DEANS FOR IMPACT

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IMPLEMENTING THE SCIENCE OF LEARNING:
Temple University College of Education

How might a deeper understanding of the science of learning impact the development and practice of early-career teachers? In October 2015, a subset of the diverse teacher-education programs led by members of Deans for Impact (DFI) came together to try to answer this question by implementing pilots at their respective programs. In particular, the programs considered how teacher candidates might a) build understanding of cognitive science principles, b) learn to analyze and evaluate how these principles are enacted in others' practice, and c) learn to apply the principles in their own teaching. Their exploratory efforts generated several useful lessons to inform future efforts in teacher preparation, which we will explore in a series of brief case studies.

Introduction

The state of Pennsylvania requires all teacher candidates to demonstrate a strong grasp of how students think, learn, and develop. Thus, when Temple University faculty answered the call to embed the science of learning in teacher preparation, they aimed to help their students build on this foundation of knowledge and apply it in their classroom practice. In this case study, we explore the efforts of Temple University's pilot led by Dr. Julie Booth, associate dean of undergraduate education and associate professor of educational psychology, and Dr. Kristina Najera, assistant dean of teacher education. Temple's pilot adopted the structure and methods of traditional experimental research. The following sections highlight the pilot's design, implementation, and initial learning in four main areas:

1. Pilot focus and theory of change
2. Pilot activities and assessment
3. Preliminary results and insights
4. Ongoing challenges and questions

The findings in this case study may shed light on future directions for programs interested in reframing the relationship between research and practice in teacher education.

The Science of Learning

What do we know about how students learn, and what does that knowledge mean for how we teach? *The Science of Learning*, a publication released by Deans for Impact in September 2015, summarizes existing research from cognitive science about student learning, and connects this research to practical implications for teaching and learning. The report identifies six key questions about learning that should be relevant to nearly every educator. For example, how do students understand new ideas? What motivates students to learn? Building off many efforts that came before it and reflecting the general consensus of the scientific community, *The Science of Learning* is intended to be a resource for teacher educators, new teachers, and anyone in the education profession who is interested in how learning takes place.

Defining the Pilot Focus and Theory of Change

At a Deans for Impact convening in June 2016, Booth shared the pilot's theory of change: "If we provide multiple opportunities for teacher-candidates to engage with cognitive science and co-locate those opportunities with clinical experiences, then candidates will be better able to understand cognitive science principles and use them to make instructional decisions." As at many other traditional teacher-education programs in Pennsylvania, Temple's teacher candidates study cognitive development near the beginning of their program, prior to their courses on content methods, teaching practicum, and student teaching. The cognitive science content isn't revisited later in the program, leaving it to candidates to make connections between the principles learned in their cognitive development class and how those principles might apply in their methods classes or clinical experiences. Booth wanted to do a better job of threading cognitive science throughout the program, so settled on the idea of "infusing" a review of cognitive science concepts into content methods instruction. She believed this infusion might help students more actively make connections between cognitive science and their practice.

Pilot Activities and Assessments

Booth and Najera provided materials and training for instructors of three early childhood (ECE) content methods classes to deliver a series of five cognitive science mini-lectures (about 12-15 minutes long) over the course of a semester (in addition to the material typically covered in the course). These mini-lectures were intended as a refresher for undergraduates, who

AT A GLANCE

TEMPLE UNIVERSITY COLLEGE OF EDUCATION

College of Education
TEMPLE UNIVERSITY

Temple University College of Education is located in the heart of North Philadelphia. Since the College's founding in 1919, it has cultivated a special relationship with the School District of Philadelphia and continues to provide Philadelphia with more teachers than any other college.

- **1,200 undergraduate** students across eight bachelor degree programs
- **Accelerated five-year** dual B.A. or B.S. and Ed.M. programs in education
- **1,000 graduate** students in master's, doctoral, and certification programs
- **3 main departments:**
  - ✓ Teaching and Learning
  - ✓ Policy, Organizational and Leadership Studies
  - ✓ Psychological Studies in Education
- **Strong research** focus among Educational Psychology faculty

had already been exposed to the concepts in an earlier course. Early childhood students in the three remaining methods classes would follow the regular curriculum. The team designed surveys to measure and compare the impact of the cognitive science review on pre-service teachers' knowledge, pedagogy, and attitudes for math and science instruction. They also compared results between the experimental group and students who were enrolled in the cognitive development class at the time. When these students enrolled in content methods for the spring semester, they became the new experimental group. In spring, the pilot also expanded to include 10 middle grades teacher candidates whose methods instructor held dual expertise in cognitive science and math/science pedagogy and might offer a more integrated learning experience.

