

# **Advancing Research on Learning Variability**

## Research Agenda

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## Abstract

Variability is commonplace in children's development and learning. Individual children vary over time and across domains of functioning (within-person variability); groups of children learning together have heterogeneous skills, behaviors, characteristics (within-group variability); and children are expected to operate successfully in a world of divergent and ever-changing contexts (contextual variability). Yet, educational systems rarely meet the demands of these different types of variability. Research, likewise, can do much more to fully embrace learning variability across the subfields of learning and development. If education systems are to address the various and morphing needs of children, the research community must build on existing traditions in population variability, child development, and learning research to vastly expand the knowledge base of how children change and differ in learning settings, and how children come to be prepared for the multitude of contexts they will encounter throughout life.

This document was developed by the Jacobs Foundation with input and feedback from more than 50 experts on learning and development. This research agenda is intended to establish a scientific basis for designing education systems and programming that consider variability, and to support a multidisciplinary research community that seeks to improve children's learning and development globally. The agenda will be used by the Jacobs Foundation as a guiding framework for its research work and to serve as a public resource to inspire conversation among researchers and research funders on supporting and embracing learning variability in child development and education.

# Introduction

## Learning Variability

Childhood is full of encounters with learning variability – inconsistency within one’s own behavior, diversity within the peer learning groups to which one belongs, and differences between the contexts one encounters each day. Yet in education, children often experience one-size-fits-all models of instruction that cater to a hypothetical average student rather than classrooms of varied and multidimensional learners.<sup>1</sup> Education systems continue to value standardized instruction and outcomes over attention to how children vary over time and contexts, creating an uphill battle for promising efforts which provide children with experiences tailored to their skill levels or interests, or which support individualized learning plans for neurodivergent students. As a result, too few children have learning experiences that sufficiently prepare them to fulfill their unique learning potential or meet the demands of the different contexts in which they will operate now and in the future. At the Jacobs Foundation, our three decades of supporting cutting-edge, multidisciplinary research on child and youth development has shown that education systems across the globe do not adequately address children’s individual needs and do not sufficiently account for the multidimensional factors that shape learning.

The Jacobs Foundation embraces learning variability and invests in the creation of learning environments, experiences, and ecosystems that adapt to children’s various and changing needs and equip each child with the knowledge, skills, and qualities to reach their full learning potential<sup>2</sup>. This investment starts with research. Researchers are the source of growing knowledge of how cognitive, social, and emotional development are influenced by genetic, cultural, and environmental factors and epigenetic processes to determine what and how well children learn in a given situation. They can further our understanding of how variability in learning groups arises from prior gene-experience interactions on the one hand and how it is influenced by the current learning context on the other hand, knowledge which should contribute to the design of learning experiences. Importantly, researchers also can play a critical role in practical educational decision making by providing policy makers, educators, and designers with the findings and frameworks which ground their practical decisions in rigorous scientific thinking. With this in mind, it is imperative that scholars embrace the study of learning variability across the subdisciplines of learning and development research, in particular addressing three types of multidimensional variability – within learners, within groups of learners, and across contexts. A deep understanding of variability in synchronic and diachronic development and learning should help improve the design of children’s learning experiences compared to current practices, potentially supporting children more effectively to achieve their full potential as dynamic individuals in a changing world.

Currently, learning and development research still favors methods focused on short snapshots of time, group averages, and single environments, which ignore the fact of variability within people over time, between people, and across contexts. When learning variability is acknowledged, across disciplines researchers disagree about its origins, significance, how to address it, and when to embrace versus reduce it. For example, regarding origins, individual differences research has flourished over decades to explain and describe differences between people, with much success, but it may benefit from further consideration of social and institutional causes of individual differences, such as differential impacts of political conditions on some groups compared to others. Regarding how to address variability in learning groups, there is promising evidence in adaptive personal technologies on the one hand, and adaptive group instruction on the other hand, but there has been less investigation into for whom, for what purpose, and in what combinations these might be appropriate. Regarding when to decrease versus maintain or enhance learning variability, there are disciplines that focus on eliminating within-group variability, and disciplines that work to embrace it, but few ask when variability may be beneficial versus detrimental to a learner, or a group of learners. A lack of directed effort toward understanding and addressing variability results in fragmented and incomplete sets of insights ill-suited to solving some of the hardest problems in supporting all children to learn.

<sup>1</sup> For a compelling extended read on the history, importance, and opportunity of learning variability, see Todd Rose’s 2016 book *The end of average: How we succeed in a world that values sameness*.

<sup>2</sup> “Potential” or “full potential” refers to the genetic makeup of a person and its desired epigenetic realization over time. The potential of an individual can only be approximated because it is an integral over many functions whose optimization through contexts over time is not yet understood.

To address children’s varied and changing needs and to vastly improve learning and development outcomes over current standards, education must create learning systems grounded in knowledge on variability within learners, within groups, and across the contexts learners encounter on a daily basis and over time.

