Working in the research-to-practice gap: Case studies, core principles, and a call to action

Anna Shusterman¹, Natalie May^{1,2}, Samantha Melvin^{1,3}, Sona Kumar¹, Stephanie Blumenstock¹,
Mary Toomey¹, and Sydney Lewis^{1,4}

¹Wesleyan University

²New York University

³Erickson Institute

⁴New York City Department of Education

Corresponding Author:

Anna Shusterman

Department of Psychology

200 High Street

Middletown, CT 06459

Phone: (860) 685-4849

Fax: (860) 685-2761

Email: ashusterman@wesleyan.edu

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ABSTRACT

Developmental science offers many research findings that are relevant for real world settings, but there are significant challenges in moving research beyond university walls. This paper presents a framework for the translating developmental science to practice, primarily in educational settings, articulating ten core principles for research-to-practice translation. The principles summarize the key lessons learned from two long-term research-to-practice translational projects: the development of an early childhood numeracy curriculum (the Wesleyan Preschool Math Project) and a research-based summer pre-K for low-income children (Kindergarten Kickstart). The principles reflect central tenets of community-engaged research and intervention design: 1. Understand the gap; 2. Invest in developing the intervention; 3. Appreciate the naturalistic, real-world context; 4. Maximize uptake, not just efficacy and effectiveness; 5. Acknowledge power and status differentials; 6. Collaborate; 7. Leverage resources; 8. Establish mutual respect; 9. Practice iterative development; 10. Simplify the final product. We emphasize the importance of collaborating with community members; acknowledging power differentials between researchers and practitioners; respecting practitioners as experts in their own right with valuable insight into their classrooms; appreciating naturalistic context; and recognizing the motivations of end-users at every step of intervention design and development. The paper also includes strategies for researchers to maximize translational opportunities, such as leveraging untapped resources and mobilizing undergraduate students. This paper is both a call to action and an initial blueprint for developmental scientists who are interested in translating their research into practice.

Key words: implementation science; early childhood; early numeracy; intervention design; cognitive development; research-practice gap

There does not exist a category of science to which one can give the name applied science. There are sciences and the applications of science, bound together as the fruit of the tree which bears it.

-- Louis Pasteur, Revue Scientifique (1871)

How do we connect the output of our research to real-world problems? Developmental science lives on the knife's edge: as a basic science, we focus on intellectual puzzles with laser focus, concentrating on details like exceptional research design, the latest statistical trends, and explanatory adequacy for complex problems. These scientific pursuits are deeply important. However, for a variety of reasons, we are often unable to fully realize the real-world applicability of our findings. One possible reason is that, when we focus on application, it calls into question our validity and status as natural scientists. However, we posit that we, as scientists, should prioritize the problem of connecting the research to the real world. Our participants – children, families, and schools – deserve better, and should reap the putative benefits of our research. And more fundamentally, children, families, and schools need us. They need the knowledge that we have produced, the deeply elaborated theoretical frameworks about how children develop, and the evidence-based advocacy that we are uniquely suited to provide.

About ten years ago, we started wondering why so much of developmental science research, especially in cognitive development, seemed trapped in the dissemination pipeline. Visiting preschools for our own research projects, we saw teachers and classrooms who would benefit from the last few decades of the knowledge we have developed, but who had limited access to it. We became curious about what mechanisms could be used to move research from campus to the world, but at first we could not envision them: How could this work? Which mechanisms would be successful? We encountered skepticism from fellow scientists about whether educators are receptive to our work, and exasperation from educators about the

impractical nature of what researchers had to offer, along with a real desire for research-based information.

Since then, we have set about building a framework for the translation of developmental science to practice, primarily in educational settings. This paper reports on that process, articulating ten principles for research-to-practice translation. First, we present two long-term projects, which serve as case studies for this question. Then, we lay out ten principles, which were developed based on these cases, several smaller projects, and many informative failures. Where relevant, we draw on the examples from these projects to develop the principles.

TWO CASE STUDIES

By way of introduction to the theoretical principles described below, we start with two large projects that took place over a decade: the Wesleyan Preschool Math Games Project and the Kindergarten Kickstart project. Both projects were explicitly designed to find new ways to translate current findings in the cognitive development literature into education-relevant applications, particularly for locations and populations with high need. Many conversations with teachers taught us that, as interesting as it can be to learn about research findings, it is not always obvious *how* to translate the research-based suggestions into concrete materials, lessons, guidelines, curricula, or practices. These two projects were envisioned as creative workspaces to address the question of *how* this translational work occurs.

The explicit focus of this paper and of these cases is on design and development, as opposed to evaluation. We therefore want to add the caveat that neither project has been subjected to a rigorous, fully powered randomized control trial (RCT) to test efficacy or

effectiveness. That said, both projects have been tested multiple times with small pilot evaluations. While the cases here focus explicitly on translating cognitive development research to education settings, we suspect that some of the translation principles derived from these cases are broad enough to apply to other settings and translational outputs.

Case study 1: The Wesleyan Preschool Math Project

What will it take to bring developmental science into early childhood math education?

The goal of this project was to address the well-known limitations in the quantity and quality of supports for the development of mathematical and scientific reasoning in early childhood education settings (ECE; Early et al., 2010). While this is a widespread challenge, the scope of the problem is even more dire for non-signing deaf and hard-of-hearing (DHH) children, who show significant delays in math achievement, which can be traced all the way to preschool (Kritzer, 2009).

In response to the need for increased numeracy instruction in early childhood, substantial public and private investment has been devoted to creating curricula with remarkably good outcomes in RCTs (e.g., *Building Blocks*: Clements & Sarama, 2007; *Big Math for Little Kids*: Lewis Presser, Clements, Ginsburg, & Ertle, 2015). Teachers, programs, and districts could use these curricula, but mostly they do not choose to do so (Lo, 2014). The few teachers who do use high-quality published curricula tend to pick and choose activities like recipes from a cookbook, rather than following the carefully sequenced structure validated by the rigorous RCT studies. Our project started with two hypotheses: First, that the problem does not primarily lie in teachers' utilization of the materials, but in the initial construction of these materials, which shows a poor understanding of typical ECE settings. Second, that undergraduate students could

be effectively trained in contemporary cognitive development literature to create more accessible research-based materials for typical settings as well as preschools for the deaf.

The initial goal of the project was to translate the last several decades of cognitive development research in early numeracy into usable early childhood (EC) classroom materials. At first, the target population was non-signing deaf and hard-of-hearing (DHH) children; this goal shifted when we recognized the commonalities between the challenges for DHH students and for students facing other risks for academic success and language development. Given that vocabulary development is strongly correlated with early numeracy (Negen & Sarnecka, 2012; Slusser, Ribner, & Shusterman, 2017), children with slower vocabulary development are likely to progress more slowly through numeracy milestones, such as cardinality (Slusser et al, 2017). This delayed learning puts children at risk as they face the high expectations of contemporary kindergartens (Bassok, 2016). The project aimed to teach undergraduates about early numeracy research and issues in deaf education, and allow them to creatively and collaboratively invent lessons, activities, and materials that could be delivered to EC settings with DHH children. Students would share and iteratively revise draft ideas together, collaboratively pilot and refine the activities, and eventually test the collection as a curriculum. Like many research-based interventions, the project as initially conceived flowed in one direction: from lab to classroom.

Several factors changed the one-dimensional lens of the project and contributed to a more open, collaborative, and bi-directional exchange. First, the course developed into a service-learning class, with students visiting local, non-DHH preschools as “Math Ambassadors” to helping with general classroom needs and bring math activities. This led to a channel of information moving from classrooms back to the university and lab, and helped us to realize commonalities between the needs of DHH children and those at academic risk due to poverty.

