Conceptualizing and Tracing Learning Pathways over Time and Setting

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> I have always have had friends who were pretty interested in computers. So, um they started doing some Web design in Geocities using HTML and then they told me it was really fun so I joined in and they sort of taught me what was going on, and so that is where I learned HTML. I started making my own Web pages then I started joining classes like Industrial Technology and Programming because it was like becoming an interest for me.
>
> A 13-year-old girl attending a public school in Silicon Valley

Many adult readers will be immediately impressed by this middle school student's interest in and sustained engagement with technology, as reflected by the breadth of her self-described knowledge of programming, digital art making, and Web design. Our research team learned from interviews with this student that her interests in digital production began not at school or home, but within hobby-oriented activities she engaged in with her friends beginning in the sixth grade.

Her growing interest led her to pursue additional learning opportunities both in online digital art communities and in school. She started new projects on her own time in order to advance her ability to create, and she actively sought out resources like "how to" guides and tutorials online that explained concepts and gave her ideas for her own work. She borrowed books on programming languages and studied examples generated by her online peers. She downloaded free software programs that allowed her to experiment with different genres of media production. In

National Society for the Study of Education, Volume 109, Issue 1, pp. 113–127

sixth grade, she participated in a museum-sponsored design challenge along with a group of friends. At school, she chose elective classes that could advance her practical digital media creation skills and give her a broader understanding of the concepts underlying computer science and technical industries.

A more complete analysis of her learning biography reveals an intergenerational link to visual arts through her grandfathers, both of whom were artists, and links to the domains of technology and science long valued and practiced professionally by her parents and more generally by her parents' Chinese cultural community. By the end of middle school, this teenager had developed a rich, interconnected learning ecology with learning activities distributed across more and less structured environments, including home, school, virtual environments, and community contexts. Her learning network included her parents, close friends, teachers at school, and digital artists she had never met or even spoken with. Her production-oriented activities engaged her imagination, and her desire to create what she imagined helped sustain her continued learning.

Learning sciences research has been focused primarily on studies of design innovations for schools and on knowledge that develops during brief periods of time (e.g., as a result of the implementation of a science or mathematics unit). This chapter advances the argument that research on learning should also focus on how learners initiate and sustain engagement in activities that advance their learning in particular domains. I argue that learning sciences research needs to expand its focus to include an examination of engagement as an outcome and to consider how engagement develops across different settings, timescales, and networks of support. This argument represents a human sciences perspective on learning research in its attention to how participants in learning situations both interpret and create learning opportunities.

WHY FOCUS ON ENGAGEMENT?

A decidedly social turn in the field of the learning sciences has challenged researchers to go beyond articulating psychological processes that underlie near-term knowledge acquisition to better understand learning as a process of becoming that takes place across longer scales of time and within and across the multiple life spaces that a learner inhabits (Cole, 1996; Lave, 1996; Lemke, 2000). This turn is the result of growing scholarship from social scientists that reveals how an understanding of historical context, timing, social networks, and access to various forms of social and human capital are necessary to explain learning over time (Elder, 1994; Saxe & Esmonde, 2005; Serpell & Hatano, 1997). Attention to cultural arrangements for learning (Serpell & Hatano, 1997) along with a renewed focus on the learner as an active contributor to his or her own development (Barron, 2006), highlights the important role of engagement and meaning-making for sustained participation in learning activities.

A focus on engagement in research on learning, in contrast to an exclusive focus on knowledge acquisition, is consistent with contemporary theories of learning that conceptualize moments of learning as part of a process of becoming (Beach, 1999; Nasir, 2002; Wenger, 1998). Participatory views of learning draw attention to membership in communities of practice that are defined by affinity groups (Gee, 2000) based on interest-driven activities (Wenger, 1998). For newcomers, joint endeavors offer not only opportunities to develop knowledge in a particular domain but also increasing levels of commitment, sense of belonging, and identity as a practitioner that develops and is sustained across time and place. Members of affinity groups come to develop practices and sets of experiences that position them to engage the world in particular ways that offer continual opportunities for learning.

