Family Collaboration in the Digital Age: Parent Learning Partner Roles Are Linked to Child Expertise and Parents' Work

Brigid Barron, Caitlin K. Martin, and Judy Nguyen
barronbj@stanford.edu, ckmartin@stanford.edu, judynguyen@stanford.edu
Stanford University

Abstract: Our quantitative study investigates how parents' use of technology in their work relates to their roles as learning partners for their children. We also examine whether parent learning partner roles are associated with children's opportunity to experiment with digital production activities. Based on earlier ethnographic studies we predicted that there would be variability of the number of roles played across our sample, and that parents active in the technology industry would play more roles, especially those potentially catalyzed by some level of expertise or knowledge, such as teaching, modeling practice, collaborating on technical projects, or lending resources. Our findings were consistent with these hypotheses. For both mothers and fathers, the level of technology use at work was associated with the diversity of learning partner roles. Counts of the diversity and density of parent roles was significantly associated with the breadth of children's experience with digital production activities. Implications for equity are discussed.

Introduction

Jonathon, a 13-year-old student in Silicon Valley, developed the front and backend of websites including linked databases and ran his own computer consulting business. Much of his knowledge developed at home as he tinkered and taught himself new programming languages, using the Internet and books as resources and collaborating with his parents on projects. Books, computers, and software were at the ready, lent and purchased by his parents, and broad expertise was available in his family and their network of friends and colleagues to help him advance his goals. His father was an engineer and programmer who introduced him to educational computer games in preschool and continued to teach him about computers and programming until his son's knowledge surpassed his own in some areas. His mother was a small business owner and contributed her expertise to Jonathon's own money-making ventures. In another Silicon Valley neighborhood was 12-year-old Andres, an avid gamer who became an expert in game design and graphic tools that allowed him to create characters and backgrounds for his game environments. Andres accessed resources and learned most of what he knew at a Computer Clubhouse space in a local community center and brought that knowledge home to his family. At home, he taught his mother how to use the mouse and keyboard and organize documents within folders and helped her to figure out how to pay bills online.

These examples from qualitative work illustrate some of the ways networked technologies and digital tools provide rich opportunities for novel and varied forms of intergenerational learning with family members dynamically taking on roles as teachers, learners, collaborators, and brokers (Barron, Martin, Takeuchi, & Fithian, 2009). Sources of variability in family-based learning opportunities are particularly important to understand from an equity perspective. There is growing evidence that expertise with digital technologies is related to further networked learning such as job opportunities (Peng, 2017), the tendency to use technology to learn (Horrigan, 2016), and teaching friends and family to use technology (Barron, Pinkard, Gomez, & Martin, 2014). Recent national data suggests that opportunities for computational learning are unevenly distributed (Google Inc. & Gallup Inc., 2016). Communities with fewer technology learning opportunities and knowledgeable networks may need additional supports while those with parents in jobs that require the use of technology or that involve its design may be in a particularly powerful position to support their children's digital hobbies that will prepare them for empowered and critical use. In the examples above, Andres and Jonathon had similar levels of interest but vastly different access to resources at home and in school (Barron, 2010). In this paper we report on a study of how the supporting roles parents play in the lives of their children vary with parent use of technology in their occupations.

The 2019 CSCL conference theme of *combining embodied, enactive, extended, and embedded learning in collaborative settings* (4EC) highlights the complexity of cognitive phenomena, encouraging analysis and understanding at a comprehensive systems level. Family networks are important as they represent the place where children spend much of their time and parents and other adults at home engage in guided participation as informal teachers and resource lenders (Rogoff, 1998). How and when adults and children take up roles as more expert learning guides at home is influenced by their cultural repertoires of practice around teaching and learning

(Gutiérrez & Rogoff, 2003) as well as opportunities and needs that arise due to rapidly changing technologies. In this paper, we consider the family as a networked learning ecosystem. That is, family members are connected to each other and to their own broader environments through learning opportunities at work, school, or in the community and these influence interactions at home. We explore the interactions between people as *enactive* elements of the system and look at those interactions through the lens of *extended* environments, in this case parent jobs that influence family learning within a child's broader learning ecology. We close with implications for future research and family learning opportunities.