The Jacobs Foundation invests in research because we believe that advances in fundamental knowledge on variability will give rise to more research-based, variability-focused innovations, which in turn will lead to scaled interventions, environments, and ecosystems that effectively support all children to fulfill their full potential. Over the next 8–10 years, the Jacobs Foundation commits to supporting research on learning variability in healthy, typically developing children between the ages of 2 and 12 in high-, middle- and low-income countries, through grantmaking and other research programming. These efforts will be guided by the present research agenda.

## The Research Agenda

The Research Agenda is a set of guiding research themes and questions on learning variability within children, within groups, and between contexts, for children ages 2-12. The foundation will use the agenda to inform its funding decisions and to inspire collaboration and investigation on learning variability in research communities in the developmental and learning sciences. This research agenda is a statement of key priorities for the foundation, not a literature review or a technical paper. It accompanies the Jacobs Foundation 2030 Strategy, which commits 500 million Swiss francs to advancing education from 2020–2030.

This document begins with goals and context. Next, the process for creating the research agenda is described. Then, the resulting themes and questions are listed, along with priority research approaches. Finally, we lay out a set of transformative topics identified as potentially high-impact for the foundation and others.

## Goals and Use of the Agenda

The research agenda seeks to meet goals for external impact and objectives internal to the foundation.

*External Impact.* **The goal of the research agenda is to build the science upon which variability-based education systems and programming may stand. We also aim for the researchers supported by this agenda to become the backbone of a larger multidisciplinary learning variability research community working toward improving children’s learning and development globally. Finally, as an open resource for like-minded organizations and individuals, we hope the research agenda will inspire broader conversation and action among researchers and research funders on understanding and embracing learning variability in the development of children.**

*Foundation Objectives & Use.* Internally to the foundation, the agenda will be used to inform resource allocation decisions, especially within the Learning Minds Portfolio, whose flagship programs include a research fellows program and a bi-annual conference. It seeks to meet the foundation’s objectives as a research funder:

- Contemporary science funding upholding scientific freedom, making science’s value visible to society, and connecting research and practice.
- Open, public-goods-driven research agenda serving the foundation’s thematic focus and where external individuals and organizations can pick up themes to work on, independently or partnering with the Jacobs Foundation.
- Maintain the Jacobs Foundation’s position in funding frontier research.

## Embedding the Research Agenda in the Work of the Jacobs Foundation

This research agenda most closely reflects the work of the Learning Minds portfolio, one of three portfolios that are devoted to the Jacobs Foundation's mission of understanding and embracing variability so that all children can realize their learning potential. The Foundation has a 30-year history of supporting state-of-the-art research on learning and development. The Learning Minds portfolio nurtures a multidisciplinary community of the most innovative researchers, with a view to strengthening the global research and evidence base and helping to shape the future of learning and development. Its current aims are:

1. To promote breakthrough scientific research on learning variability, thereby unlocking the potential of new pedagogies and technologies that embrace children's individual differences and preferences. In so doing, to enable more children to access the learning experiences they need to reach their full learning potential.
2. Through increased cross-sectoral, multi-disciplinary collaboration, to catalyze new scientific opportunities and shape the future of learning and development.

Complementing the Learning Minds portfolio are the Foundation's Learning Schools and Learning Societies portfolios. They focus on promoting evidence-based practices across the global school system, as well as embedding evidence into national education policy, respectively. For its part, the Learning Minds portfolio remains focused on research seeking to understand the mind of the child, rather than on investigations of aggregate or community-level outcomes or group differences. Accordingly, although we acknowledge that education systems and structures are powerful levers for addressing learning variability in the school system, much of the research that is devoted to systems and structures is outside the scope of this research agenda and is the focus of the foundation's forthcoming translational research efforts directed at influencing school-level practice and government policy.

## Research Agenda Compilation Process

The research agenda was created based on ideas and feedback from over 50 scholars of human learning and development. The first draft was compiled from a set of interviews, conversations, literature reviews commissioned by the foundation, and a review of existing research agendas<sup>3</sup>. Then, eleven scholars convened over two days to discuss transformative research and provide general feedback. The final agenda reflects their recommendations and a final vetting process with Jacobs Foundation staff, board members, and key stakeholders in the research community.

<sup>3</sup> Ideas from the field were collected via the following:

- 35 interviews with scholars of psychology, neuroscience, education, and economics. Interviewees were asked to name topics of research and challenges for the field that would advance our understanding of variability and how to embrace it over the next 8–10 years.
- Discussion with ~20 scholars on learning and edtech at the Jacobs Foundation EdTech meeting, May 2022.
- 5 commissioned "rapid reviews" of literature. Reviews included open research questions for each topic.
  - Addressing Learning Variability Through Personalization, by Leonard Tetzlaff and Garvin Brod
  - Learning Variability and Motivation in Ages 2–12, by Lisa Bardach
  - Addressing Learning Variability Through Social Learning Approaches, by Sunny Avry
  - How Can Developing Countries Address Heterogeneity in Students' Preparation for School?, by Alejandro Ganimian and Sharnic Djaker
  - Learning Variability and Executive Function in Ages 2–12 in the Global South, by Ishita Ahmed
- Review of existing research agendas: How People Learn II: Learners, Contexts, and Cultures (2018); the National Commission on Social, Emotional, and Academic Development: A Research Agenda for the Next Generation (2018); Learning First: A Research Agenda for Improving Learning in Low-Income Countries (Wagner & Murphy, 2012).

