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IMPLEMENTING THE SCIENCE OF LEARNING: *Boston Teacher Residency*

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

This case study traces the evolution of the action-research-style project led by members of the Boston Teacher Residency Induction team. Over a six-month iterative process, the pilot evolved through four main phases:

1. Selecting a focus and theory of change
2. Identifying evaluation questions and data measures
3. Designing and implementing pilot activities
4. Collecting and analyzing data

This report describes the details and key insights from each of these phases, though – as with many complex endeavors in education – the pilot's activities did not unfold in an entirely neat, linear order. We conclude with a discussion of the challenges, lessons, and ongoing questions for consideration.

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 how learning takes place.

An Evolving Program Focus and Theory of Change

Curiosity is contagious among Induction Director Julie Sloan's team of coaches for early-career graduates of the Boston Teacher Residency. In *The Science of Learning*, math coaches Elizabeth Sweeney and Sarah Langer recognized many of the practices and principles they had developed and intuited implicitly through years of teaching experience. They wondered how making these principles explicit to novice teachers might enhance their development.

In December 2015, Sweeney launched an inquiry group – a form of collaborative teacher learning around a shared question or problem – with 11 elementary teachers. They decided to focus on one of the questions from *The Science of Learning*: What motivates students to learn? A month later, after learning from these initial efforts, Langer recruited and launched a parallel group of nine secondary teachers to explore "How do students learn and retain new information?" Teachers studied the science of learning, memory, and motivation and the implications for practice, tested out new ideas in classrooms, analyzed their impact, and shared their learning within their group.

After several months of experimenting with these new ideas, coaches met to clarify and articulate their theory of change: If teachers and coaches

AT A GLANCE

BOSTON TEACHER RESIDENCY

Boston Teacher Residency (BTR), a program of Boston Plan for Excellence (BPE), recruits talented college graduates, career changers, and community members and gives them the tools they need to make an immediate impact in the classrooms of Boston Public Schools.

BTR "Fast Facts":

- Clinical teacher educators: **7**
- 2015-16 student enrollment: **37**
- 2015-16 program completers: **33**

BTR's model includes:

- Year-long classroom apprenticeship
- Targeted master's-level coursework
- Practical learning, hands-on experience
- Ongoing support through induction coaching

BTR's induction coaching has several different elements:

- Team-based approach to new teacher development
- Partnerships between coaches and new teachers to set goals and collect data to track progress
- Tailored early-career coaching for teachers in years 1-3 and beyond

collaborate to connect observation, feedback, and reflection on teaching to cognitive principles of learning, then early-career educators will gain explicit awareness of common patterns in the classroom and plan more strategic instruction to advance student learning.

Identifying Evaluation Questions and Data Measures

Curious about their own learning as well as that of teachers and students, the pilot team organized their assessment around the following evaluation questions:

1. **Impact on teachers' thinking and practice.**
   - How, if at all, have early-career teachers changed their mental model of student learning and their own learning as a result of their participation in the inquiry group?
   - How has participation in the inquiry group influenced early-career teachers' instructional planning and practice?
2. **Impact on coaches' thinking and practice.**
   - How, if at all, have induction coaches changed their understanding of learning and their ideas about teaching and coaching as a result of leading the inquiry group?
   - How has participation in the inquiry group influenced instructional coaching practice?

Plans for data collection included pre- and post-surveys assessing teachers' beliefs about how students learn, weekly teacher reflections and journals, notes from three in-person group discussions and four to five meetings online, coaching logs and classroom observation rubrics, K-12 student feedback pre- and post-surveys, and notes from coach reflections and interviews.

Pilot Activities: Generating and Assessing Teacher and Coach Learning

Pilot activities aimed to increase both teachers' and coaches' ability to:

1. Understand and explain cognitive science principles
2. Identify and analyze use of the principles in others' classroom practice
3. Apply the principles in their own practice

Guiding the design of the activities was recognition of the cognitive rigors of teaching and a core belief that, as professionals, educators should be able to use cognitive science to inform their instructional decisions. The coaches of the two groups – elementary and secondary, which met separately – identified activities from the set described below that would fit the specific needs and interests of their groups. (Neither group did all the activities.)