Studies of young children illustrate the idea that engagement in activities develops interest and knowledge across multiple settings and longer timescales than are typically the focus of learning sciences research. Crowley and Jacobs (2002) have introduced the construct of "islands of expertise" to reflect the fact that young children often develop considerable knowledge about topics of interest during their preschool years and that these areas of expertise become foundational for their acquisition of school subjects. They give the example of a boy whose interest in trains developed initially through stories and then by trips to museums and viewing videos related to trains. Over time, he and his parents built up a great deal of shared knowledge, including vocabulary, schemas for scenarios involving trains, and knowledge of mechanisms that allow for train travel. The shared knowledge that develops from such islands of expertise can support rich conversations that include explanations, elaborations, and analogies to related domains that prepare the child for future conversations with non–family members. Building an island of expertise also sets in motion other learning processes when parents and peers recognize an interest by engaging in conversation about it or providing resources, such as books, toys, and equipment, that encourage reengaging in topic-related activities that sustain learning.

The notion of islands of expertise implies a key role for persons in learners' social networks who can serve as learning partners that bridge contexts, settings, and learning opportunities and support interest and identity development. Research conducted as part of the Learning in Informal and Formal Environments (LIFE) Center, a research center devoted to the study of lifelong, life-wide learning processes, shows that parents, siblings, mentors, teachers, peers, and coworkers can play critical roles in sparking and sustaining engagement in learning activities within and across settings (Barron, Martin, Takeuchi, & Fithian, 2009; Bricker & Bell, 2008; Goldman, Booker, & McDermott, 2008; Stevens, Satwicz, & McCarthy, 2008). These roles go beyond informal teaching and mentoring to include collaborating, providing resources, or brokering connections to new learning opportunities, and often are facilitated by access to technologies that support sharing and joint work. Of particular importance is how, in enacting these roles, guides (whether teachers, peers, parents, or other adults) help learners navigate within and across settings to create new opportunities for learning, thus providing young people with valuable social capital that they can use to develop skill and knowledge (Coleman, 1988). Attending closely to learning partnerships and relational contexts foregrounds social processes like positioning (Harré, 2002) that help us understand ways that face-to-face interaction in the moment connects learners to the past and to possible futures. These forms of interactions are implicated in processes of identity formation, insofar as they contribute to individuals "authoring" a self through a process of constantly being addressed by, and answering back to, a "figured world" that offers different possibilities for the self (Holland, Lachicotte, Skinner, & Cain, 1998).

THE NEED FOR LONGITUDINAL, CROSS-SETTING ANALYSES OF LEARNING

Expanding the temporal dimension of study from seconds, minutes, hours, or days to months and years in turn invites us to ask new questions about the origins, evolution, and development of engagement in activities over time and how these patterns of sustained activity result in more stable interests and areas of expertise (Hidi & Renninger, 2006). Understanding the origins and concurrent conditions of sustained engagement with content over years requires research methods that go beyond more commonly assessed near-term knowledge gains (e.g., after the completion of a course) and that allow researchers to trace connections between learning activities and to characterize how content-related interests originate and evolve over time and across life settings. Although learning scientists rarely use longitudinal methods in their research, the fields of sociology and developmental psychology have long embraced such approaches.

In sociology, for example, the life course paradigm (Elder, 1994) has yielded a rich set of constructs that can contribute to studies of learning, including the intertwining of development with historical context, the principle of "linked lives" (i.e., the idea that parents' and children's development influence one another throughout the life course), and the role of human agency in shifting the course of a life trajectory. Renewed attention to the role of agency in learning directs our attention to the ways that learners not only choose but also *create* their own learning opportunities by choosing to pursue lines of activity that they find meaningful and worthy, by developing relationships with potential mentors or collaborators, and by pursuing material resources that sustain projects that support their interests (Barron, 2006). Considering how lives are linked across generations calls attention to larger historical forces that can shape an individual learning trajectory, both to the relationships that span generations and to the technologies, symbolic systems, or institutional practices that span them. Most relevant to the discussion here are the new opportunities for specialized interests to develop that are due to what has been called the "long tail" of learning resources (Anderson, 2006). The Internet, for example, allows for the proliferation of communities of learning that cater to very specific kinds of interests and that are available to anyone who has access to the Internet and the skills to understand them, such that even young learners like the middle school student described earlier can achieve a level of competence that some have called "Pro-Am," or professional amateur (Leadbetter & Miller, 2004).