When we began compiling the research agenda, we knew its contribution to the current state of the field would be most significant if we gleaned priorities directly from input across different scientific disciplines, rather than pre-determining a framework to fill in or a subtopic of focus. Thus, the perspectives reviewed for the agenda were intentionally diverse, spanning researchers who study infancy through adolescence; through the lens of development, learning, or schooling; using methods from learning analytics to intervention design to neuroimaging. All told, we considered views from psychology, education, sociology, economics, computer science, neuroscience, and public policy. For all interviews and commissioned reviews, the broad question at hand was, “what are the most important questions, topics, and challenges that will grow the world’s understanding of learning variability over the next 8–10 years?”

From this open-ended inquiry, the final research agenda was synthesized to meet three criteria: (1) It should uplift rigorous scientific pursuits of foundational knowledge on learning and development. For each agenda theme and question, if answered, how crucial would be the gain in knowledge? (2) It should encourage research with practical significance for children’s learning and development. Does the research ultimately – whether in one year or thirty – lead to more effective learning and development experiences, materials and tools, or ways of thinking? (3) It should embody the Jacobs Foundation’s values of enabling scientific freedom, communicating effectively as a public good, and supporting frontier research.

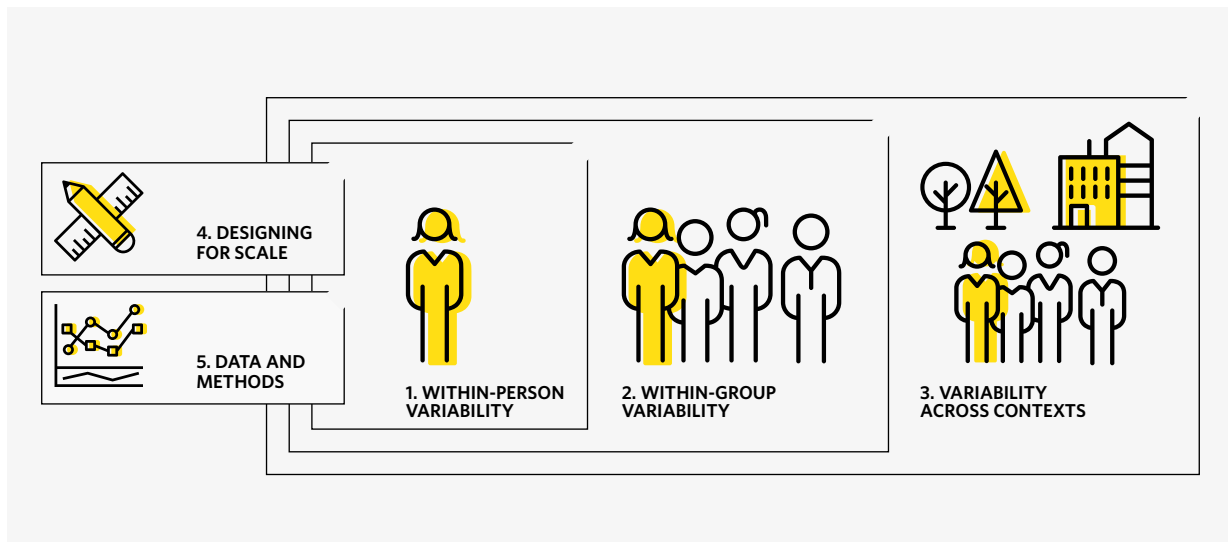
## Research Agenda Overview

The core of the research agenda is the set of guiding questions and topics that were identified from the field as having potential to advance our understanding of learning variability over the next 8–10 years.

In addition, interviewees encouraged us to emphasize *how* research is done as a critical factor in promising research. Certain ways of thinking about or doing research might especially lead to scientifically rigorous and practically impactful investigations in learning variability. We thus identified from the input a set of Priority Research Approaches, described later. The Jacobs Foundation may consider these approaches in funding decisions to increase the likelihood of supporting research at the frontier of scientific contribution and impact.

# Research Agenda Topics: Learning Variability Across Time, People, and Contexts

We segment the concept of learning variability into three categories: *within-person variability*, *within-group variability*, and *contextual variability*. *Within-person variability* refers to how a single person changes within and across skills, characteristics, and behaviors. Children behave inconsistently over time and across skills; why is this and how can it be influenced productively? *Within-group variability* refers to differences between the people in a group, such as the differences between the students in a 3rd grade classroom. Children live and learn in a social world with diverse others; how can we ensure their needs are met in group learning situations? *Contextual variability* refers to the many different contexts a child encounters throughout their day and lifetime. Children learn across many environments and into a changing future; how do we prepare them for such diverse contexts? Together, these categories of variability comprise a rough sketch of the variability children experience in their day-to-day lives. For the research agenda, they constitute the primary organizing themes, framing a set of high-level questions on how to meet the individual needs of all children across contexts and time. Joining the three variability themes is a design category called *Designing for Scale*, which highlights research into how learning programs might be adapted to work in different contexts. Finally, a supporting theme of *Data and Methods* promotes new advances in research methodology in support of the other themes.