Elementary group

- **Initial question:** What motivates students to learn?
- **11 elementary** teachers
- **Majority with 1 – 4 years** of teaching experience
- **December 2015 – May 2016**
- **Coach:** Liz Sweeney

Secondary math group

- **Initial question:** How do students learn and retain new ideas?
- **8 Math, 1 ELA teacher**, grades 6-12
- **1 - 8 years** of teaching experience
- **January – May 2016**
- **Coach:** Sarah Langer

Building Understanding of Cognitive Science Principles

Teachers participated in a range of activities aimed at building their knowledge of cognitive science, including readings, interviews with experts, and reflections.

- **Teachers read excerpts from books intended to translate cognitive science research for a lay audience** – Dan Willingham's *Why Don't Students Like School?* and *Make It Stick: The Science of Successful Learning*, by Peter C. Brown, Henry L. Roediger III, and Mark A. McDaniel.
- **Coaches led three group meetings** in late December/ early January, March, and May – with discussion of the readings and activities to make teachers aware of their own cognitive processes.
- **Through weekly online reflection prompts**, teachers connected their reading with experiences in their classrooms.
- **Teachers engaged in a conversation with a cognitive scientist** via Skype. Teachers had the opportunity to ask their questions about cognitive science in practice to Dr. Jon R. Star, an educational psychologist at Harvard Graduate School of Education who studies middle and high school mathematics learning.

Identifying and Analyzing Principles in Others' Classroom Practice

Analysis of both videotaped and real-time teaching was intended to help teachers understand the connections between cognitive science and classroom practice.

- **Teachers analyzed video from classrooms,** identifying and evaluating evidence of the cognitive science principles at work in students' thinking or in the teacher's instructional moves.

- **Teachers observed a colleague's classroom** and reflected on connections between the lesson they observed and principles related to memory, motivation, practice, and transfer.

Applying Cognitive Science Principles in One's Own Practice

Targeted activities helped candidates practice using cognitive science in their daily instruction, and repeated reference to cognitive science during coaching helped embed those principles.

- **Teachers designed a project** to address a problem or challenge they were grappling with in their classrooms. Teachers were asked to plan and implement an instructional strategy or classroom structure to address their challenge and explain their rationale using one or more of *The Science of Learning* principles. (See example below.) Teachers developed tools as part of their projects, including a planning checklist for cognitive science and written worked examples. These resources were posted on a BTR-maintained website *(www.btrgrad.org)*.
- **Teachers received an average of four 1:1 coaching cycles** with a cognitive science lens through classroom visits, debriefs, and virtual "check-ins." Coaches used cognitive science "coaching cards" to help structure their observations and debriefs. (See page six for more information.)

Key Insights from Data Analysis

While the pilot was not designed as (or intended to be) a "gold-standard" research project, BTR was able to collect data from a variety of sources, including pre- and post-surveys on teachers' beliefs about how students learn, teachers' online reflections, journals, and discussion notes, and observation rubrics tracking application of cognitive science principles. These data point to several trends in teacher learning and coach learning that might inform future endeavors.

EXAMPLE COGNITIVE SCIENCE PROJECT (SECONDARY)

THE SITUATION	Students in my Algebra often forget or fail to apply what they already have learned when solving new problems.
I'M GOING TO TRY	Using the Do Now problems on Fridays to spend 10 minutes reviewing key algebra skills. Review three skills per Do Now, six skills total. Alternate sets of three skills each week.
MEASURING PROGRESS	I'll present solutions; students trade papers, and correct. Publicly track the class's % problems correct on a wall chart and track individual students' scores in a private spreadsheet.
BECAUSE	Cognitive science research suggests practice should be spaced, varied, and interleaved in order to support students' long term retention.

SPOTLIGHT

Cognitive-Science Coaching Cards

Coaches designed "coaching cards" to help structure their observations and feedback debriefs. These coaching cards highlighted key cognitive science ideas and associated teacher and student behaviors, helping coaches to observe instruction with a cognitive science lens. The coaching cards prompted ideas such as: motivating student investment in content, focusing on what students were thinking about, grounding abstraction in concrete representations, and incorporating practice into instruction. The coaching cards became useful scaffolds for coaches' own working memory during observations and debriefs. The cards also became tools for the early-career teachers in their post-lesson reflections, prompting them to consider whether their instructional decisions had been grounded in the science of learning.

Coaches each developed their own card, testing multiple iterations, playing with format and tweaking the language to be more accurate to the science. Langer used the ideas on her one-page coaching card to help structure group online discussions. Liz separated the principles and implications for practice onto individual cards to be able to differentiate the relevant principles embedded in teachers' lesson.