Parents as learning partners

There is evidence that being technologically fluent is increasingly important. Studies suggest that youth engage in gaming and social networking more than creative digital production activities (Barron, 2006; Ito *et al*., 2009) but that these production activities using technology to create are linked to important competencies. Research focused on middle school students found that greater involvement in technology production experiences was significantly related to more confidence in their own capacity to generate new ideas, stronger self-efficacy with professional tools, a propensity to share technical expertise with a broader network of people, and intent to continue to develop technical expertise in the future (Barron & Martin, 2016; Martin, Barron, Stringer, & Matthews, 2014).

There is extensive research on how children learn through family interactions in areas such as language, academic skills, and traditional crafts, and in most cases, parents pass on their more expert knowledge (Rogoff, 2003; Whiting & Whiting, 1970). We know less about how young people learn and build fluencies with these newer technologies and how families fit in. Recent large-scale survey research in the UK suggests that active engagement with media by youth, such as creative production, is linked to parents' higher confidence using technology while more restrictive mediation of technology at home is correlated with parents with less confidence (Livingstone *et al*., 2017). An in-depth case study of 22 Hong Kong students found positive links between parental supportive mediation and technology competence and youth generative use of information technology (Yuen *et al*., 2018).

An ethnographic study of highly engaged middle school students committed to digital hobbies that ranged from robotics to making music videos found that parents played eight unique roles in surfacing, supporting, and coordinating learning opportunities for young people: teacher, learner, collaborator, learning broker, employer, financier, non-technical consultant, and resource lender (Barron *et al*., 2009). Despite the fact that all youth were from one affluent Silicon Valley school, there was substantial variability in the level of parent engagement as indexed by the number of roles played in the household and the frequency with which these roles were played (for example across parents and over time). Greater parent involvement was associated with higher levels of child expertise and early onset (prior to age five) of a child's engagement in new media production activity. A number of smaller qualitative projects have validated these findings, particularly emphasizing how the practice of adults brokering for young learners, both in the community (Ching, Santo, Hoadley, & Peppler, 2016) and at home (Louw, Barbuto, & Crowley 2016) can expand youth opportunities and social networks. To validate and extend these findings, we created a survey measure of parent learning partner roles to administer to a larger sample.

Research questions

In the current study we use survey data to ask (1) whether parent learning partner roles are associated with children's opportunity to experiment with digital production activities and (2) how parents' use of technology in their work relates to their roles as learning partners. Based on earlier ethnographic findings we predicted that there would be variability of the number of parent roles played across our sample, and that parents active in the technology industry would play more roles, especially those roles that are potentially catalyzed by some level of expertise or knowledge, such as teaching their child, modeling practice, collaborating on technical projects, or lending resources.

Methods

Participant sample

We surveyed the entire eighth grade cohort of students from a public middle school in the Silicon Valley region of California (N=366 students). The school was high performing (over 90% of students met or exceeded standard in math and English language arts on state tests) and affluent (only 3% were eligible for subsidized lunch programs). Approximately half of the students surveyed were male (51%). The sample had a high Asian-American population: 34% self-selected Chinese as their ethnicity, 26% Asian Indian, 23% White, 19% other Asian

(Japanese, Vietnamese, Korean), 5% Hispanic-Latino, and less than 1% African American (13% selected more than one option). Almost a quarter (23%) were born outside the United States, and 34% lived in multilingual households. Although the school was located within a hub of technological innovation, it did not offer computer science classes.

Measures

Students were administered a survey of Access, Experience, and Interests in Computing (Barron, 2004; Barron, Walters, Martin, & Schatz, 2010) during their 40-minute mathematics period. In this paper, we report on a subset of measures including youth digital production experience, parent jobs, and our new parent learning partner roles item.

Student digital production experiences

Students were asked to indicate the frequency with which they had ever engaged in a set of nine computer-related production activities from a choice of never, once or twice, three to six times, or more than six times. Activities queried included making a computer program, a website, digital art, a digital 2D or 3D model, a digital movie, an animation, a computer game, digital music, and a robot or other technology invention. Activities were presented as descriptions of possible products and/or potential software applications, such as "Made a publication or a newsletter (e.g. PageMaker, Word, Comic Life)" and "Designed a 2D or 3D model or drawing (e.g. CAD, ModelShop)" (For the full item, see Barron & Martin, 2014). The number of activities students reported any experience with were counted to create a breadth of digital production experience score.