The methods that my research team used provide what might be called a wide-angle view of learning focused on offering a glimpse of the dynamics of learning and interest development in relation to resources over weeks, months, and years. In one recent study our goal was to solicit retrospective accounts of the emergence of engagement in activities that by their nature offered opportunities for developing conceptual knowledge, self-efficacy, a sense of agency, and interest in a broad range of subject domains, including digital arts, computer science, and human–computer interaction (Barron, 2004). Our focus within this agenda involved further specification of the roles that people play in a learner's knowledge network and how these support learning interactions, the nature of activities that propel learning, the ways that activities evolve over time, and the role of distributed resources such as books or Internet-based communities.

We drew on interviews as a key data source, creating portraits about learning (primarily about technology) in a genre that Henwood, Kennedy, and Miller (2001) called *technobiography*. Our portraits chart a learning history in terms that go beyond metrics such as numbers of courses taken, focusing instead on the meaning and attribution behind decision-making and narratives of how the learning activities unfolded across time, resources, and historical context (Bruner, 1994; Elder, 1994; Linde, 1993). In addition, interviews can reveal processes that are missed through other methods and provide us with portraits that go some distance toward "recovering the person" in our theorizing about human development (Mishler, 1996). The very ideas underlying the perspective on learning presented here originated from interviews with youth and are thus grounded in accounts of learning as offered by adolescents, as the method of grounded theory advocates (Glaser & Strauss, 1967). As such, they represent an emic, or "insider's" perspective on learning from the point of view of learners themselves (also see Stevens, 2010, this volume).

ILLUSTRATION OF THE APPROACH: TWO CONTRASTING CASES OF BECOMING TECHNOLOGICALLY FLUENT

To illustrate what kinds of portraits these analyses can yield. I share the cases of two boys of the same age living in the same metropolitan area, but whose trajectories and contexts differed in ways that were consequential for their development of technological fluency. Both these teenagers were active users of technology, but their motivations, conditions, and social supports for pursuing their interests in technology differed. These differences correlated with the accumulation of expertise, opportunities for learning, and the possibilities for future learning.

JONATHON

Jonathon was an only child growing up in a Silicon Valley neighborhood. When we interviewed him, he was an eighth grader attending a local public middle school. By the age of 13, he was engaged in a broad range of technology-related activities that reflected his strong interest in computers, programming, and the Internet. He was running two online businesses and a third computer consulting business, and he served as the Web developer and administrator for a nonprofit educational organization. At home, he had 16 computers in various states of working order. A visit to his home also revealed bookshelves full of programming books and a room devoted to his business, shared only by the family's pet hamster.

Jonathon considered himself first and foremost to be a programmer and used his interest and knowledge to build money-generating businesses in both the virtual and actual world. Jonathon spoke about a variety of factors that motivated him to pursue knowledge about technology and computers, ranging from the pure enjoyment of designing an elegant solution, to an interest in knowing more than the person next to him. In describing the motivation for starting his computer businesses, Jonathon sounded like a Silicon Valley entrepreneur: “Free Web hosts weren’t that good and I didn’t want to pay for one, so I made my own because I had some computers. I learned a lot doing that. I got some books and a lot on the Internet because it’s kind of complicated.”

From Jonathon’s point of view, his own experimentation and initiative were the most important sources of his learning about technology. For the most part, Jonathon maintained that he “learned how to do that by experimenting.” Though he had taken some courses in computers and technology at school and attended summer camps that taught technology skills, he preferred to learn independently. “When I do stuff myself then I can jump ahead and do more. They are not controlling what you’re learning. It’s more freeform.”