**Figure.** Five Themes: (1) within-person variability, (2) within-group variability, (3) variability across contexts, (4) designing for scale, and (5) data and methods

Aligned with the Jacobs Foundation 2030 Strategy, the research agenda prioritizes children ages 2-12 in the healthy, typically developing population. Within this age range, the foundation will continue to focus on allocating resources based on the dual values of scientific freedom and frontier science. Additionally, the foundation seeks to support research within low- and middle-income countries (LMICs).<sup>1</sup> Around 90% of children live in LMICs, yet LMICs historically have been omitted from research on learning and development, resulting in many insights on human behavior being gleaned from only a small subset of the world's population living in social contexts that do not much resemble those of the majority. Increased LMIC research is likely to improve the field's ability to generalize developmental and learning concepts, and surface new foundational questions on learning and development which are apparent in LMIC contexts but hidden in high-income societies. Thus, the foundation invites LMIC investigations on all themes and questions in the research agenda, particularly, but not exclusively, in Colombia, Côte d'Ivoire, and Ghana, where the foundation has invested in other educational programs.

<sup>1</sup> For a review on addressing classroom heterogeneity in low- and middle-income countries, see Ganimian and Djaker, 2022.



Below, each theme is introduced along with an exemplary practical challenge relevant to the theme. Then high-level questions are listed for each, identified as core inquiries for furthering understanding of learning variability. Most of the questions would be best addressed with multidisciplinary research that integrates traditionally siloed areas of work, and most motivate deep consideration of the dynamic interaction between the child and the context over time, which may be well-addressed by repeated measures. For examples of specific research questions that fall under each theme and question, please see Appendix A.

## **Theme 1: Within-person Variability**

Understanding variation within and between skills, behaviors, knowledge, and characteristics over time.

Human behavior is not consistent from one time to the next – a child may seem to understand the mathematical concept of place value one day, but not the next. Between skills, relatively high performance on one skill often predicts high performance on another, but this is not always true – a child who expertly identifies emotions in others may not bounce back easily from her own disappointment. Given this within-person complexity, how can educators, parents, or caregivers, know what a particular child needs in a particular moment? How will the child respond to a teacher's actions given her multidimensional state, and how will she respond differently tomorrow? Research may help shed light on these practical questions through interrogation of the following topics identified for the research agenda:

- 1.1 Why do children show inconsistent behavior, skills, knowledge, and characteristics from one time point to the next? What are the explanations of such variability and what is its developmental purpose? Insights into these questions may help educators and caregivers interpret children's behaviors – is the particular child in front of us performing erratically today because she didn't understand the concept she learned yesterday, or because testing out different behaviors helps solidify her understanding in the long run?
- 1.2 When should learners perform at the upper end of their range of abilities and what experiences or factors can bring them there? Insights here support instruction that is developmentally appropriate or learning-appropriate for the individual in the given context.
- 1.3 How do children vary in their multiple characteristics, knowledge, and skills over time and at different ages? Through this descriptive question, ultimately the field may identify multiple common clusters of developmental trajectories across children, enabling educational programming designed to meet the needs of each.

## **Theme 2: Within-group Variability**

Addressing and embracing heterogeneity in learning groups.

Children spend much of their time learning in social groups like daycare settings, classrooms, and formal or informal out-of-school learning experiences. Each child brings her own unique needs and experiences to these groups, which then influence how she learns and participates. In relatively homogenous contexts, this may mean classrooms of students have diverse interests but similar home lives, academic preparation, and expectations of a secondary education degree. In relatively heterogeneous contexts, this may mean that students in one classroom span 6 grade levels in academic preparation.

How does a teacher effectively teach heterogeneous groups of children to meet their needs and foster deep understanding of the lessons at hand? We highlight two promising solution pathways. First, teachers may use instructional strategies that engage a whole class at once in a way that enables each child to participate fully, but differently, in learning activities as aligned to their skills, proclivities, conceptual state, and interests. Second, educators may employ level-based tutoring or groupings within a class to guide children through academic content at an appropriate level of challenge. For instance, programs such as [Teaching at the Right Level](#) offer students group-based instruction matched to their assessed academic level, with much success. Computer-based adaptive tutors, on the other hand, offer such individualized instruction through solitary computer activities which adapt to students' performance as they go. A pressing practical challenge with regards to within-group variability is to figure out when each approach is most appropriate, with what balance, and why. The research agenda questions that follow may be relevant:

- 2.1 Social learning: How can group instruction in social environments like classrooms both cater to the needs of individual students and take advantage of learning variability for improved learning for all?
- 2.2 Personalized learning: How can 1-1 learning experiences more effectively adapt to cater to individual children's academic and nonacademic states and foster their development?
- 2.3 What classroom practices can accelerate the learning trajectories of lower-performing students while maintaining or accelerating the trajectories of higher-performing students?
- 2.4 Teachers: How can teachers be better supported to embrace and best address within-group variability in a group learning setting such as a classroom?