Technology in parent jobs

Students were asked to indicate the degree to which their parents' jobs involved technology. First, they were asked if their parents used computers in their jobs from a choice of *Yes*, *No*, *I don't know*; with mother/female guardian and father/male guardian queried separately (in the interest of space we refer to these two categories as *mothers* and *fathers* in the remainder of the paper). For those who responded *Yes*, a follow up question asked about the degree of occupational technology use from a choice of: *Occasionally as a productivity tool as part of a larger job (e.g. is an author and uses word processing, is a financial planner and uses record keeping software)* (occasional user) and *job is defined by the computer/technology; it is their primary tool (e.g. works as a Web designer, networking consultant, computer programmer, engineer, etc.)* (technology professional). Participants with unclear or incomplete answers were dropped from the analysis.

Silicon Valley is a technology hub with a growing concentration of the labor force in this industry. Eighty-eight percent of students for whom we have parent job information reported having at least one parent who was a technology professional. Over three quarters of fathers were classified as technology professionals, while mothers were more evenly distributed (Table 1). The predominance of fathers with technology-defined jobs (twice as many fathers as mothers for this sample) is reflective of a recent Silicon Valley workforce analysis, documenting persistent underrepresentation of women (John & Carnoy, 2017).

Table 1: Degree of technology in parent jobs for mothers and fathers

	Degree of technology use in job					
	No usage		Occasional user		Tech professional	
	N	%	N	%	N	%
Mothers (n=316)	75	23.7	118	37.3	123	38.9
Fathers (n=326)	14	04.3	58	17.8	254	77.9
Both parents	6	01.9	28	08.9	99	31.3

Parent learning partner roles

The measure of parent learning partner roles is based on interview and ethnographic studies looking at roles played by adults that seem to be generative in young people's digital production interests and hobbies (Barron *et al.*, 2009; Barron *et al.*, 2014). The item asked students if their parents (mother and father queried separately) ever played each of 10 roles to support their learning about computers and technology (Table 2). Roles include those that provide new opportunities for learning by connecting children with activities and resources and those that involve joint engagement as child and parent(s) work and learn together (Takeuchi & Stevens, 2011). In the Table 2, roles are organized within these two conceptual groups by frequency for this sample, from those most to least played.

Table 2: Survey descriptions of parent learning partner roles in youth technological learning

Role	Survey Item
Providing new opportunities	
Financier of entertainment resources	Bought me entertainment related technology (*like games, console*)
Resource lender	Had things (*like books, equipment, software*) at the house that I use.
Financier of educational resources	Bought me things to support my computer activities and learning (*like hardware, software, books, courses*)
Learning broker	Looked for technology-related activities for me to do and/or signed me up for them (*like classes, clubs, camps, etc*.)
Employer	Paid me to do something technical or on the computer for her/him.
Learning together	
Teacher	Taught me how to do something on the computer (*like typing, how to create a Web page, etc.)*
Learner	I have taught them how to do something with the computer.
Model	Let me watch how they do something *(like turn on the computer, set up the printer)* that I eventually learn how to do from observing them.
Non-tech consultant	Gave me advice on non-technical issues that helped me with my technology activities.
Collaborator	Worked with me on a technology- or computer-related project (*like built a robot together, worked on a Flash tutorial together*)

Results
Consistent with our ethnographic study (Barron *et al*., 2009) there was variability in terms of the number of learning partner roles played by mothers and fathers. Below we address three questions related to parent role variability in relation to child experiences and parent occupation.

Did the number of roles played correlate with children's digital production experience?
We created a measure of the *diversity* of roles (number of roles played by mother or father, with a possible total of 10) and a measure of the *density* of roles (number of roles played by mother and father, with a possible total of 20). In this sample, students reported an average diversity of 6.90 roles (SD = 2.17) ranging from 1-10, and an average density of 11.12 roles (SD = 1.84), ranging from 1-20. There was a significant association between these measures and youth experiences with digital production. Pearson correlation indicated a positive association between digital production experience scores and diversity of parent roles ($r(360) = .31$, $p < .001$) and between digital production experience scores and density of parent roles ($r(360) = .32$, $p < .001$).