When the students developed a list of criteria for successful lessons based on their experiences in the classrooms, it included characteristics such as: fun, easy to use, engaging, hold children's attention, easy to differentiate for more and less advanced students, do not require the whole class's undivided attention, and respects teachers' desire for autonomy. The value of incorporating play and games into preschool math programs, as well as materials that can be flexibly adopted into EC settings, echoes past literature (e.g., Ramani & Siegler, 2008; Ramani, Daubert, & Scalise, 2019); one possible reason that EC math curricula are not widely adopted is that they are not sufficiently playful, engaging, and flexible (Lo, 2014; Toomey, 2017). Second, teachers began to watch and inquire about the activities that the undergraduates brought. This unassuming and organic way to model new teaching techniques stands in contrast to the standard model of expert-delivered PD workshops, and it raised the possibility that elements of this soft approach could be used intentionally for disseminating research-based practices.

Third, as the undergraduates observed expensive materials languishing on shelves and teachers who expressed dissatisfaction with the tools at their disposal for teaching math to their preschoolers, we asked how teachers felt about their own training, the materials provided to them, and their desire to teach math and other STEM domains. This line of questioning led to a qualitative interview project, which yielded a surprising finding: while recent studies emphasize teachers' own math anxiety (e.g., Schaeffer et al. 2021), most teachers in our study expressed that they simply needed better materials and information (Lo, 2014). Fourth, while developmental scientists are often advised to keep their messages simple and straightforward when disseminating research, and to focus on providing strategies rather than academic research findings, interviews with administrators revealed the opposite—the practitioners we met with

were hungry for interesting, intellectually stimulating research findings, and wished that they had better access to research-based material.

Ultimately, the project yielded a set of twelve flexible, engaging preschool math activities that are easy to use and simple to differentiate for varying skill levels. A succinct professional development module orients teachers to the research background and the intellectual framework that guides the activities and introduces each game in a few minutes. All the games have been extensively piloted with children of diverse ages and backgrounds and modified until they work across ECE settings, from Head Start classrooms to private preschool centers. The entire set was piloted in a teacher implementation study with the majority of early childhood education providers supported by a public school district ($N=22$). All of the games were exceptionally well received, with high ratings on quality, satisfaction, child engagement, and feasibility scales ($M=9/10$ on all four measures; Toomey, 2017).

We also looked for evidence of the benefits to children, with a brief, one-month pilot study in the local classrooms where students were volunteering as Math Ambassadors. Overall, the four treatment classrooms (total $N=77$) and one control classroom ($N=17$) did not show statistically significant effects on a test of number knowledge (Point-to-X task Wynn, 1992), but the control group's mean score of 70% did not change from pre- to post-test, while the treatment group improved from 70% to 80% correct. A subgroup in one classroom had received a particularly high-dose intervention ($N=8$), with daily visits from undergraduates to play the games. This group showed a statistically significant improvement from pre-test to post-test ($t(7)=3.40$, $p=.012$, and we noted particularly striking increases of about 7% for the four English-language learners (ELL) in the group). The teacher and student outcomes provide a proof-of-

concept that the curriculum could meet the goal of supporting STEM experiences in ECE classrooms, though further research is needed with fully powered and longer trials.

As important as the curriculum itself was, the lessons learned through this project transcend the math activities and can be applied to new domains. Ultimately the project created a template for a collaborative, iterative process for turning research into practical activities; the articulation of multiple ways that undergraduates can foster a bridge between knowledge produced in campuses and real-world settings where that knowledge is sorely needed; and the blueprint for assessing teachers' needs before attempting to implement curricular materials.

Case study 2: Kindergarten Kickstart

How can we better transfer developmental science research to early childhood settings?

As a result of the Wesleyan Preschool Math Games project and its increasing integration into early childhood networks in the area, we were invited by a school readiness coordinator in a neighboring town to help with Family Math Night, an event envisioned as an evening for all newly registered kindergarteners and their families to engage with math. We agreed, and decided to bring the math games that we had developed; at that point, there were just a few and they were in early iterations. The evening was a success; parents commented how much their children enjoyed the "Wesleyan games" and engaged in conversation about child development research. Family Math Night became an annual outing of our lab.

The most important development, however, was the opportunity to witness the undergraduate students playing the games and interacting with children, after just half a semester of academic work about developmental science and weekly visits to preschool sites. They were astonishingly gifted: warm, engaging, energetic, and nimble; they scaffolded children's language

and concepts with surprising skill considering their limited training, and captured children's interest in the games. This episode was the seed of Kindergarten Kickstart.

Family Math Night demonstrated that a small amount of knowledge about developmental science goes a long way in facilitating positive, educational interactions with children. It also highlighted that undergraduates have energy and time to spare, creativity and talent for working with children, and desire for meaningful work. These observations led to a question: how much we could gain by adding research-based developmental knowledge to early childhood experiences, and could this be accomplished using the talents of undergraduate students. The idea of Kindergarten Kickstart was to combine the energy and enthusiasm of undergraduates with their academic preparation, access to university resources, and training in developmental science to provide high quality, research-based early childhood education. It was not immediately obvious how to implement this idea, but eventually it became clear that summer was a fruitful window for intervention: undergraduates had free time and interest in trying something new, children needed more pre-K preparation than they had access to, and school facilities were underutilized. When a community organizer and the local elementary school principal expressed interest in the project, we launched the project, which ran for eight years (until the 2020 pandemic).

Launching Kickstart was exponentially more complex than the preschool math project, with many more stakeholders and problems to solve, and requiring a much higher threshold of trust. However, the translational principles were fundamentally the same. One of the goals of Kickstart was to push the limits the iterative model we had developed in the translational research course: studying research findings, thinking deeply and collaboratively about how to make them tractable, testing those ideas in the classroom, and vigorously and constantly revising

them. We hoped to enact a research-practice design loop, and looked to literature on iterative design, which explicitly posits the benefits of a rapid and cyclical repetition of the create-test-evaluate feedback process (Larman & Basili, 2003). We also wanted to explore if this process would be equally successful with other domains of cognitive development, such as oral language, literacy, scientific reasoning, and self-regulation.

Furthermore, we wanted to understand how research-based interventions play out in a real-world context. For example, how could teachers make choices about allocating their time, when they have ideas for more activities than could possibly fit into a day? How would they adjudicate, for instance, between allocating time to structure experiences using principles of guided play to support concept learning (Fisher et al., 2013), and providing ample time for children to engage in self-directed play, to support executive functions (Barker & Munakata, 2015)? To our knowledge, research has not deeply investigated questions like the optimal balance between these two beneficial, evidence-based forms of play, yet in real classrooms, these are the types of decisions that need to be made. In order to help facilitate teachers' uptake of these strategies, researchers need to have an answer to practical questions like this one. Kickstart provides a real-world laboratory not only to answer many such questions at once, but also to discover what questions need to be answered in the first place for research to migrate smoothly into the classroom. In short, the scholarly goals of the project were to replicate the successful iterative development process, expand to new domains of development, and identify barriers and supports for adopting research-based practices. The people who carried out this work were undergraduate students engaged in the earlier translational project and were willing to fulfill the triple roles of student, researcher, and teacher.

Kickstart project met two critical needs in the community by providing preschool experiences to children who were starting kindergarten without any experience at all, and by extending preschool activities for those children who were enrolled in programs that closed for the summer. The elementary school where the project was based is high poverty, with 80% of the children receiving free and reduced lunch, and the well-documented consequences of poverty apparent at school entry (Perry et al., 2018). Thus, our project aligned with a critical pre-existing need in the community for enriched early childhood experiences during the summer before kindergarten.

