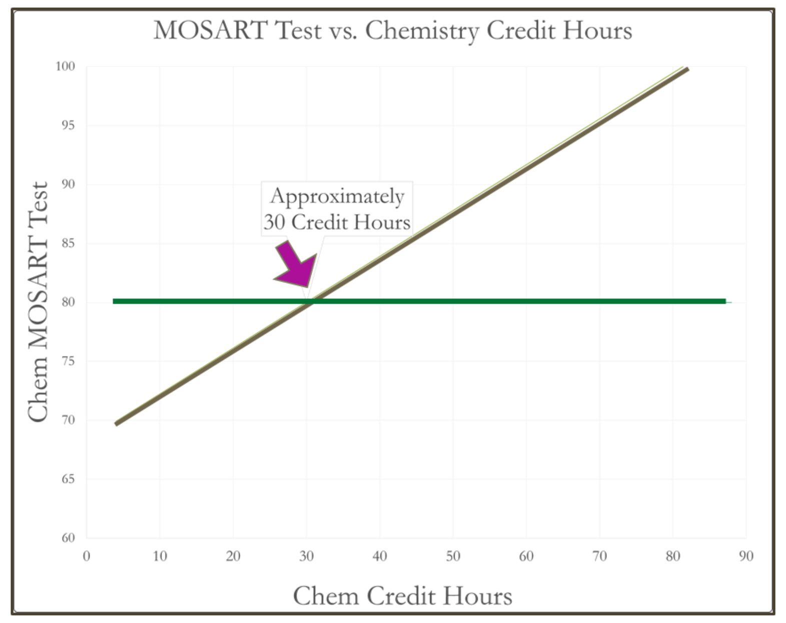

Figure 2. Empirical minimum chemistry credit hours to pass MOSART test: **30 credit hours** & **GPA = 3.21**

Therefore in this case,

1. **Policy:** Nebraska's certifications, especially general science, underestimates the # of credit hours necessary to ensure teachers overcome common chemistry misconceptions.
2. **Preparation:** The UNL MAT program requiring an **undergraduate major in chemistry ensures sufficient SMK to teach chemistry** (Lewis et al, 2018).

- Multiple variable regression and logistic regression were used to predict **MOSART physics (grades 9-12)** test scores.
- Relationship between mathematics GPA and physics credit hours is a function: **likelihood of passing/failing MOSART physics test = -5.33 + 0.86 math GPA + 0.20 credit hours.**

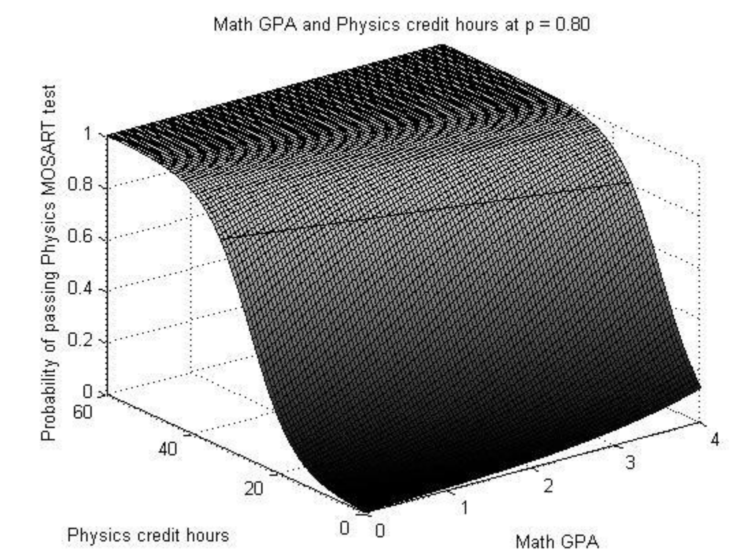

Figure 3. Function of physics credit hours and mathematics GPA to the likelihood of passing or failing the MOSART physics test.

- Each **additional physics credit hour increases the relative likelihood of passing the MOSART physics test by 22%** (e^{β} = 1.22).
- Each one-point increase in math GPA increases **the relative likelihood of passing the MOSART physics test by 136%** (e^{β} = 2.36). At a 3.0 math GPA, solve for the number of necessary physics-related credit hours, which is 30 credit hours.

$$0.80 = \frac{e^{(-5.33 + 0.86 * 3 + 0.20 \text{ physics credit hours})}}{1+e^{(-5.33 + 0.86 * 3 + 0.20 \text{ physics credit hours})}}$$

Study Findings: Connections to Inquiry-based Instruction

- Two-level hierarchical generalized linear models were built to investigate the relationship between proficiency in inquiry-oriented instruction and the predictor variables at both levels (Table 2).