Was diversity of roles played associated with level of parent technology use at work?
We also created measures of the *diversity* of learning partner roles each parent separately played for their children and looked at those measures by parent job classification (Figure 1). Almost twice as many roles were played by parents defined as technology professionals than by parents who did not use technology at work. An ANOVA with mother technology job focus as the between subjects factor revealed a significant effect of job on the number of roles played by mothers ($F(2,313) = 31.51$, $p = <.001$). For mothers, these phenomena increased with the level of technology focus within their jobs, with tech professionals playing more learning partner roles than those who used technology occasionally in their jobs, and those mothers playing more roles than mothers who did work at all with computers. An ANOVA with father technology job focus as the between subjects factor also revealed a significant effect of job on the number of roles played ($F(2,323) = 14.76$, $p = <.001$). Fathers who used technology at all at work played significantly more learning support roles than those who did not. For fathers, differences between technology professionals and occasional users and were smaller and not significantly different.

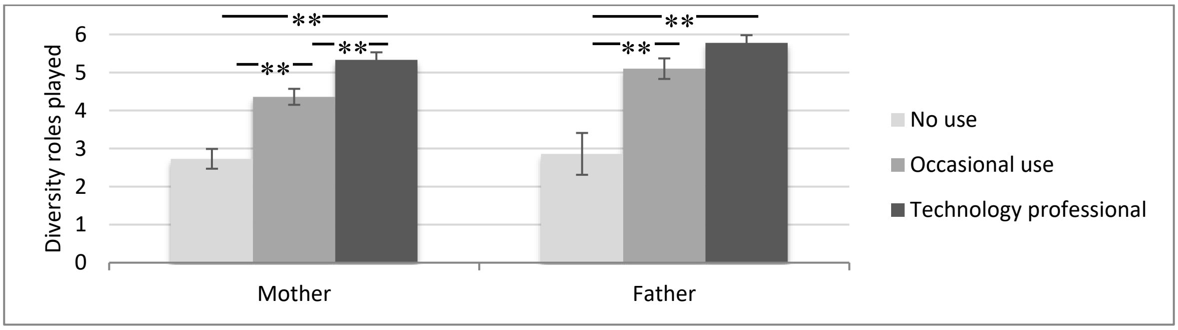

Figure 1. Number of learning partner roles played by parent (diversity) by parent job classification.

Did the kinds of roles played by parents differ by parents with technology jobs?

Analysis reveals striking differences in roles played by parents with more and less technology focus in their professional life. For both mothers and fathers, using technology at work significantly increased the likelihood of engaging in every learning partnership role with the exception of parent as learner. Roles such as modeling, collaborating, and teaching were much more likely when parent jobs required the use of technology.

Mothers or female guardians

Mothers whose work was not at all defined by computers and technology (no usage) were less likely to play every role queried than those who did (occasional users and technology professionals) except for learning from their child and employing them to help with technology issues (Table 3). In terms of those roles that may provide new extended opportunities for learning, mothers who used technology at all in their jobs were more likely to finance equipment. This suggests differing levels of technology tools in the house and possibly financial differences between families. Mothers classified as technology professionals were more likely than both other groups to lend or share their own resources with their children and were more likely than mothers who did not use technology in their jobs to broker learning events for their children. In terms of learning together, roles that require some parent technology knowledge or expertise (teacher and model) were significantly different across all three groups, with likelihood increasing with increased technology job focus. Mothers classified as technology professionals were four times as likely as those who did not use technology in their work to teach their children about computers and technology and to model technical and computational practices, and three times as likely to collaborate with their children. Mothers who were technology professionals were more than twice as likely than the occasional users to collaborate with their children.

Table 3: Roles played by mother as a function of mother's use of technology at work

Roles	Degree of technology use in job			X^2	p
	No usage n=75	Occasional user n=118	Tech professional n=123		
Providing new opportunities					
Financier (entertainment)	44.0% $_a$	63.6% $_b$	72.4% $_b$	16.08	<.001
Resource lender	25.3% $_a$	40.7% $_a$	63.4% $_b$	29.27	<.001
Financier (learning)	24.0% $_a$	41.5% $_b$	49.6% $_b$	12.75	.002
Learning broker	30.7% $_a$	39.8% $_{ab}$	55.3% $_b$	12.61	.002
Employer	06.7% $_{ab}$	18.6% $_b$	08.1% $_a$	08.86	.012
Learning together					
Teacher	18.7% $_a$	52.5% $_b$	76.4% $_c$	62.65	<.001
Learner	81.3% $_{ab}$	86.4% $_b$	72.4% $_a$	07.57	.023
Model	13.3% $_a$	39.0% $_b$	57.7% $_c$	38.30	<.001
Non-tech consultant	17.3% $_a$	38.1% $_b$	41.5% $_b$	13.11	.001
Collaborator	12.0% $_a$	15.3% $_a$	35.8% $_b$	20.74	<.001
Teaching and learning	16.0% $_a$	43.2% $_b$	52.8% $_b$	26.82	<.001

Items in a row that share a common superscript or that do not have superscripts do not differ significantly.