Ultimately, the details of the program design looked as follows for the first six years: We created a translational summer Pre-K program that combines insights from developmental science research with the structural components of high quality ECE classrooms. The setting was an elementary school in a poor neighborhood, near a private college campus, within a small, economically diverse city. The program was a full-day program for five weeks, for children who would attend kindergarten in the subsequent school year, mostly at that same elementary school location. Each classroom had an approximate 4:1 student-teacher ratio, with three undergraduate student teachers and one certified lead teacher serving 12-18 children per classroom. The project was led by our laboratory and operated in close partnership with the school district, school readiness council, local early childhood services, and other public agencies. The program included important components of any ECE program (e.g., experiential learning opportunities, guided play, supportive teacher relationships), with the careful combination of explicit developmental science and research training. The curriculum aimed to develop children's skills in key domains of school readiness and served as a professional learning model for early childhood educators to build their understanding of the developmental roots of best practices in

ECE. (The program model shifted after six years to accommodate changing needs in the city: with more summer programming made available to children, a standalone classroom was no longer in critical demand, but teachers in many programs expressed a need for more support, especially for those children about to enter kindergarten. To respond to this need, the program, using its foundational principles and existing curriculum, transitioned to a visiting high-intensity intervention at several existing settings. An advantage of this model is that it can be continued throughout the year and provides a basis for extended contact between the university child development labs and the early childhood educational settings.)

A note on funding: There is a financial cost involved with mounting a program like this one. We have utilized a patchwork of private donations, foundation grants, university allocations, financial commitments from partner agencies, and many in-kind donations of time and resources to help run the project, with the exact funding plan shifting each year. The overall cost is kept low by utilizing free resources, such as donated space. The largest cost is the labor of the students and the certified teacher. A standing commitment from the university has provided stability to help when external funding is not available.

While working with real people in a real community, the Kickstart project seeks to build capacity for a more streamlined integration of research and educational practice in early childhood settings. First, it develops new early childhood educators by providing training on developmentally appropriate, play-based pedagogy. The focus on developmental science provides a shared core approach for the Kickstart teachers, guiding both high-level strategy and in-the-moment decisions. Second, the project articulates the gaps between the promise of a research finding and real-world implementation in actual classrooms, bringing the problems of translation into focus for researchers. Third, it serves as an incubator for the development and

assessment of easy-to-implement, high-impact curricular interventions. The program design enacts a feedback cycle from developmental science research to educational practice and back, by encouraging teachers to try out ideas, analyze what worked and what didn't, and loop back to try again. The process is reflective and analytical, and scaffolds teachers' participation in the iterative design process. Finally, these research-based materials, in turn, go on to inform the classroom practice of the new and seasoned early childhood educators in other settings. Already, Kickstart has helped to refine the math games and develop new research-based, classroom-tested materials and practices in a variety of domains, including children's self-regulation, nutrition, conceptual knowledge, teachers' emotion regulation, and families' integration into the school community.

At the core of the project is human development and interaction. A collaborative team of undergraduates powers the project – a strong, often-underutilized resource that draws on multiple perspectives to move ideas quickly through development, piloting, and revision processes. Although the students are new to teaching in an ECE setting, they can model their practices on the certified teacher; with the standalone classroom model, the quality, expertise, and confidence of the model teacher proved one of the most critical elements for a successful classroom. The high ratio of teachers to students, the knowledge that gets passed down from year to year, and the intensive training and coaching offset the undergraduate students' lower level of experience. Respect is key for success; the short time frame necessitates a rapid building of trust among the staff, community partners, EC center staff, and parents, and this starts with a positive, welcoming atmosphere. In particular, we observed a benefit to the novice of the young project staff, namely the reduced social distance between them and the parents. Having young, accessible staff eased

communication, especially with younger parents who did not initially feel comfortable in the school setting.

The pilot outcomes are promising for the program, with the caveat that we have never run an RCT on the Kindergarten Kickstart program (for lack of any children who could serve as a control group, since every child who was recommended for the program was accepted). Kickstart served 116 children in ten classrooms from 2012-2017. Thirty undergraduate student teachers and six certified public school teachers participated. Children were recruited through community and school engagement, and nearly all of them either had no prior pre-kindergarten experiences or were identified as needing additional support prior to kindergarten. In aggregate data over five years ($n=72$), we observed a statistically significant increase in total scores on the Speed-DIAL-4 school readiness assessment from Pretest, $M(SD) = 96.5(15.6)$, to Posttest, $M(SD) = 100.7(15.9)$, $t(71) = 4.15$, $p < .001$, Cohen's $d = .5$. Statistically significant gains were also observed on other domains, such as executive function, measured with the Head-Toes-Knees-Shoulders assessment (HTKS; Ponitz, McClelland, Matthews, & Morrison, 2009), Pre-test $M(SD) = 12.0(13.3)$, Post-test $M(SD) = 21.3(16.4)$, $t = 4.3$, $p < .001$, with larger gains observed for children with lower initial scores. Scores on the Pre-K CLASS® assessment measured in a single year indicated that classroom process quality was high across domains, with average scores of 6.42 out of 7 on emotional support, 5.89 on classroom organization, and 3.61 on instructional support.

Some notable benefits that emerged from Kindergarten Kickstart were not anticipated. One benefit is that the experiential training in developmental science seems to nurture and strengthen students' commitment to becoming child development researchers or teachers. Of the 30 undergraduate student teachers who have participated with the program, 80% became

teachers or began graduate study in a child development or education related field upon graduation.

Kindergarten Kickstart laid a foundation to start articulating principles of translational research for cognitive development, especially in a university-community partnership. Three themes emerged: an explicit iterative design process, an intensive focus on research, and attention to the human element in bridging research, practice, and design. Drawing on these two case studies and the lessons learned, we lay out ten principles, related to the themes of design, research, and people, to sketch out a theory of what is needed to bridge the research-to-practice gap in translating of cognitive development research to real world settings.

TEN PRINCIPLES FOR RESEARCH-PRACTICE TRANSLATION

1. Understand the gap

The first principle of translating research to practice is to recognize quite how large and complex the gap is. Many research findings imply a behavior that caregivers should or should not adopt. Take, for example, the finding that phone calls interrupting parent-child interactions interfere with toddlers' word learning (Reed et al., 2017). This research just gave parents one more reason to be careful with smartphones – potentially negative effects of chronic interruptions on children's language development. Even clear instances of take-home messages from research such as this one, become fraught when migrated into the real world. The finding is very useful from the perspective of understanding learning mechanisms, but it is not as clear as it seems when it comes to implementing the tacit suggestion. If it were easy, parents would simply nurture their children's language development by silencing their phones. The challenge is

identifying the *barriers* to the desired behavior that prevent people from adopting it, and *bridges* that can facilitate successful uptake of the evidence-based behavior or practice.

In this case, we have identified the situation from the researcher's perspective: an elegant experiment, a clear finding, and a straightforward implication. To appreciate the size of the research-to-practice gap, it helps to consider the situation from the parent's perspective. Due to changes in telecommunications, the cell phone is likely the only phone in the house; there may not be a landline. Turning the ringer off may not be an option; what if one's older child is sick at school, or there is some other emergency? Maybe, due to the exorbitant cost of childcare in the United States, the parent is working from home and needs to keep an eye on the phone. The problem, then, is not simply disseminating research findings in ever-glossier formats or simplifying the message or printing them on diapers. The deeper issue is building a bridge from research finding to implementation, with a more complete understanding of the context into which the research-based suggestion or intervention will be integrated. The better we understand that end-user context, the more distance is apparent between research findings and practice (or behavior, or policy). Even in the most clear-cut cases, translation is hard. Thus, the first principle of translating research to practice is to understand the research-practice gap, appreciate its size, and recognize how much more there is to this type of project than spreading research-inspired suggestions.

2. Invest in developing the intervention

On the road from research to practice, there are countless options for which direction to take and how far to travel. One option is to focus on dissemination, and some developmental scientists have taken this task seriously. In my opinion, you can never have enough dissemination. Send those lab newsletters. Say yes when you are invited to speak with groups of

parents and teachers, or offer up your services. Of course, there is an art to making it snappy and relatable. We can observe the heroes of this work – Alison Gopnik’s TED talks (2011) and Roberta Golinkoff and Kathy Hirsh-Pasek’s HuffPost blog posts (2015) come to mind – and notice that dissemination can be done in a way that is both true to the research and engaging for the audience (Cook & Odom, 2013). This is an area where, collectively, our field could ramp up its efforts. Few teachers and parents are aware of current findings in developmental science, and we have an opportunity to improve the situation.