## **Theme 3: Contextual Variability**

Preparing children to thrive across contexts and time.

Children encounter many learning contexts throughout their day – home, math class, their neighborhood, a playground – and they are expected to navigate successfully within each. Multiplying the number of contexts over years and decades, it is clear that children need to be equipped with the ability to adapt to and shape the different contexts surrounding them. This adaptive flexibility is instrumental to a child's long-term success in our rapidly changing world, yet the design of educational settings often focuses only on the child's learning goals within the setting at hand (e.g., proficiency on 1st grade math standards for numeracy), rather than enquiring how the child's present learning can and should benefit their future learning elsewhere. In the effort to prepare children for life, researchers can help by solving several puzzles about learning across contexts and time:

- 3.1 What are the skills, behaviors, knowledge, and characteristics that prepare children to learn in future contexts and how do they interact with each other and the context?
- 3.2 How might we teach such skills, behaviors, knowledge, and characteristics?
- 3.3 How do we know children are learning such skills, behaviors, knowledge, and characteristics, and are able to use them in different contexts?
- 3.4 The environment shapes how a child interacts and learns within it. How might environments be described such that we may better understand how to facilitate children's successful adaptation within and across them?

## **Theme 4: Designing for Scale**

Making learning solutions effective across multiple contexts.

“Scalability” can turn expensive proof-of-concept learning experiences into change-agents for many children. Yet effective scaled learning programs are still elusive, often failing to retain their efficacy as they grow. For years, this was presumed to be largely a problem of implementation fidelity, or whether the program was run as intended in different contexts. Now, with growing recognition that different people and contexts need different approaches, the challenge is no longer to precisely copy a program as it spreads from place to place, but rather to adapt program elements as needed to suit the commonalities and differences between implementation contexts.

There are two components to this challenge – understanding why a program works for some children and not others, in some contexts and not others; and figuring out how learning solutions should be adapted across different contexts to maintain their functional psychological mechanism and program components. Research on learning and development has a prominent role to play in these inquiries via the study of psychological mechanisms of learning and motivation, the study of how children and contexts interact, and the study of learning design. The questions below focus on scalability and adaptability in the design stage of a learning solution. Subsequent research on implementation and effectiveness are outside the scope of this research agenda.

- 4.1 In a learning solution (i.e., an educational program, app), what mental processes or psychological mechanisms (e.g., curiosity, consolidation, connecting to existing mental representations) are engaged to lead to learning? What program components or “active ingredients” instantiate these mental processes?
- 4.2 What characteristics of use environments interact with children’s experience of the core learning mechanisms of a learning program and how?
- 4.3 How does community-based research or inclusive design impact solution development and the potential for impact within and across communities?
- 4.4 To what extent are the social-emotional skills promoted in developed countries conducive to learning in LMICs? What other skills (not currently studied in high-income countries) are particularly helpful for children to thrive in LMICs?

## **Theme 5: Data and Methods**

Enabling next-generation research, assessment, and design for variability.

Across the interviews and reviews conducted for this agenda, the topics most frequently identified as potentially transformative for the field were advances in data and methods. New methods for measurement and analysis can enable researchers to better track, understand, and intervene in complex systems, including systems that change over time, across multiple dimensions, and in response to internal and external input, such as a developing child. Additionally, high-quality measurement is crucial to addressing the inquiries in themes 1–4. The following questions enable investigations within the prior four themes and highlight emerging opportunities in data and measurement.

- 5.1 How might we advance measurement instruments and practices to be more reliable, valid, and unbiased in the study of learning and development in ages 2 through 12?
- 5.2 How can different timescales of study on learning and development enrich our understanding of within-, between-, and across-context variability?
- 5.3 How might new types of data (physio, interaction logs, sensors, wearables) at various levels of analysis – especially collected via practical, non-intrusive methods – provide new insights into multidimensional learning and developmental processes and outcomes?
- 5.4 How can classroom assessments (i.e., formative assessments, process assessments) better enable students and teachers to rapidly see and act upon within-student and between-student variability across multiple dimensions of learning and development?
- 5.5 What in-school research methods and assessments are equally valuable to practitioners and researchers in meeting their practical goals and knowledge goals?
- 5.6 What new evaluation methods can provide more rapid feedback on education programs' impacts and mechanisms in different contexts?

Through the themes and questions above, we outline research needs for three types of variability salient in the lives of children: within-person variability, within-group variability, and contextual variability. We focus on learning and development in the minds of children ages 2–12 across the globe, while also incorporating research questions on the instructional skills and perceptions of teachers and parents (see Appendix A for more examples) who have immense influence over children's experiences.

Notably, aligning with the focus of the Learning Minds portfolio, the agenda favors investigations of the mind of the child over investigations of systems and structures. Although we recognize the immense potential of educational systems and structures to cause and address learning variability challenges in schools and societies, here we limit structural and systemic questions to those which probe how these interact with the minds of learners and educators. Inquiries into the role of education systems on aggregate outcomes indirectly related to the mind of the child, such as average school attendance, teacher retention, GDP, and dropout rates, are out of scope. Similarly, the work highlighted here is complementary to but not inclusive of "what works" impact evaluations of educational programming.