We were especially interested in parents playing the bidirectional role of both learner and teacher, considering it a unique look into potentially generative interactions between parent and child as they share knowledge. In this sample, 55% of students reported at least one parent who both learned from and taught them, and 19% reported this to be true for both parents. There were no differences between occupation groups in terms of the frequency of fathers who played this bidirectional role but there were for mothers (Tables 3 and 4). Mothers who used technology in their jobs were more likely to have a teaching and learning relationship. It is of note that the majority of mothers in all groups are playing the learning role for their child, but this was not true for fathers.

Fathers or male guardians

Father occupation groups did not differ in terms of brokering new learning activities for their children, but they did provide material resources differently (Table 4). Fathers who did not use technology at all in their jobs were less likely than the other groups to finance technology resources for their child than the other groups. Technology professionals not only purchased more learning resources for their children but were also more than twice as likely to lend their own resources than those fathers who did not use technology in their jobs. In terms of learning together, technology professionals were more likely than both other groups to teach their children, and this was true for occasional users compared to fathers that did not use technology at all in their job. On the other hand, the technology professionals were less likely than fathers who did not use technology at all in their jobs to learn from their child. Fathers who did not use technology in their jobs were more than twice as likely to learn from their children than fathers who were technology professionals. A similar pattern was observed for modeling and collaborating.

Table 4: Roles played by father as a function of father's use of technology at work

Roles	Degree of technology use in job			X^2	p
	No usage n=14	Occasional usage n=58	Tech professional n=254		
Providing new opportunities					
Financier (entertainment)	42.9% $_a$	77.6% $_b$	82.7% $_b$	13.45	.001
Resource lender	28.6% $_a$	63.8% $_{ab}$	70.5% $_b$	11.06	.004
Financier (learning)	28.6% $_a$	53.4% $_{ab}$	66.5% $_b$	10.68	.005
Learning Broker	00.0%	24.1%	26.8%	05.09	.078
Employer	14.3%	12.1%	13.4%	00.09	.958
Learning together					
Teacher	35.7% $_a$	79.3% $_b$	91.7% $_c$	40.93	<.001
Learner	78.6% $_a$	46.6% $_{ab}$	35.8% $_b$	11.58	.003
Model	28.6% $_a$	67.2% $_b$	79.1% $_b$	20.19	<.001
Non-tech consultant	21.4% $_a$	39.7% $_a$	52.0% $_b$	07.15	.028
Collaborator	07.1% $_a$	46.6% $_b$	59.1% $_b$	16.27	<.001
Teaching and Learning	21.4%	32.8%	33.5%	00.87	.647

Items in a row that share a common superscript or that do not have superscripts do not differ significantly.

Discussion and future directions

Learning to use technology as a tool of creative production has been recognized as a key capacity that will help position young people for work, civic engagement, and future learning. Understanding how these capacities develop is critical for tracking variability in access to learning opportunities provided at home, in schools, or in virtual or online communities. In this paper we provided findings that stress the importance of interactions between people as *enactive* elements of the system and consider those interactions through the lens of *extended* environments, in this case parent jobs that influence family learning within a child's broader learning ecology. Describing and differentiating supportive roles played by parents and being able to quantify roles played in social environments has implications for measuring learning networks and corresponding design-based interventions. In this paper we focused on learning partnerships at home, asking whether parents who worked with computers and technology in their jobs played more roles for their children than parents who did not work in the field or use technology in their work at all. Our findings indicated that the diversity of roles experienced by young people was significantly related to parent use of technology at work.