Activities and assessments focused on teacher candidates' learning in two categories:

1. declarative knowledge, or the ability to accurately describe the principles of cognitive science; and
2. applied knowledge, or the ability to answer questions about application of cognitive science in instructional decision-making.

FIGURE 1 | **TEMPLE'S RESEARCH DESIGN**

PHASE 1

Fall semester 2015

Experimental group

- 3 classes of ECE juniors in math and/or science content methods with cognitive science "infusion"; the candidates had previously taken a one-semester cognitive development class.

Control group(s)

- 3 classes of ECE juniors in standard math and science content methods; the candidates had previously taken a one-semester cognitive development class.
- 25 ECE sophomores in cognitive development class

Data collected

- Cognitive science application test
- Written reflections that justified instructional decisions in lesson plans
- Lesson observations in Practicum course

PHASE 2

Spring semester 2016

Experimental group(s)

- 30 ECE students in math and/or science content methods class with cognitive science "infusion"; the candidates had previously taken a one-semester cognitive development class.
- 10 middle grades juniors in math/science content methods with cognitive science infusion taught by a "hybrid" instructor; the candidates had previously taken a cognitive development class and a lesson-planning class using cognitive science.

Control group

- 25 ECE sophomores in cognitive development class

Data collected

- Cognitive science declarative knowledge assessment
- Cognitive science application test

Building and Assessing Declarative Knowledge

Principles of cognitive science were embedded in math and science content methods courses to refresh student understanding.

- **Professional development for ECE course instructors.** Prior to the start of the school year, Booth led a 2.5-hour workshop presenting the five cognitive science mini-lectures to math and science content methods instructors and practicum supervisors, many of whom had not revisited the concepts since they had been students in educator-preparation programs. In follow-up meetings, she worked with methods instructors to weave the lectures into the sequence of their curriculum.

- **Cognitive science mini-lectures for students in ECE content methods courses.** Lectures refreshed students' memory on the following topics:

  1. attention and memory
  2. experts vs. novices
  3. student and instructor misconceptions about learning
  4. problem solving, practice, and transfer
  5. student motivation

  The lectures, which were presented using slides and materials created by Booth, encouraged students to think about how these concepts might inform the teaching methods they were learning to use in the classroom.

- **Declarative knowledge assessment.** Booth and Najera developed and administered a declarative knowledge test to evaluate the accuracy of candidates' understanding of the science of learning.

Developing and Assessing Applied Knowledge

Candidates' ability to apply cognitive science principles to their practice was measured in several ways, including through coding of lesson plans, observations of lessons and an assessment.

- **Lesson plan reflections.** As an interim performance measure, teacher candidates in their junior year at Temple are required to write lesson plans, accompanied by reflections explaining the reasoning behind their instructional choices. Booth examined the reflections written by candidates in both experimental and control groups and coded them for use of cognitive science language. Reflections were evaluated based on whether candidates named reasons for instructional decisions that were consistent with cognitive science, or whether they relied on what Booth described as "folk" reasons.

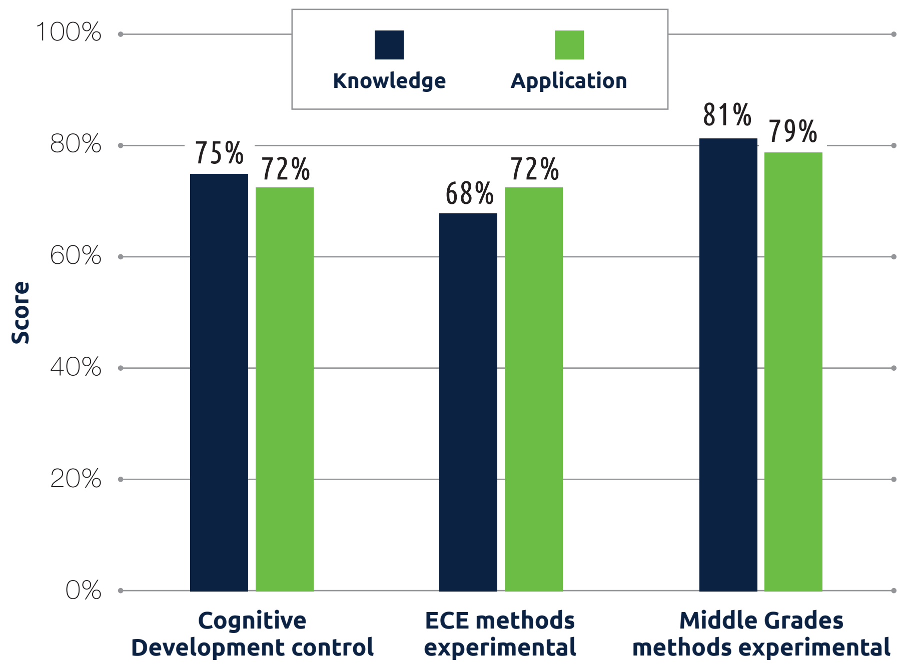
- **Lesson observations.** Booth modified the college's existing practicum observation rubric by adding a few questions related to applying cognitive science principles to instruction. This modification allowed practicum instructors to note the kinds of feedback pre-service teachers gave to students, their sensitivity to working memory, motivation strategies, response to student errors, and attention to students' background knowledge. The rubric's non-scientific language was accessible to instructors.