It may also be worthwhile to question some common dissemination models, particularly one-shot professional development (PD) workshops. Despite their popularity, the literature on PD suggests that such sessions typically fail to change practice in any meaningful way (e.g. Neuman & Cunningham, 2009; Kennedy & Lees, 2015), unless it is accompanied by coaching, which many academics do not have the time to develop and deliver through multi-session programs or individualized follow-up. Moreover, even when participation in PD sessions is required, participant buy-in is often limited.

Importantly, dissemination of findings is not the *only* path to bridging research and practice. A further step might involve designing one or two specific strategies for implementing the research-based suggestion, accounting for more aspects of the natural context. For example, rather than simply explaining the research finding, or suggesting that people find ways to limit phone use around children, one might consider the constraints on parents and aim for small, tractable recommendations. For example, try to find a way to designate 30 minutes each day when you don’t need your phone and can sit with your toddler. Alternatively, consider adopting a different ringtone for work-related calls. With a bit of brainstorming, it is easy to come up with some initial ideas.

What if, however, these are not quite the right ideas, because we have not appropriately assessed the constraints on parents (or whatever naturalistic context applies)? The noteworthy thing about not-quite-right suggestions and completely-wrong suggestions is that both are unlikely to be adopted. Therefore, it is useful to find out about the environment that we hope will absorb the research finding. This is not a matter of creativity and brainstorming; it is a matter of asking questions to the affected people, with open-mindedness, curiosity, and non-judgment.

In our lab, we have stumbled upon a variety of strategies to understand the end-user context, loosely categorized under the umbrella of ‘needs assessment’. These include focus groups, observations, and interviews to gain a better understand of why certain practices are or are not in place, or which kind of suggestions might be more or less likely to be taken up. We use all of these, sometimes as part of a formal process, but sometimes less formally. One particularly effective strategy involves inviting key gatekeepers of the intervention to a nice lunch out, asking questions, building a relationship, and demonstrating genuine interest in their perspectives. Edwards et al. (2015) have employed a conceptually similar “user-centered” design, which placed the needs of the end-user at the forefront of an intervention design for community college faculty.

This work is not a traditional ‘needs assessment’ because, in the case of translational research, the goal is not simply to solve a problem for a particular constituency, but rather to find the smoothest path to integrate research-based findings into a particular environment (Atkins et al., 2006). There is a tension between the distinct demands of the research and the context. Nevertheless, taking a foray into the intervention context, and understanding the needs of the people who will use the research, always yields surprises that enrich and improve the intervention itself. In this case, we use the term “intervention” broadly; this could refer to the

development of an educational intervention, an app, advice for families, a framework for museum signs, or any other practical innovation.

At this point one might ask: *Whose job is it* to translate the research into an intervention that still has integrity to the core concepts? Is it sufficient for developmental scientists to disseminate research findings, and then hope that educators turn them into effective applications? This is, in effect, the status quo: we do not think it is the right one. Even as scientists with a common training, we often misunderstand or misinterpret each other's work; why do we expect that people with a completely different training or perspective will do a better job interpreting our work than we could?

This is not to say that, as developmental scientists, we should try to do all the work ourselves without the input and collaboration of professional educators, curriculum developers, and other experts. But we can decide whether to take on these roles as distant consultants or as primary architects of research-based intervention. By advocating for developmental scientists to “invest in developing the intervention,” we mean that we should invest time, money, mentoring, and our own creativity, jump into the trenches, and see what happens when we try to put our research into practice in the real world. The odds are that it will not work as expected on the first try, and the real investment, and payoff, lies in working to understand the source of the failure and trying to overcome it. Just as in our research studies, where small, seemingly minor variables make a difference in outcomes, so too do minor changes in the interventions affect how individuals respond. This takes multiple attempts and lots of tinkering. No educator will be as invested in developing a high-quality intervention as the scientist whose theory convinces them that the intervention should work. If we want to get to effective research-based interventions, it is

critical for scientists to get involved and stay involved in the iterative development process. Otherwise, many the fruits of many potentially powerful interventions will die on the vine.

3. Appreciate the naturalistic, real-world context

Traditionally, the gold-standard measure of an intervention's success is a positive finding on a randomized controlled trial (RCT), i.e., statistically significant result with a healthy effect size. A common perspective is that a positive finding on the RCT provides a proof-of-concept for the idea behind the intervention. Once an intervention works under ideal conditions, it can be tested in more naturalistic conditions, to see if the benefits survive (for instance, by implementing the intervention via teachers instead of researchers). (For an excellent example of this progression in cognitive development, see Tominey & McClelland, 2011; Schmitt et al. 2015).

Critically, a great deal of work can happen to develop an intervention that will work well under ideal conditions, but that is likely to fail in the real world. Even a seemingly successful intervention, with a strong RCT to back it up, may not be straightforward to translate into an educational setting, due to teacher, classroom, school, or other external factors (Atkins et al., 2006; Cappella et al., 2008). Excluding the end-user context from any point in the process, from development to testing to implementation, creates a serious risk that, even if the intervention looks promising, it won't translate well (Atkins et al., 2006). In fact, prioritizing the 'clean' test of an intervention for ideal conditions might lead to misleading conclusions; a promising intervention might not fare well under the tight controls of an RCT design, while another intervention might seem useful under ideal conditions but have little to offer for real-world contexts. The key ingredients that can be tested easily in RCTs are those that are discrete, systematic, and identifiable. But what if, *in situ*, the ingredients that support the intervention are

not amenable to this structure (Cappella et al., 2008; Zatzick et al., 2006)? Putting our energy into optimizing interventions for experimentally controlled testing often shifts focus away from the design elements that would have made it useful in real settings. Substantial energy is poured into getting interventions to work for the purpose of RCT's, with relatively low promise of migrating to successful implementation. What is the purpose of this exercise; whom does it serve? We would argue that the best development process will keep in mind, at every single step, how the design will play out under natural conditions. If this focus is broken at any point, the integrity and promise of a research-based intervention is diminished (McIntyre, 2006).

As one example, what if the intervention works best with autonomous, flexible decision-making by the teacher about when, how much, or to whom to administer the intervention—knowledge about individual children to which researchers don't have access? This ingredient is likely to be removed from an initial RCT when standards are developed for dosage and fidelity of implementation. In such a case, a very promising idea might be abandoned, or determined to be weak, when in reality it has a lot of potential to benefit children.

The slippage between gold-standard, experimental control on the one hand, and high-quality trials in authentic settings on the other, has been discussed in domains other than cognitive development and education. Researchers studying mental health outcomes have documented the challenges of research translation in their field (Zatzick et al., 2006). In the traditional approach, *efficacy* trials take place under optimal conditions with as many variables controlled as possible, in order to maximize the possibility of finding any effect of an intervention, and *effectiveness* trials take place under authentic conditions to see whether the intervention show a benefit despite the noise of naturalistic settings (Atkins et al, 2006; Singal et al., 2014). However, ideas that work well in tightly controlled RCTs often fail when migrated to

authentic settings, and picking apart the ‘magic ingredients’ of the success of an intervention becomes such a time- and labor-intensive project that years go by before any patients, or students, have hope of benefitting from promising treatments.

Consequently, Atkins et al call for a ‘hybrid’ translation model in the domain of mental health work. This model integrates efficacy and effectiveness goals simultaneously rather than sequentially, asking researchers to consider the needs of the authentic setting from the very initial stages of development, and insisting that each stage of the development and testing process accounts for how likely the intervention is to work *under the conditions in which it will be used*. This approach highlights the goal of intervention research – to bring the fruits of academic labor to the community who can benefit from it. As Atkins et al (2006) state: “Given the enormous public health consequences of the lack of available and effective mental health services, we no longer can afford research that neglects the natural state of affairs or that leaves others to translate research into practice. It is time to acknowledge that the process of testing interventions in the university for transfer to the community is neither efficient nor empirically justified.” The same thing can largely be said of cognitive development and education. Formulating a paradigm for hybrid research models in cognitive development and education should be a goal for translational research in developmental science.