The themes and questions in the research agenda are prompts for the field, from the field, which we hope will inspire research of scientific and practical significance to deepen the field's understanding of learning variability. They are not comprehensive, nor representative of a field consensus. Rather, they are important questions within a much larger set of inquiries about how children learn and develop in a variable world, all of which may enable educators, designers, and policy makers to better harness learning variability toward improved educational and developmental experiences for all children.

# Priority Approaches: Promising Ways of Doing or Thinking

These **Priority Approaches** emerged from input conversations with researchers, some of whom named the approaches as impactful for the field in general, and others of whom additionally highlighted that funding novel approaches may be a way for philanthropy to distinguish itself from government and corporate funding institutions. As a comparably smaller and more nimble funding source, it was noted that philanthropy could make a lasting impact by supporting promising approaches to thinking or researching that have yet to be fully established in the field.

Most frequently mentioned was the need for **Integrative Research** to make productive connections across research traditions, like child development and learning, or early childhood research and middle childhood research of similar topics. Second, **Contextualized and Generalizable Research**: Interviewees emphasized a need for more attention to the interaction between context and learner. Each learner is situated in a history, a culture, an identity, a current state of development, a current environment, and a set of interactions, all of which contribute to the child's next state of learning and development. Beyond simply acknowledging the fact that learners exist in context, how should researchers operationalize the contextualized learner into research and design? Third, interviewees and reviews called for the field to think more deeply about **Strengths-Based Learning** – reframing variability (between individuals and within individuals) from a challenge to be overcome, to a feature to be taken advantage of.

The **Priority Approaches** may be used by the Jacobs Foundation as guidelines on how to prioritize research proposals within the agenda themes and questions. While the agenda questions can be answered in many ways, prioritizing funding for these approaches would increase the likelihood that the Jacobs Foundation will continue to support frontier research, while relying on other types of funding institutions like governments to support relevant but more traditional studies.

## **Priority Approaches:**

### **1. Integrative Research**

This approach aims at fostering insight into variability in development by integrating evidence:

- a. across ages, specifically connecting early childhood with middle childhood
- b. across fields and disciplines, e.g., cognitive neuroscience and social psychology; machine learning and developmental sciences
- c. across timescales, e.g., moment-to-moment variations and long-term changes
- d. across levels of analysis, e.g., social and physical environment; behavior, and brain with behavior as the central concept of interest; computational-level explanations and process models of behavior

### **2. Contextualized and Generalizable**

Researchers pursuing this approach seek generalizable knowledge by studying learners as individuals contextualized in ...

- a. various learning environments
- b. various relationships and interactions
- c. history, cultural norms, and identities
- d. their genome and epigenome

### **3. Asset-Based Learning as Strength**

In a strengths-based approach, researchers assume that learners' current states (of knowledge, emotion, etc.) are opportunities to build upon, rather than gaps to fill. This leads to questions such as, "For students who are not native speakers of the school language, how can the characteristics of their home language be used to provide a foothold into the content domain?" Rather than, "In what ways do children's home language practices hinder their learning of standard academic topics at school?"

# Transformative Questions

As a final addition to the research agenda, we wished to spotlight the need to support Transformative Ideas in learning variability, in line with the Jacobs Foundation's commitment to funding frontier research. As one contributor noted, "The research with the biggest impact is that which yields conceptual and paradigmatic change."

While it is impossible to predict which research will ultimately transform a field of study, such work is more likely to be generated if we engage in intentional inquiry into how an idea might change the way a field asks its questions, considers its data, or interprets its findings. The following are examples of Transformative Questions that emerged from a 2-day workshop with 11 scholars across various subdisciplines of learning and development, who were tasked with identifying transformative questions and ideas within and across the five research agenda themes.

- T.1 **Can we develop a multidisciplinary ontology of learning contexts?** Currently, while there is a common recognition across academic disciplines of the importance of context or environment, there does not as yet exist a shared understanding of which features are salient for learning and development when, for whom, or why they matter.<sup>1</sup> This lack of a shared understanding of context prevents transdisciplinary learning, holds back the broader science of learning and development, and makes it difficult to have meaningful conversations about learning variability in any kind of holistic sense, that is, beyond a narrower focus on specific skills or children of a specific age. It also handicaps discipline-specific academic researchers who too often have "disciplinary blinders" that prevent them from seeing (or measuring) aspects of context that are not part of their disciplinary tradition but that may matter for the phenomena they study. The process of co-developing a unifying, multidisciplinary theory of context would itself be richly generative for the work of the individual scholars involved. Knowledge generated from one specialized line of research would also be able to inform a broader understanding of context if there existed an emerging, common schema onto which new information could be mapped. The end result would allow for researchers studying the development of particular skills and domains and researchers studying the power of particular aspects of context to be in conversation with one another, to apply lessons learned from other disciplines to their own work, and to collectively contribute to a growing science of learning contexts.<sup>2</sup>
- T.2 **When is learning variability beneficial versus detrimental to learning and development? And thus, when should we focus on reducing versus leveraging variability in group and individual settings?** Researchers in different disciplines tend to think of within-subjects or between-subjects variability as either a feature to embrace or a challenge to eliminate. If, instead, we asked in what instances variability is beneficial versus detrimental to a child, a host of changes would emerge for the field of child development. Answering the question would require new tools to study specific constructs over time, which would enable a paradigm shift in the study of children's development. New insights into developmental and learning processes would be promoted as researchers consider variability rather than try to control it. And the field would seek to answer a fundamental question as a prerequisite – How do we define and measure within-child variability for different domains, contexts, timescales, and developmental periods? Practically, this work promotes insight into how best to intervene (e.g., with whom, when, and how?) for individuals and groups.<sup>3</sup>