Our Silicon Valley sample is from a highly unique community in terms of its technological expertise and capital, and specific patterns found here may not transfer to other locations or be broadly representative of the

U.S., although as shared in the introduction, there is variability even in this highly concentrated area. It would be productive to know more about the types of jobs that are represented in this sample and the expertise they require. Analyses of technical occupations suggest that jobs vary along multiple dimensions and we would expect that what parents know and might possibly share would vary accordingly. Beyond content knowledge, technical expertise is a form of cultural capital that includes values, beliefs identities, and access to knowledge networks. It may be the case that some regions or occupations provide access to specialized technically relevant social capital through networks and learning partnerships that can support knowledge development (Bourdieu,1986). Recent quantitative data on the geographical histories of patent holders suggests that regional social networks are critical for surfacing and sustaining talent (Bell, Chetty, Jaravel, Petkova, & Van Reenen, 2017). Andres, a learner described in the introduction to this paper, shared his knowledge in contributing to his church community, using Adobe design products to create a song guide that scrolled lyrics projected on a large screen. Jonathon's consulting business was utilized by teachers at his school. From an equity perspective it is imperative to document the conditions that allow for and constrain the development and recognition of innovation of all types. Combining geographical analyses with more nuanced ethnographic research would set the stage for future experimental intervention-oriented research intended to help democratize the potential of all young people to innovate and share their innovations more broadly. As a first step, we intend to refine our retrospective survey questions to carry out a nationally representative survey that could see how these patterns play out or not across a larger and more diverse sample of youth and/or parents. Gender is also an area for more research, although in this sample there were no significant differences between boys and girls in this sample in terms of diversity or density of parent roles played or their own digital production experience. There were differences between mothers and fathers in the proportion engaged in technology focused jobs and in the frequency of roles. For example, mothers were more likely than fathers to broker learning opportunities for their children. In other analysis not reported here we show that the broker role is very important in this sample—students who report parents who play the learning broker role also report learning outside of school about a greater number of technology-related topics.

In closing, our findings underscore the value of deepening our understanding of informal family-based learning partnerships as a contributor to the technical expertise of young people. This is a particularly important goal for addressing issues of innovational equity (Barron, 2004). A well-documented lack of diversity in those who are lead designers is increasingly recognized as significant challenge and a threat to creativity and innovation in the technology industry. To the extent that we have a more homogenous group of professionals imagining and building future tools we fail to capitalize on diversity of perspectives, ultimately limiting potential solutions. It is generally agreed that this is a multidimensional problem that includes early gaps in experience, gender and racial stereotyping of technical work, and workplaces that create climates that suppress rather than invite contributions from all (e.g. Google & Gallup, Inc., 2016; Williams, Li, Rincon, & Finn, 2018). Our findings suggest that by supporting all parents as learning partners we might increase the likelihood of engaging a more diverse group of young people in activities that will position them to be future designers in service of their own goals, their communities' needs, or their workplaces. Given that families are central sites for learning interactions, working to help expand their opportunities to co-learn may be one of the more important things we can do to fulfill the potential promise of technology as a resource for the greater good. At the same time, to support more equitable robust learning ecologies, it is essential that schools, libraries, community organizations and other public institutions provides access to opportunities to complement the important work that families do.

References

Barron. B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecologies perspective. *Human Development*, *49*, 193-224.

Barron, B. (2004). Learning ecologies for technological fluency: Gender and experience differences. *Journal of Educational Computing Research*, *31*(1), 1-36.

Barron, B. (2010). Conceptualizing and tracing learning pathways over time and setting. In W. R. Penuel, & K. O'Connor (Eds.), *Learning research as a human science. National Society for the Study of Education Yearbook*, *109*(*1*), 113-127.

Barron, B., Gomez, K., Pinkard, N. and Martin, C.K. (2014). *The Digital Youth Network: Cultivating digital media citizenship in urban communities*. Boston, MA: MIT Press.

Barron, B. & Martin, C.K. (2016). Making matters: A framework for assessing digital media citizenship. In K. Peppler, Y. Kafai, & E. Halverson (Eds.) *Makeology (Vol 2): Makers as learners* (pp. 45-72). New York: Routledge.

Barron, B., Martin, C.K., Takeuchi, L., Fithian, R. (2009). Parents as learning partners in the development of technological fluency. *International Journal of Learning and Media*, *1*(2), 55–77.