4. Maximize uptake, not just efficacy and effectiveness

In education research, it is critical to think not just about efficacy and effectiveness, but also *uptake*—whether the people who could adopt an intervention decide to implement it, follow through on this decision, and incorporate it into their settings. Just because an intervention can work, does work, and has a strong evidence base supporting it, does not mean it will be adopted in educational settings. (For a detailed analysis of this issue from the mental health field, see

Proctor et al., 2011). In some clinical fields and in prevention science, this sub-area of research exploring how interventions make their way into community settings is known as implementation research, which focuses on questions such as how and why interventions succeed or fail once they cross the gap into real-world practice (for an example of one comprehensive implementation framework and the ways in which it can be applied to existing interventions, see Meyers et al., 2012). For instance, studies may explore whether a failed intervention was poorly conceived in the first place, or whether there were problems with the implementation of a potentially effective intervention that explain a poor outcome in that setting (for an in-depth explanation of the differences between planned interventions and planned implementation systems, see Greenberg et al., 2005). The last several years have yielded a rapidly growing appreciation for the importance of developing a systematic framework for implementation science, and various taxonomies and frameworks that could be applied, at least in part, to addressing the relationship between cognitive development and education (see Michie & Abraham, 2004; Michie et al., 2011; 2013; Neal, et al., 2011).

Out of the many variables that could be considered under the umbrella of implementation research, cognitive development and education have focused primarily on feasibility and fidelity. Both are highly important for understanding how well interventions can withstand variable conditions – for instance, some interventions require high fidelity to show their effectiveness, while others might not. Reflecting on our lab’s efforts to migrate our research output into the community, we propose that we add *uptake* to the list of high-priority considerations. By uptake, we mean taking into serious consideration as to whether the gatekeepers for adopting new ideas—in an educational ecosystem, these might include teachers, superintendents, curriculum personnel, preschool directors—will meet the intervention with enthusiasm and motivation to

incorporate it. One successful strategy to increase uptake is to meet the expressed needs of those gatekeepers. Qualitative methods for conducting observations, interviews, and focus groups can eliminate much of the guesswork about what teachers or other gatekeepers need and want, and what deters them from implementing the research-based materials that already exist in the marketplace (see Everhart & Wandersman, 2000, for a model of community stakeholder needs assessment in school-based prevention programs).

In the implementation research literature, needs assessment is often listed as an early step in deciding whether an intervention will fit into an existing organization—in this case, an educational setting (e.g., Mendel et al., 2008). However, we suggest it is useful to think of it as an ongoing mindset rather than a discrete step. Needs assessment is useful in the early stages of developing, thinking through, or implementing an intervention, to make sure that the final product will match somebody's existing needs; it is also useful once an intervention project is underway, to continually monitor the match between the priorities of the educational setting and the capacity of the intervention to address them.

We have found that taking substantive concern to find out teachers and other gatekeepers' desires can help to illuminate gaps in practice and overturn presumptions that researchers often bring to the table. For example, it has been commonly noted that there are many missed opportunities to teach mathematics in preschool classrooms (Early et al., 2010; Hindman, 2013; Phillips et al., 2009). One reason for this often given in the research literature is that preschool teachers are math-averse (Baroody et al., 2006), and their math anxiety keeps them from engaging with the subject matter (Geist, 2015). Such conclusions about preschool teachers extrapolate, to some extent, from studies on early elementary teachers (Beilock et al., 2010). In order to better understand the reality for early childhood educators, Angela Lo

embarked on a qualitative study in which she interviewed 14 preschool teachers, in diverse settings, on their approaches to math (Lo, 2014). What she discovered was that teachers expressed less anxiety about math than one would expect given the literature, and more a sense of frustration about the lack of comprehensive training, well-articulated standards, and high-quality materials to use in their classrooms (see also Cook, 2017). Lo concluded that teachers have received the message that math should be taught in early childhood, but little information about how to do so. The gap in research-to-practice translation became very clear in these conversations: teachers were missing research-based materials and training; in fact, it seemed plausible that such tools would alleviate anxiety and increase their self-efficacy in this domain.

This example is instructive because, by focusing on what teachers want and need, we increased the chances that they would be interested and enthusiastic about what we had to offer. We were able to focus on the critical problem from teachers' perspective – their lack of high-quality materials and information – rather than analyses of the problems from other points of view, such as lack of intensive math training or high math anxiety. Addressing those other problems might get results, but it is unlikely to get the same *buy-in from educators*. When teachers, or any stakeholders, feel their needs are being addressed, they are more likely to become invested partners in the project at hand. Now, when addressing groups of preschool teachers, we can say, "I have heard from other early childhood educators that this [in this case, lack of high-quality, research-based materials] is a big concern. Is that also the case for you?" Because there are many commonalities across diverse settings, the audience will often agree, and then we can address their problem with novel solutions; they are receptive because we can validate and solve a real problem that they have experienced. In the end, a research-based solution, from developmental psychology or anywhere else, will be of no use if practitioners do

not choose to use it. By focusing on uptake at every stage in the research-to-practice translation process, we can differentiate among interventions that have equal levels of efficacy and effectiveness, but vastly different likelihoods of gaining traction in educational settings.

5. Acknowledge power and status differentials

One of the biggest challenges in university-community partnerships is the difference in power and status granted by society to university researchers and teachers, especially early childhood educators with whom we have done the bulk of our work. This status difference takes many forms, from salaries to benefits, job stability to working conditions, support for professional innovation and autonomy to differences in whose knowledge is admired and compensated. In light of these inequalities, pretending to be ‘status-blind’ with stakeholders in our intervention work does not make us egalitarian, any more than pretending to be ‘color-blind’ makes us anti-racist (Neville et al., 2000). Universities carry a certain social capital, but this can actually undermine the work of building bridges from campuses to educational settings, because the difference can cause conversations to start from a place of distrust rather than collaboration. This barrier needs to be acknowledged and worked on for meaningful partnerships and for the work of the university to find a place outside of academia.

Researchers should treat the project of disseminating and translating research as a two-way street with practitioners, thinking beyond transfer of knowledge from university to world, and shifting to a model for exchange of ideas (Cain, 2015; McIntyre, 2006; Huberman, 1992). When the information flows in multiple directions, insights from practitioners will necessarily influence researchers’ thinking about the research-practice gap and illuminate natural opportunities for bridges. By demonstrating genuine openness to what practitioners have to offer, the dynamic shifts; practitioners become more open to the resources and knowledge that

researchers have to offer, and researchers gain more understanding about the context and settings where their work can be applied (Han, 2012; Knight et al., 2000).

Several approaches can help break down power hierarchies and facilitate more meaningful exchanges between researchers and practitioners. First, researchers can try their hand at developing everyday classroom practices based on their research. This can be a humbling experience that helps researchers build empathy with teachers, and it can demonstrate to teachers that we are willing to try to solve the translation problem rather than just provide theoretical findings. A developmental researcher's willingness to get into the classroom indicates an appreciation for the gritty work of spending long days with young children, reducing the distance between researchers and practitioners (Atkins et al., 2006; Hiatt et al., 1997).