- **Cognitive science application assessment.** Booth developed and administered a written test that included different scenarios teachers might encounter in the classroom, to evaluate students' knowledge of how to apply cognitive science principles in practice.

Preliminary Results and Insights

An analysis of the initial data from the pilot revealed no significant differences between experimental and control groups on either declarative or applied knowledge, although students who had instructors who were experts in cognitive science did show increased knowledge and understanding of how to apply cognitive science principles. However, students in the experimental group showed less reliance on the "learning styles" myth to explain instructional decisions.

Chart 1.
Declarative knowledge and application ability, Spring 2016



- **Students in the cognitive development class and those receiving the cognitive science "infusion" showed similar understanding of cognitive science principles.** On declarative knowledge measures testing how well students know the science of learning principles, there were only slight differences between the students in the cognitive development class and students refreshing that content through mini-lecture review in methods class. *(See chart 1.)*
- **Students in the cognitive development class and those receiving the cognitive science "infusion" in the ECE program showed similar ability to apply cognitive science principles.** On the cognitive science application test, measuring how well students understand how the principles might affect classroom instruction, the team found no significant differences between the experimental and control groups.

According to Booth, "It's going to take more than just 'refreshing their memory' about the principles and implications in the classroom… they're not improving their knowledge of cognitive science, nor are they improving their ability to apply it." While the experimental ECE group did not show increased understanding of cognitive science application, neither did their understanding decrease significantly over time, which might have been expected without the mini-lecture review of the content they covered in their cognitive development course.

- **Better understanding of cognitive science principles and their application from students with "hybrid" instructor.** The middle grades students whose content methods instructor was expert in both cognitive science content and math and science pedagogy *did* show increased knowledge and understanding of how to apply the principles as measured by the surveys. These students also benefited from a second course with the instructor that was focused explicitly on planning using cognitive science principles.

- **Busting the myth of "learning styles."** In their fall lesson reflections, some teacher candidates justified instructional choices using reasons consistent with cognitive science, using language related to students' prior knowledge or working memory, while others relied on "folk" reasons, using broad language and buzzwords. While the groups did not differ in the number of cognitive science reasons, they did differ in the number of