Barron, B., Walter, S., Martin, C.K., and Schatz, C. (2010). Predictors of creative computing participation and profiles of experience in two Silicon Valley middle schools. *Computers and Education*, *54*(1), 178-189.
Bell, A. M., Chetty, R., Jaravel, X., Petkova, N., & Van Reenen, J. (2017). Who Becomes an Inventor in America? The Importance of Exposure to Innovation (No. w24062). National Bureau of Economic Research.
Bourdieu, P. (2011). The forms of capital. In I. Szeman & T. Kaposy (Eds.), *Cultural theory: An anthology* (pp. 81-93). Madden, MA: Wiley-Blackwell.
Ching, D., Santo, R., Hoadley, C., & Peppler, K. (2015). On-ramps, lane changes, detours and destinations: Building connected learning pathways in Hive NYC through brokering future learning opportunities. White paper for the HIVE Research Lab. Document retrieved from: http://hivenyc.org
Google Inc. & Gallup Inc. (2016). Diversity Gaps in Computer Science: Exploring the Underrepresentation of Girls, Blacks and Hispanics. Retrieved from http://goo.gl/PG34aH
Gutiérrez, K. D., & Rogoff, B. (2003). Cultural ways of learning: Individual traits or repertoires of practice. *Educational Researcher*, *32*(5), 19-25.
Horrigan, John B. (2016). Digital Readiness Gaps. Pew Research Center. Retrieved from http://www.pewinternet.org/2016/09/20/2016/Digital-Readiness-Gaps/
Ito, M., Horst, H., Antin, J., Finn, M., Law, A., Manion, A. et al. (2009). *Hanging out, messing around, and geeking out: Kids living and learning with new media*. Cambridge, MA: MIT Press.
John, J. & Carnoy, M. (2017). Race and gender trends in computer science in the Silicon Valley from 1980-2015. Retrieved from https://cepa.stanford.edu/sites/default/files/JohnCarnoy_Sept2017_0.pdf
Livingstone, S., Ólafsson, K., Helsper, E., Lupiáñez-Villanueva, F., Veltri, G., & Folkvord, F. (2017). Maximizing opportunities and minimizing risks for children online: The role of digital skills in emerging strategies of parental mediation. *Journal of Communication*, *67*, 82-105.
Louw, M., Barbuto, N., & Crowley, K. (2016). Designing Learning Pathways in a complex learning ecology: A research-practice partnership focused on parent brokering. In B. DiSalvo, J. Yip, E. Bonsignore, & C. DiSalvo (Eds), *Participatory Design for Learning: Perspectives from Research and Practice* (pp. 93-112). New York, NY: Routledge.
Martin, C.K., Barron, B., Stringer, D. & Matthews, J. (2014). Patterns of engagement: How depth of experience matters. In B. Barron, K. Gomez, N. Pinkard, and C.K. Martin *The Digital Youth Network: Cultivating Digital Media Citizenship in Urban Communities*. Boston, MA: MIT Press.
Peng, G. (2017). Do computer skills affect worker employment? An empirical study from CPS surveys. *Computers in Human Behavior*, *74*, 26-34.
Rogoff, B. (1998). Cognition as a collaborative process. In W. Damon (Series Ed.) & D. Kuhn & R.S. Siegler (Volume Eds.), *Handbook of Child Psychology, Vol. 2: Cognition, perception and language* (pp. 679-744). New York: Wiley.
Rogoff, B. (2003). *The cultural nature of human development*. Oxford, UK: Oxford University Press.
Takeuchi, L., & Stevens, R. (2011). The new coviewing: Designing for learning through joint media engagement. New York, NY: The Joan Ganz Cooney Center at Sesame Workshop.
Whiting, B., & Whiting, J. (1970). Methods for observing and recording behavior. In R. Naroll & R. Cohen (Eds) *A handbook of method in cultural anthropology, Vol 2* (pp. 282-315). Garden City, N.Y: Natural History Press.
Willliams, J.C., Li, S., Rincon, R., & Finn, P. (2018). Climate control: Gender and racial bias in engineering? Center for Worklife Law & Society of Women Engineers. Retrieved from https://research.swe.org/climate-control/
Yuen, A. H., Park, J., Chen, L., & Cheng, M. (2018). The significance of cultural capital and parental mediation for digital inequity. *New Media & Society*, *20*(2), 599-617.

Acknowledgements

This research was funded through the LIFE (Learning in Informal and Formal Environments) Science of learning Center, an NSF-funded (REC-354453) effort seeking to understand and advance human learning through a simultaneous focus on implicit, informal, and formal learning, thus cultivating generalizable interdisciplinary theories that can guide the design of effective new technologies and learning environments. Writing and analyses were supported by the TELOS (Technology for Equity in Learning Opportunities) initiative at Stanford University.