A second strategy, one that we stumbled upon by accident, involves inviting undergraduates to facilitate the bridge-building work. Much of the research-to-practice work was initiated when the course described in the case studies added a service-learning component for students to volunteer weekly at preschools. While the initial goal was simply for students to get out into the community and enhance their academic learning, much deeper benefits soon became apparent. An enormous benefit came from the relationships between the students and preschool teachers. Individual teachers, some of whom had been reluctant to participate in professional development about early mathematics, allowed the undergraduate students to set up math games in their classrooms. When children responded well to the undergraduates and the math games they brought, the teachers expressed curiosity about the materials and activities. Over weekly visits, the teachers began to approach and ask questions about the games. We discovered surprising and substantial benefits from sending enthusiastic, young, well-prepared 'math ambassadors' who did not apply any pressure to the teachers to change but simply and quietly

modeled some new possibilities for engaging children in math. The same story unfolded in classroom after classroom; after three or four weeks, the volunteers would come back and report that teachers were asking more engaged questions about the math activities, or that in between visits the teachers had pulled dusty old math materials off the shelves and found new and inspired ways to use them in the math center. What became apparent was that the undergraduates unraveled the status hierarchy that puts science above teaching. Teachers felt free to approach and explore new strategies and ideas, and to reject some, without feeling scrutinized or judged.

The surprising and consistent effectiveness of the ‘math ambassadors’ project led us to think about the role that power and status play in blocking people’s receptivity to new ideas. Ultimately, we concluded that undergraduates could and should be marshaled as a central resource for spreading research-based materials through classrooms. Students can go out in large numbers and visit schools over sustained periods of time, make themselves useful in busy classrooms, and demonstrate new research-based tools that teachers might choose to adopt. The ease of transmitting new ideas in this project stands in stark contrast to the well-documented difficulty of convincing people to adopt new behaviors after explicit training in PD.

While undergraduates provide a useful mechanism to shift the status dynamics and lower the barriers to invite teachers to try something new, over time we realized that any steps to deconstruct the expert/non-expert distinction help to ease the conversation and increase educators’ openness to new ideas. A few genuine words to remind early childhood educators that we recognize the importance of their work can help to offset negative societal messages about the relative value of different occupations.

A third strategy involves shifting economic resources in order to remediate some status and power differences. This involves finding or using money or other resources at your disposal

for that purpose, for example by paying people to participate in your dissemination or translation projects. One year, a small foundation gave us a parent engagement grant, but insisted that we pay the parents as ‘co-researchers’ in the process of discovering how best to conduct parent engagement workshops. This was a new idea for us, but it seemed interesting enough to try. It was a transformative learning experience. The financial reward may have motivated some people to attend who might not have otherwise, but the effect of the payments went beyond simply spurring people to show up. It elevated the importance of the work all around, and fostered a mutually respectful atmosphere in which everybody had a common purpose and a stake in the outcome. Over the weeks that we met, this small equalizer – the idea that we are all getting paid to do work – infused the tone of the workshops and fed forward from session to session. It was clearly evident in the level of participation, quality of discussion, and sense of commitment. When we tried to replicate the same workshops in a subsequent year without the payments (the mission of the funding agency having shifted to other priorities), the difference was palpable. Collectively, academics can allocate grant budgets to support dissemination to non-scientific audiences, or petition their universities to fund this work in the interest of valuing university-community partnerships. Before this experience, stipends for participants in research outreach workshops was not a line item in our budgets. Money changes people’s relationships to the interaction, and paying everybody, even if the project is not explicitly or implicitly a research project with participants, honors people’s investments and contributions. More importantly, a stipend tilts the status differential from one person who is paid for knowledge and another who receives the knowledge, to a mutual space of shared knowledge.

6. Collaborate

Although it seems obvious that university-community partnerships will entail collaboration, any list of core principles must include collaboration, and it is worthwhile exploring what collaborations might look like – when, how, and with whom (e.g., Flaspholer et al., 2012). As illustrated in the sections above, the most important collaborators are teachers, parents, or other end-users of research-based interventions; this perspective respects the knowledge that they bring to the work and increases the odds of research uptake in natural settings.

Other researchers are also natural collaborators. One of the barriers to developing high-quality research-based interventions is the suspicion that researchers often have that their work is not ready or complete enough to be applied. While this might be the case for an individual's work, when we consider bodies of research in developmental science, there is often a basic consensus that emerges in research communities. This consensus about the weight of the evidence can support the development of suggestions for practice. Any individual research program does not have to be perfect in order for its findings to start being applied; in fact, the sense that research is 'not ready' may lead to hesitation about diving into the translation of research to practice. Collaboration with other researchers can be helpful to decide on a consensus position to support translation, and to add complementary knowledge and perspectives. Translational research benefits from many minds and it is not a zero-sum game, so banding together to move the field forward makes sense for all.

The other arena where other researchers become valuable partners is to fill in gaps in areas far away from one's own expertise. In our work, we found that many of the children we work with had histories of trauma. It would have been irresponsible to continue the work without taking a deep dive into developing an understanding of cognitive and emotional development in

children with trauma. The situation called for the development or recruitment of new expertise. We benefitted greatly from bringing in child mental health professionals who have worked with the same families to help us develop new big-picture strategies and provide training and support.

A third area of collaboration is with community agencies, such as schools or nonprofit organizations, as well as funders. The relationships with these organizations are often highly dependent on local, ephemeral conditions of staffing, personalities, priorities, and money. Often, the positions of researchers at universities are more long term and stable than any of these other groups. In a sustained, multi-year project, everybody else may rotate out over time while the university researcher stays. This stability is an asset; faculty are in a good position to weather storms like school personnel changes or shifts in funding. Over time, sticking around through ups and downs in a community can engender trust and result in opportunities to engage in more innovative translational work that would not get off the ground if the relationships were new. It is helpful to build redundant relationships with multiple stakeholders; if one exits the system, others are in place so a long-term project does not collapse; and to build flexible relationships, so that different resources can be marshaled when needed.

When thinking about potential community partners, there is often a treasure trove of knowledge in offices around one's own university. In our case, the translational projects we have carried out would not have been possible without supportive individuals in the Office of Community Partnerships to provide infrastructure for initial meetings and ongoing perspective, and the Wesleyan's Patricelli Center for Social Entrepreneurship to coach students and lend expertise on bridging academic work with community projects. Students need substantial mentoring to behave professionally in the community and to think about their community impact

more than one semester at a time; these offices were critical to facilitate both a general culture of civic engagement and students' specific skills for entering the wider community.

Over the years, the one consistent lesson we learned is that you never know where help will come from when you need it – and lots of help is needed when bringing research-based programs into the community. One time we wanted to bring a group of children on a field trip to the school building for them to see their future kindergarten classrooms, but the transportation fell through. With the school district offices quiet in the summer, and the cost of buses exorbitant, the Superintendent herself heard about the problem and jumped in to help; within ten minutes, she had materialized a bus for the afternoon, recognizing the value of a visit to the school building as a rich experience for the children and a thoughtful complement to the gentle ramp to kindergarten that our program provided. Before this moment, we knew she had signed off on the program but we did not know if she had any investment in it; after, we knew she was our ally.

Finally, some of the most intensive and fruitful collaboration in translating research to practice happens among students. This process requires constant creativity, imagination, intellectual synthesis, and perspective-taking. It is difficult, if not impossible, for one person to think through all of these pieces at the same time. The breakthroughs often come through working in collaborative groups to develop more complex ideas and hone materials and activities through discussion. In a group, different members can help cycle through the critical questions – Does this activity make sense given the research? How will it feel from the teacher's perspective? The child's? What are we missing here that will make or break this activity? – to attain the level of polish that is necessary for successful implementation in the classroom.

Different priorities, knowledge bases, and work styles can enhance or impede collaborative efforts. Sometimes these differences can seem difficult or even intractable; the more one tries to collaborate with people with completely different backgrounds, the more risk there is of conflict in priorities. Developing a deep bench of collaborations in the community can help buffer this risk. Therefore, our advice in bridging research to practice and the community is to cast a wide net and find as many trusted partners as possible to support the work.

7. Leverage resources

Faculty, staff and students at universities should not underestimate how many resources we have access to, and consider strategies to share these resources more widely. It can be disheartening to look at US education systems today with all of their challenges, to see vast inequities in spending, overinvestment in after-the-fact remedies to systemic problems, and underinvestment in preventative measures. But in all this challenge lies opportunity—for improvement, engagement, and refusing to cynically dismiss the future of children’s education. In every community and educational system, powerful assets can be found. At universities especially, there are many resources that can be leveraged in service of solving complex problems like those in education—knowledge, expertise, capital, labor, space, time, creativity, credibility, and so forth.