Teacher Learning

An analysis of data from a variety of sources revealed several promising trends about how to help teachers better apply cognitive science principles to their practice.

- **When journal prompts included specific, targeted references to cognitive science, teachers were more likely to make explicit connections** between the principles and specific aspects of pedagogy. In other words, prompts that activated teachers' prior knowledge about cognitive science were more effective at getting teachers to link that knowledge to pedagogy. For example, a teacher responding to an excerpt from Willingham, in which he noted "A student with deep knowledge knows more about the subject, and the pieces of knowledge are more richly interconnected," generated the following questions for herself: "This sounds extremely related to using mathematical structure (math standard MP7) to me. But how do we teach in order to support kids in developing deep knowledge? Does it ever make sense to push to procedural fluency before kids have deep knowledge?"
- **The reflections where teachers made the clearest connections between specific strategies or moments in a lesson and the underlying cognitive principles tended to come after multiple exposures** to the abstract principle *and* opportunities to see the principle put into use in a classroom scenario. During initial learning and early discussions, teachers tended to focus on either the principle or a related strategy, but struggled to integrate the two.
- **Teachers who had a solid foundation in their content area seemed to make greater progress applying the principles** in their classroom practice. Teachers in the secondary group, who had a narrower focus and deeper expertise in a particular content area, made more progress with application – an area where the elementary teachers seemed to struggle. This could be because elementary teachers have to cover multiple content areas, each with its own curriculum; for novice teachers, that means more content to master, which could perhaps hinder their application of cognitive science principles.

Coach Learning

In mid-April, several insights emerged when coaches met in person to discuss how the lens of cognitive science was affecting their coaching practice.

- **Coaching through the lens of "what students are thinking about" helped make feedback objective and centered on student learning.** Sweeney and Langer reported that structuring conversations about a teacher's practice around cognitive principles of learning instead of what teachers were doing made the coaching feel more "neutral." Coaches felt less pressure to rely solely on their past experience or personal opinion.

- **Cognitive science as a shared lens enabled collaboration across the induction team.** According to Sweeney, "It gives us a structure and a shared purpose… these are all things that we think are important, these are the things that we're going after… rather than each having our own individual view of good instruction."

- **Teachers and coaches developed more nuanced understanding through an exchange with a "hybrid" expert in both cognitive science and math pedagogy (who also had past experience as a classroom teacher).** One teacher remarked, "What really struck me was that right at the outset, [Jon Star] gave us all permission to think about the cognitive science research and findings in conjunction with our own expertise as instructors in the field. It seemed to open the conversation with a level of mutual respect that can be missing" in interactions between researchers and practitioners.

Ongoing Challenges and Questions

Members of BTR's Induction team and participating teachers agreed that their learning and work at the intersection of cognitive science and teaching has only just begun.

- **Teacher educators recognize that they are still novices** in the realm of cognitive science. Exploring what, how, and why teachers should learn about the science of learning raises the question: What should teacher educators know about the science of learning as it applies to teaching? How can they free up time and balance multiple areas for professional learning to develop more connected conceptual understanding in cognitive science?

- **How to sequence and differentiate cognitive science learning for teachers** remains an open question. Sweeney observed, "What are the qualities and characteristics of a teacher who is ready for applying cognitive science? What are the basic things that even pre-service teachers should learn about? Does one principle build on another? Could I unroll this as a sequence?" Coaches hope to learn more about how contextual factors such as the length of experience teaching, the kind and quality of feedback teachers receive, and their level of background in content and pedagogical content knowledge for the subject(s) they teach might affect teachers' learning and application of cognitive science in practice.

- **What kinds of organizational resources and support within schools support early-career teachers' learning in cognitive science?** In developing the program logic for the pilot, the induction team rested their theory of change on three assumptions. The first is that early-career teachers have the time and cognitive and emotional resources after a day of teaching to engage in additional learning. Second, that coaches have accessible, valid translations of cognitive science research and the time for extended professional learning in cognitive science. Third is the assumption that schools are organized to support teacher learning. Over the course of the pilot, the demanding context of teaching in urban public schools sometimes put those assumptions to the test and made scheduling coaching visits or gathering regular and reliable data challenging. Considering these factors in the design of future efforts will be essential to continued improvement and learning at the intersection of cognitive science and instructional practice.