Table 2. *Classroom observation-level (Level 1) and teacher-level (Level 2) variables included in the models.*

Variables Included in the Models			Science Lessons (*N*=455)
Observation-level (Level 1)	Time	Year 1	174 (38%)
		Year 2	149 (33%)
		Year 3	100 (22%)
		Year 4	32 (7%)
	Level	High School	350 (77%)
		Middle School	105 (23%)
	Lesson Length	Block (90 minutes)	11 (24%)
		Regular (50 minutes)	344 (76%)
	Mode of Observation	Video	78 (17%)
		Real-time (In-person observation or via teleconference)	377 (83%)
			Teachers (*J*=51)
Teacher-level (Level 2)	Sex	Female	31 (61%)
		Male	20 (39%)
	Teacher Preparation Program	Bachelor's (secondary science education major)	13 (25%)
		Master's + certification	38 (75%)

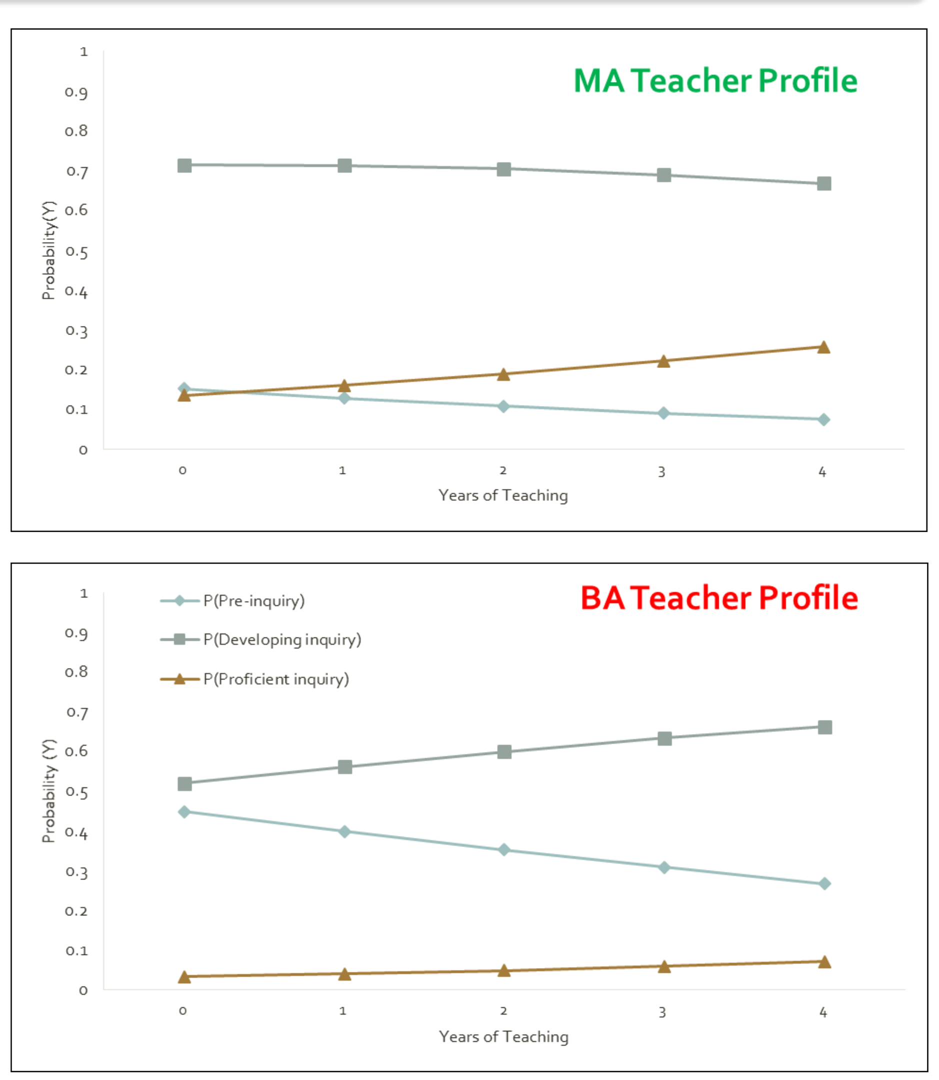

Figure 4. BA and MA Teacher Profiles (Lucas & Lewis, 2017)

- Controling for all other variables in the best-fitting model, **the likelihood of an observed lesson being at the proficient inquiry level is significantly higher for teachers who graduated from the master's program.**

Acknowledgments & References

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