We believe the most powerful resource on campuses is its students. When we first launched this long inquiry into translational research, the workspace was the course described in the first case study above. The goal was to learn about an area of research and try to develop some new, research-based materials for preschool children. Instantly, fifteen people were invested in the journey. Because it was both academic and emotionally resonant, there was something for everybody in the course; different students latched onto different aspects. They

spread out to a range of preschool settings, from Head Start to a private childcare center, and returned with stories. The comparison across centers allowed us to think widely about how different kinds of activities worked in different settings. Where it could have taken months to research subtle and stark variations across settings, with fifteen people we could gather that information in a week. Relative to other methods of needs assessment, the service learning placements provided a less obtrusive, less formal, and more sustained pathway to learn about the constraints of educational settings. Sometimes, an idea that seemed fantastic in the abstract would be shot down by an undergraduate who could explain quickly why it wouldn't work in their setting—usually because of banal realities like the location of the refrigerator or the timing of teacher breaks. This model allowed us to rapidly filter out some ideas and refine others, moving toward ideas that were more likely to work well across settings. The course allowed students to harness their academic preparation, creativity, and passion for meaningful work, and to collectively try out many ideas before settling on the most promising ones. The sheer amount of human power in an undergraduate classroom, when channeled toward a common purpose, is hard to replicate.

Another approach to leveraging resources is seeking under-utilized or untapped spaces, materials, and time. For example, we decided to develop a summer bridge-to-K program because in the summer school buildings are available but under-utilized, and undergraduates are looking for interesting work. Summer suddenly presented itself as a bundle of opportunities. As it turned out, the preschool classroom in the elementary school near our campus was leased to an external program, which closed for the summer. This room became the first home of Kindergarten Kickstart. What we learned from this experience is that university-community partnerships are much easier to develop if the resources required are easily available. For instance, space is at a

premium during the school year, but abundant in the summer. It helps to discover and capitalize on these gaps. Finding existing resources can also mitigate the cost and expenditure associated with translational projects, limiting the need for substantial outside funding.

Additional helpful resources might be found on campus. One of the best discoveries of our project was the capacity of the university machine shop to help produce the physical math games for our early numeracy project. The director of the machine shop took an interest in translating student prototypes into sturdier objects and he became a mentor to students who, it turned out, loved going to the shop to build the math toys using all kinds of different woodshop tools. This turned into a serendipitous and long-term design collaboration. The point is not that everybody needs a machine shop with a cooperative director; rather, that in every community and university, there will be hidden treasures that can be harnessed in support of the goals of a translational project, and it is worth finding them.

Community-based resources can also fill in gaps when needed. As mentioned earlier, child mental health professionals from the community communicated their willingness to help in training and coaching, and they donated time to work with families in need during our summer program. Some summers, the level of mental health needs that presented themselves were much higher than what we had anticipated or prepared for. The clinical staff sometimes knew the families already from previous interactions in other settings, and thus provided invaluable continuity for support. Importantly, if they encountered a high-needs family first in our program, this represented a last chance to work with the family before they entered the school system, and also indicated a potential gap the early childhood screening systems in the community. This information was useful and important for them. Because they saw our mission as aligned with theirs, and because we welcomed their help, this resource transformed our ability to provide a

service and create the platform for research-based intervention. Were it not for these critical supports, it would have been tempting to give up on the program entirely. Their commitment to facilitating positive experiences for children with high needs allowed us to find our footing.

In each of these examples of leveraged resources, both sides were willing to collaborate and everybody got something out of the arrangement. Students in the course, in addition to a course credit, gained an opportunity for creative, rigorous, innovative work. The preschools that welcomed them for volunteer service gained extra hands at no cost. The staff at the elementary-based preschool site was happy to know that summer experiences would be provided for the students leaving their program and heading to kindergarten, and the elementary school personnel appreciated a summer program that was likely to be beneficial for their newest students. The director of the campus machine shop enjoyed the strange design challenges we brought forward and the opportunity to mentor a new cohort of students in his craft. The mental health professionals were deeply invested in their work and therefore were glad to consult on cases with families they already knew as well as support what they saw as a positive early childhood program in their community. In each case, the resource was initially identified without a clear path toward collaboration; but the resources were made available, and became increasingly valuable, because both sides found mutual goals in which to invest.

8. Respect

This is the most important of the ten principles. Nobody wants or intends to be disrespectful to teachers; after all, most researchers also consider themselves teachers. But, based on my experience collaborating with educators on these projects, we would like to examine some assumptions that sometimes are apparent when researchers interact with teachers and make suggestions for different practices. Some critical elements of demonstrating respect have already

been mentioned. One suggestion is to shift out of ‘expert’ mode and be willing to share expertise and learn from educators. Here is a simple exercise: the next time you enter an interaction with teachers, find something that you would like to discover about their perspective, and ask about it.

A mantra that is often repeated to scientists who want to disseminate their work to lay audiences is to simplify the message. But there is a difference between simplifying the presentation so that it is straightforward, and simplifying the content so much that feels “dumbed down.” In the early days of this work, a foundation provided a grant to take educators and other stakeholders to lunch and find out what they wanted from academia. It was the same foundation that coaxed us to pay parents for attending workshops, and the request to host lunches was initially equally perplexing. We thought researchers knew what people needed – all of our scientifically accumulated information, digested into simple tips and hints.

According to the stakeholders we lunched with, this was completely wrong. Teachers, administrators, and other stakeholders in educational settings do want to know our information. But contrary to what we often hear, they are not averse to hearing about the scientific theory, experimental set-up, or detailed findings. I encountered a thirst for intellectual connection around the science of child development, especially cognitive development. The people I spoke with – program directors, legislators, advocates, and teachers – reported that they had no access to the output of research. The choices were reading primary source journal articles, which they didn’t have time to do, blurbs in Parents magazine, which underestimated their intellectual motivation and capacity, and the occasional newsletters from child-serving organizations, which might provide a few good tidbits but generally served to validate existing beliefs rather than inspire with new knowledge. While I had been trying to simplify the scientific narrative in an effort to increase interest and engagement, the target audience actually wanted *more* complexity.

I decided to follow to the results of these new ‘data’ gathered over nice lunches and informal conversations. In my numeracy training, I added theoretical material about different cognitive systems for mathematics. I discussed theories about why learning to count is hard, no longer glossing over the challenging aspects of the explanation. The result was immediate and surprising to me, and has now proven itself multiple times with different groups of teachers and settings. Teachers were fascinated to hear these details. Is it very practical and applicable to understand that other species also have something like our Approximate Number System (Dehaene, 2011)? Doubtful. But was it exciting for teachers to think about the ways that their students’ brains are in some ways similar to salamanders and in other ways uniquely human? Did it make them much more curious and motivated to engage their students in mathematical experiences? Definitely; that is what I witnessed.

The takeaway from this very informal study was that there is a large space for researchers and educators to connect intellectually. How can we make use of it to effect change and to facilitate bridge the research-to-practice gap? The first step is simply to respect the basic intellectual curiosity of teachers – people who work with children. It is safe to assume that many are interested in developmental science. The presentation of the science has to be clear and straightforward, but that is also the case when we teach any audience new to the material; in other words, we already have the tools at our disposal to captivate people’s interest in science.

Cultivating and demonstrating respect for teachers’ work – not just for their remarkable patience, organizational skills, and quick-witted problem solving, but for their journey on a parallel path to us scientists, with deep human curiosity about children, development, and cognition – is a different approach to research dissemination than the status quo. When we have the opportunity to talk about research with teachers, it is important to distinguish simplifying a

scientific explanation so that it is clear, from distilling research until it is too watered down to be useful.