<sup>1</sup> For example, a cognitive scientist may be primarily focused on the nature and affordances of the learning tasks a child is asked to engage with in a learning setting. A social psychologist may pay more attention to how a child perceives psychological conditions or social interactions in the environment that cue a sense of belonging or self-efficacy (or that induce belonging uncertainty and a sense of the futility of putting in effort in this context). An educational psychologist may be most interested in the nature of the relationship between a child and a teacher. A developmental neuroscientist may be interested in recursive relations between changes in brain and behavior on any of these dimensions.

<sup>2</sup> Justification for T.1 was written by Camille Farrington

<sup>3</sup> Justification for T.2 was adapted from a note from Julia Leonard

- T.3 **What methods might enable individual-level predictions of future behavior across contexts?** The dominant goal of human psychology is to explain the causes of human behavior. While crucial to understanding the human experience, this focus on how constructs contribute to our actions does little to help an educator or parent predict what her child will do next or how she will respond to stimuli. Accurate behavioral predictions for individuals would require advances in the multidisciplinary measurement, analysis, and theory, as accurate predictions would likely require integration of contextual, interaction information, and psychological information. Individual-level predictions would increase our ability to tailor learning experience to children's needs and enable research on different developmental and learning pathways toward an outcome. It would also likely incentivize exploration of culturally-relevant measurement and investigation as a way to improve predictive power in different communities.
- T.4 **How do we educate children for a rapidly changing future context?** Preparing humans for an unknown future has long been the realm of futurists, science fiction writers, and the World Economic Forum, but not so much the realm of development and learning researchers. If learning and development researchers were to develop a perspective on or better yet a way to systematically investigate how the future should impact what children experience today, they could mobilize a field toward future-facing instructional design educating all children for a rapidly changing future.

For these examples, the transformative potential lies in the possibility of unlocking new ways of thinking about or orienting to learning variability, or in new methods, tools, and collaborations that encourage novel questions to be asked. Each idea lies outside of a single academic domain and thus requires multidisciplinary collaboration. The Jacobs Foundation plans to allocate resources to support cross-disciplinary discussion and research on a subset of these topics, while exploring vehicles by which to support further transformative ideation.

# Conclusion

Learning variability is pervasive in children's day-to-day lives – variability within their own behavior both within and across domains of functioning, diversity within the peer learning groups to which they belong, and differences between the contexts they encounter each day. Yet education systems and research in learning and development rarely incorporate variability as a driver of instruction, policy, or research activities. We posit that if learning experiences were designed to take into account within-person, within-group, and contextual variability, then a greater diversity of children around the world would be supported, more often, toward reaching higher levels of functioning in key dimensions of individual development. A deep understanding of learning variability through developmental and learning research is likely to systematically and sustainably facilitate such experiences. With this Research Agenda, the Jacobs Foundation offers a set of guiding research questions and approaches to the field of early and middle childhood education – educators, researchers, and the funders of each – to spur productive conversations or collaborative projects on learning variability. As a funder of science as well as impact programming in education, we believe that simultaneous investments in research and practice make each stronger through bidirectional influence. Given this, we will consider the research agenda and related activities a success if, by 2030, the global research and funding communities have increased the number of inquiries into supporting learners through variability, and programs “on the ground” are regularly communicating in language that reflects within-person, within-group, and contextual variability. Please partner with us to advance the world's understanding of learning variability and support all children to achieve their full potential.



# Appendix A:

## Example Research Questions

This section lists example research questions for each of the three variability themes. The examples illustrate the breadth of research relevant to the question prompts; they are not intended to be comprehensive. Examples were identified through field input to be illustrative of the Priority Approaches as well as the concepts and topics that came up often in the input interviews, namely motivation, self-regulation, agency, and culture and identity.

### **Theme 1: Within-person Variability**

Understanding variation within and between skills, behaviors, knowledge, and characteristics over time.

- 1.1 Why do children show inconsistent behaviors, skills, knowledge, and characteristics from one time point to the next? What are the explanations of such variability and what is its developmental purpose?
  - Ex.a. What improvements to measurement tools would ensure valid and reliable measurements of within-child variability over time?
  - Ex.b. What impact do contextual factors have on children's day-to-day variability in skills?
  - Ex.c. How do children's interactions in various relationships influence their expectations, interpretations, or motivations in future interactions? How does this vary with age and development?
  - Ex.d. Parents and Families: How do cultural norms of how parents and adults conceive of children and development impact children's multidimensional development over time?
  