Chart 2.
Lesson Plan Reflections, Fall 2015

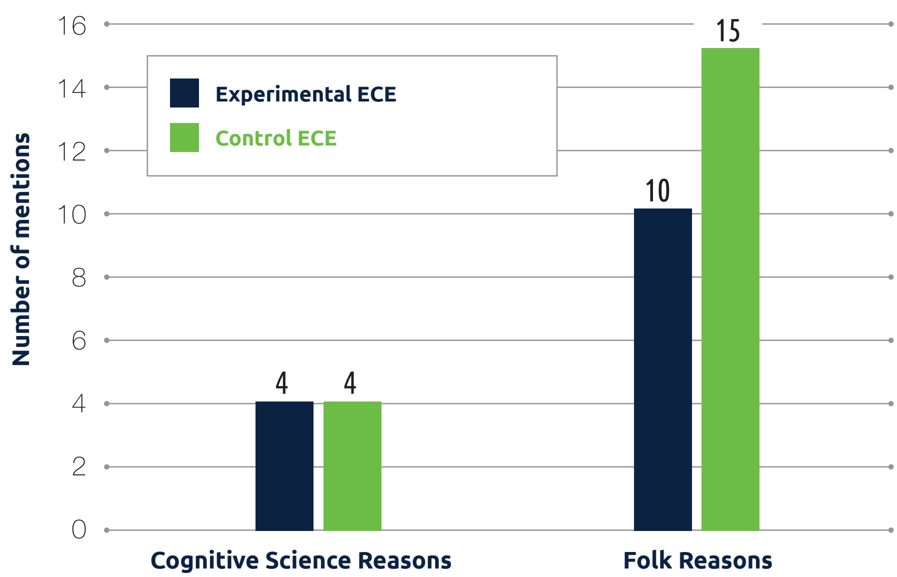


FIGURE 2 | SAMPLE REASONS USED IN TEACHERS' LESSON REFLECTIONS

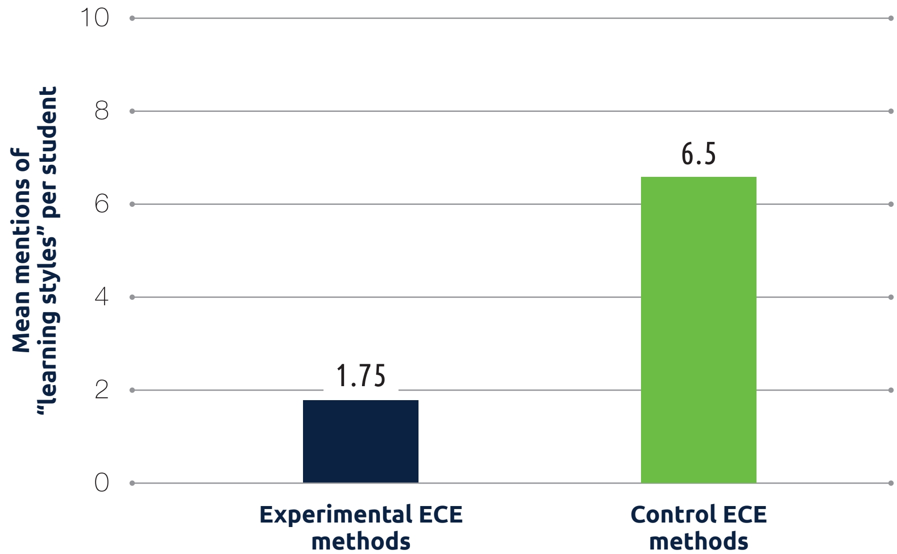
Cognitive science reasons

- Prior Knowledge
- Encoding
- Expertise
- Misconceptions
- Problem Solving
- Attention Focusing
- Working Memory

"Folk" reasons

- Active Learning
- Learning Styles
- Multiple Intelligences
- Real-world Connections

Chart 3.
Lesson Plan Reflections, Fall 2015



folk reasons *(see Chart 2)*, with students experiencing the cognitive science infusion being less likely to use folk reasons than the control group. In particular, significantly fewer candidates in the experimental ECE group (compared to the control ECE group) relied on the myth of "learning styles" to rationalize instructional methods *(see Chart 3).* The idea that students learn best through a particular modality – auditory, visual, or kinesthetic – is not supported by empirical research, but remains pervasive in education.[1]

Ongoing Challenges and Questions

Results from the pilot point to some promising avenues for future experimentation – but also raise challenges and questions that will need to be resolved in order to further advance the work.

- **Staffing challenges of interdisciplinary learning.** While results from the middle grades group suggest the promise of a more integrative approach that fuses together cognitive science and methods courses, university faculty with deep knowledge of both cognitive science and pedagogical content methods are difficult to find. Booth wondered, "How can we provide a more integrated learning experience for students who don't have access to that small pool of faculty members?" Additionally, university faculty members are often siloed within their own departments, and may lack incentives to collaborate with colleagues from a different specialty. Without empirical proof that integrating instruction in cognitive science and pedagogical methods improves teacher-candidate performance, faculty may be unwilling to disrupt the status quo. How might higher education foster a culture of flexibility and openness to encourage interdisciplinary collaboration across cognitive science and educator preparation?

[1] Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning Styles: Concepts and Evidence. Psychological Science in the Public Interest, 9(3), 105-119.

- **Assessing teachers' application of cognitive science principles.** While assessing declarative knowledge of cognitive science is mostly straightforward, assessing teachers' application of the science can be challenging. How can assessments make teacher thinking visible? What criteria constitute evidence of effective application in practice? What is the best method of assessing whether teachers are applying these principles? Booth and her team found that reliably coding the lesson reflections for cognitive science or folk reasons was not always clear-cut or straightforward; additionally, this assessment technique would be very difficult to execute at scale.

- **Designing scaffolded experiences to help teachers transition from understanding to application of cognitive science.** Lecture can be an efficient and precise way to introduce, review, or clarify information. However, an established body of research in cognitive science points to the benefits of active retrieval to support students' long-term retention of information.[2] In other words, in order to learn – and learn how to apply – cognitive science principles, teacher candidates need a series of scaffolded experiences that create more explicit opportunities to practice applying those principles. How might teacher educators draw on a variety of learning strategies to support students in integrating their knowledge of cognitive science and content pedagogy?

[2] Pashler, H., Bain, P. M., Bottge, B. A., Graesser, A., Koedinger, K., & McDaniel, M. (2007). Organizing Instruction and Study to Improve Student Learning. U.S. Department of Education. Washington DC: National Center for Education Research, Institute of Education Sciences.