In addition to sharing expertise and cultivating intellectual respect, we want to note some other mindsets that fall under the general umbrella of ‘respect’. First, it is always helpful to recognize the values of other stakeholders in educational settings, even when they differ from one’s own. If possible, it is helpful to engage others by finding alignment between one’s goals in the research intervention and the practitioners’ values (Everhart & Wandersman, 2000). Second, in designing research-based interventions, it is important to remember that most people value autonomy; overly scripted curricula or interventions diminish autonomy, and teachers express this as a central value (Lo, 2014). Third, in the design process, it is critical to find ways to fit into existing structures; even the most brilliant intervention will have difficulty with adoption if not designed to fit into the current infrastructure. I file this under ‘respect’ because when we fail to provide materials that work in teachers’ or practitioners’ real-life settings, it can signal disrespect or a lack of interest in their reality. One reality is that teachers often have limited control to change macro-level aspects of their school or program; therefore, it is incumbent on us to help figure out how interventions can be embedded seamlessly into the structure that exists.

9. Practice iterative development

Iterative development is a concept from design and engineering, often used in software design (Larman & Basili, 2003), which has now been adopted into the creation of curricular interventions (the Institute for Education Sciences recommends an iterative process for Design and Development Research, IES, 2018). The premise of iterative development is that the design process should be cyclical, going through planning, prototyping, analysis, testing, and evaluation stages and then back through the whole cycle, as many times as necessary, to improve the

product or intervention until it meets the presumed need. This is different than a traditional model in which each step takes place sequentially, with progressive phases of planning, design, development, and production. An example would be an intervention development with one or two development phases with a pilot at the end of each one, resulting in two discrete opportunities to integrate learning from the field. In the traditional model, feedback is more valuable early rather than late, and there is less flexibility to change the closer one gets to the final product. However, in the iterative model, shorter and more incremental cycles mean that there is less commitment to particular design decisions and more flexibility to adapt to feedback throughout the process. Related to the idea of iterative development is the concept of rapid prototyping, which allows the designer to get a sense of how the product will work for the end-user in context to feed back into the iterative process. These are now staple ideas in the design of products and interventions (e.g., Martin, 2014) and they are essential for developing research-based interventions bridging cognitive development and education (for examples of this in educational intervention literature, see Diamond & Powell, 2011; Kerns et al., 2011).

In the translational research class case study, the initial focus was on testing the hypothesis that undergraduates' creativity and time could be harnessed to make an impact in the research-to-practice space. Though we did not know about formal design processes or iterative development when starting this project, we implemented many of their principles. We started with the idea that contemporary research in early numeracy could inspire interesting and novel interventions for preschool math. Students in the first semester of it would learn about the research and, for a final project, design and test a research-based lesson plan. The students in the next round of the course learned the same initial information, but instead of designing a new lesson, they inherited the lessons from the previous students to test and refine them. With this

plan in mind, we thought that in two or three iterations we might have some promising ideas.

The ideas were promising, but far from complete, and an iterative framework was the linchpin for development.

The first group of students created strikingly original and exciting activities. The second group of students initially rebelled at working with those activities, wanting to throw out everything and start from scratch on their own; I had to convince them that it was important to develop lessons that worked not just for one student but that could survive being passed through many hands and tested in multiple classrooms. After making a grudging peace with the project, they gamely completed a refinement and new test of the lessons for their final project.

At this point, six students from the second class asked if they could keep working on the project. They were tasked with deciding on our next step, and what they spontaneously came up with was an iterative design process. They selected the eight lessons that they thought were the most promising, based on their own observations and on the students' write-ups about how the pilot-testing had gone. The students identified early childhood settings where they could try out the games each week: a Head Start, a community program, the campus preschool, and a drop-in playgroup, to maximize the diversity of field sites. They arranged for one person to go on Mondays to one place, another to go Tuesdays to a different place, and so on. Each week, the Monday person would test the activity, and hand it off to the Tuesday person with feedback and suggestions for how to change it; the Tuesday person would repeat this process and hand off to the Wednesday person, who handed off to the Thursday person. On Fridays, the group met and discussed that activity, drafted their notes about the adjustments that were made, and updated the guidelines for the lesson. By the end of the semester, they had completed several well-refined lesson plans that were successfully implemented across variations in instructors, groups of

children, and settings; additionally, we had developed, rather accidentally, a systematic model for iterative development of research-based lessons.

We adapted this model to continue developing and refining math activities, rounding out the mini-curriculum we now call the Wesleyan Preschool Math Games. By combining the iterative process with two other key ingredients, namely undergraduates' creative labor and collaboration from a diversity of preschools willing to let us test there, we built a research-to-practice engine. The core elements of this engine are (1) a team-based approach to bring in a variety of implementation attempts, perspectives, and new ideas; (2) explicit and incremental (i.e., daily) reflection on each instance of implementation noting what worked and what didn't; and (3) explicit decisions on what changes should be made for the next iteration and why. With this machinery in place, we are now positioned to consider what other kinds of interventions would be worth developing with this machine (as well as testing and disseminating the Math Games). This model should be replicable in other settings. Other researchers have access to courses and undergraduates, collaboration from test sites, and ideas for interventions that could be developed and refined through an iterative process. This is a model for the creative and energetic translation of research to practice that anybody can try.

10. Simplify the final product

There is plenty of complexity in research-to-practice translation. Earlier we mentioned the value of presenting background research to teachers with complex scientific detail; the iterative design process, and the process of learning to integrate one's work in communities and systems, all of which are quite nuanced. However, there is one place where simplicity is absolutely essential, and that is the product that enters the educational setting. The simpler the materials and the implementation, the fewer problems will arise, the more intuitive the product

will be to use, and the more likely it is to become successfully integrated into a classroom or other educational setting. Getting to the point where the intervention materials are simple and straightforward is one of the benefits of using iterative design, as it provides a clear process to buff out any rough patches by tinkering until the obstacles disappear. One of the surprises in developing the math games was how many more iterations were needed *after* the games were nearly finished but not quite seamless (sometimes three or more).

A more thrilling surprise was how easy the finished games were to explain to teachers once the materials were made simple and specific; on average, each game took less than two minutes to demonstrate. The games were equally simple to explain to preschool children. As a result, children took initiative to play with the materials on their own, pulling them off the shelves, creating their own mathematical experiences; the materials invited mathematical play

Simple interventions can be powerful, flexible, and well-motivated. It is helpful to develop a specific intention or goal for the materials, so that each pilot test can clearly reveal whether the intervention or material accomplished that goal. Iterative adjustments that are made with the goal in mind eventually strip away any extraneous instructions, materials, or steps. Accordingly, the complement to simplicity is specificity. Research-to-practice design plans that have a clear and specific goal should lead, eventually, to an end product that is closely aligned to that goal, well matched to the research principles that inspired it, and easy to integrate into classroom practice by a teacher who buys into that goal. In a good design process, the final product looks deceptively simple because the intention behind it seems practically transparent.

A CALL TO ACTION

The call is simple. Many of us involved in cognitive development research are cautious about overselling the educational implications or importance of our work, or we might hesitate to believe that the findings are ready to turn into interventions. On the level of individual research findings, this may be prudent. Collectively, however, as a field, we have a lot to offer, especially since the cognitive development findings that many educators have access to are decades old and often out of date. We have an obligation to share the fruits of our field's discoveries, and one way to do this is by taking on the task of translating the findings into practical use. We also have a lot to learn from the people who spend every day in community-based educational settings. If the two communities make contact, both will benefit from an ethos of respect, exchange, and shared expertise.

For those who accept that challenge, we hope that this paper provides useful guidelines and illustrative examples. A target audience for this essay is developmental science researchers who have toyed with the idea of developing research-based interventions or ramping up their outreach work, or those who have tried to do such work but encountered frustrations and pulled back from the effort. There are so many opportunities to use our field's knowledge in creative ways to support or facilitate children's intellectual, social, and emotional development, and we hope to move the dial in favor of encouraging more translation, more risk-taking, and more engagement with the world beyond the borders of laboratories and campuses.

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