- 1.2 When should learners perform at the upper end of their range of abilities and what experiences and factors can bring them there?
  - Ex.a. Teachers: How do teachers understand day-to-day variation in students' skills and how do they tailor instruction accordingly? How might they come to understand and optimally instruct for within-person variability?
  - Ex.b. Teachers: How might teachers best leverage a child's strengths in some domains to promote learning in domains where the child needs more support?
  
- 1.3 How do children vary in their multiple characteristics, knowledge, and skills over time and at different ages?
  - Ex.a. What are the relationships between a child's characteristics and skills over time and at different developmental stages?
  - Ex.b. What is the role of conscious meaning making (e.g., what is happening here and what are the possibilities for me?) versus unconscious patterned responses in explaining within-person variability?

**Theme 2: Within-group Variability**

Addressing and embracing heterogeneity in learning groups.

- 2.1 Social learning: How can group instruction in social environments like classrooms both cater to the needs of individual students and take advantage of learning variability for improved learning for all?
  - a. How does the human ability to predict the intentions of peers and teachers (i.e., form expectations) influence learning interactions and learning outcomes?
  - b. How do motivational states emerge from learning interactions between children or children-teachers? How do these states then influence future learning interactions?
  - c. What are the psychosocial and academic impacts of designing children's various strengths – cognitive and cultural – into learning experiences in group settings? How does this vary by age?
- 2.2 Personalized Learning: How can 1-1 learning experiences more effectively adapt to cater to individual children's academic and nonacademic states and foster their development?
  - a. In instruction, what is the optimal balance of building on children's strengths versus correcting their weaknesses? How does this vary with characteristics such as age and expertise development (beginners versus experts)? How does this interact with children's sense of what is interesting and meaningful?
  - b. Under what conditions and approaches does tech-enabled personalization support self-regulated learning and social skills, and when does it interfere in this development?
- 2.3 What classroom practices can accelerate the learning trajectories of lower-performing students while maintaining or accelerating the trajectories of higher-performing students?
- 2.4 Teachers: How can teachers be better supported to embrace and best address within-group variability in a group learning setting such as a classroom?
  - a. How might teachers learn to adapt their teaching moves in real time to suit the variety of cognitive and emotional states of their students?
  - b. How do incentive structures lead to changes in behaviors of teachers and principals? How can incentives systems encourage teachers and principals to better address the needs of individual children in schools?
  - c. How can teachers be supported to orchestrate classroom learning as a blend of personalized individual experiences and group learning experience?
  - d. How can teachers be supported to better elicit and respond based on children's abilities and cues across ages?

### **Theme 3: Contextual Variability**

Preparing children to thrive across contexts and time.

- 3.1 What are the skills, behaviors, knowledge, and characteristics that prepare children to learn in future contexts, and how do they interact with each other and the context?
  - a. What are the neural and psychological mechanisms by which adaptive social and emotional skills impact a child's learning experiences?
  - b. How might children's self-identities (the strength of their identities, the characteristics of them) positively impact their success across contexts?
  - c. Where does motivation «live»? In the student, in the context, in the student's perceptions of context, in social interactions? How can we integrate research on group-level motivational climate, research on differing student perceptions within a classroom, and research on individual student perceptions?
  - d. How do general skills like cognitive flexibility and other executive functions enable or co-develop with children's ability to learn and appropriately apply specific strategies?
  - e. When skills and behaviors are developed as adaptations to adverse contexts, what implications does this have for their future use in non-adverse contexts? And vice versa?
  - f. How do genetic, environmental, and epigenetic differences interact and covary to bring about changes in key aspects of development?
  
- 3.2 How might we teach such skills, behaviors, knowledge, and characteristics?
  - a. How can children learn to apply skills appropriately depending on the context?
  - b. How should learning experiences for adaptive skills vary with the age or skill of the learner?
  - c. How might such instruction productively use students' various incoming identities, experiences, states, knowledge, and skills for adaptive skill learning?
  - d. Teachers: How can teachers be supported to understand, measure, and instruct student learning for the purpose of thriving across contexts?
  
- 3.3 How do we know children are learning such skills, behaviors, knowledge, and characteristics and are able to use them in different contexts?
  - a. How can we better measure what children do during learning in formal and informal learning environments?
  - b. How can we measure children's ability to learn instead of their mastery of topics?
  - c. Can we make context\*individual assessments that tell us something about which other contexts a child might do well in?
  
- 3.4 The environment shapes how a child interacts and learns within it. How might environments be described such that we may better understand how to facilitate children's successful adaptation within and across them?
  - a. What unifying theories, generalized knowledge, and mechanisms can make the description of context into a science of context?
  - b. In addition to developmental changes, what contextual differences between early childhood and middle childhood influence children's ability to adapt and succeed over time?
  - c. For multilingual learners, what aspects of a learning domain afford greater access or greater challenges? What aspects can be vehicles for language learning? What aspect may provide a foothold into the domain?
  - d. What do classroom environments and informal learning environments afford for adaptive skill learning, respectively and in concert?

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