Though it may be true that a great deal of Jonathan’s technology-related learning was on his own, via experimentation with new languages and use of the Internet and books to help him with new subjects and techniques, he had ample material resources and a wide network of adult experts to help him. He had books, computers, and software at the ready, and broad expertise was available in his family and their network of friends and colleagues to help him advance his goals and learn new things. Jonathon credited his father, an engineer and programmer, for getting him interested in programming languages. For his first-grade science project, Jonathon explored HTML with the help of his father and books. This initial interest in programming grew, and Jonathon capitalized on his early knowledge. At age 9, he took an online course on C++ identified by his mother, and his father aided him heavily with assignments.

When Jonathon’s father could not answer a certain question for Jonathon or was unable to help him with something he was working on, he put Jonathon into contact with his friends in the field. For example, for another science fair, Jonathon wanted to refurbish an old computer. Because his father did not see himself as expert in hardware, he asked a friend to collaborate with Jonathon on the project. Jonathon’s mother, a small business owner, helped him by providing advice on his Web hosting project. She helped his Web hosting business by using it for her own work site and suggesting his services to her friends. His father’s brother, a technology expert, lived close to Jonathon’s family and was also readily available when he had a question about his work. Another of Jonathon’s uncles had owned several companies and provided consultation on how to create a contract with his business partner and how to establish competitive prices for services.

In addition, the activation of these resources and sources of social support illustrate the way that Jonathon's and his parents' lives were "linked" in patterns of reciprocal influence in ways that shaped his own development and the family. His father facilitated his earliest use of the family's Macintosh computer by loading educational games onto it for Jonathan to play; at the same time, his father also installed software to make it difficult for Jonathan to change settings that could make it difficult for his father to do what he needed to do on the computer. As Jonathon put it, "He had some software that kept me from screwing up the computer. I kept breaking through it." When his father could not access his files, he become frustrated with Jonathon, and the incidents are examples of how developing skill can disrupt the activities of others in the family. Other interactions revealed ways that his parents' needs sometimes spurred his own learning and provided him with opportunities to help or teach them. Jonathon's mother, who claimed she was not very technically savvy, looked to him for help with her computer problems. She helped Jonathon to clarify his own knowledge by having him explain things to her in simplified terms that she could understand. In turn, she shared her expertise as a designer and the owner of a small business, contributing her expertise to his own money-making ventures.

ANDRES

Andres was a seventh grader who attended a public middle school just 10 miles from the school Jonathon attended. He was born in Guatemala, and he immigrated to the United States with his parents when he was a baby. He lived at home with his mother and two younger siblings. The family spoke both Spanish and English at home, in what Andres called a variant of "Spanglish." Andres was an avid gamer. He particularly liked games that allowed him to build simulated worlds, such as Rollercoaster Tycoon, a strategy game that enables players to build and manage a theme park. Other games Andres enjoyed were Circus Tycoon and Sea World Tycoon, two other simulation games in the same series as Rollercoaster Tycoon, and RuneScape, a massively multiplayer online fantasy role-playing game. Andres's technology experience also extended to game creation. He learned how to use the Gamemaker software, a free and easy-to-use application for game creation, and he was able to make his first game in one day. He extended his ability to create games by using a tutorial available online. He used Photoshop to create images for his games, and he reported learning Dreamweaver, Flash, and Fireworks. He downloaded sounds to link to his characters' actions. Andres also found free Internet resources to create graphics for his games, using a Flash-based program that allows users to customize fonts with color, shadowing, depth, and texture. In addition to game-playing and game-making, Andres pursued more adventuresome projects. He described a 3-day project in which he learned to make his own virus, though he was quick to point out that he would never use it because he was not "a mean person." This playful exploration led to him developing an understanding the binary systems that underlie much of computing.

Andres thought of himself as a strategic thinker who liked personal challenges when it came to technology. Describing his involvement in online gaming, he said, "It is like a strategy game so you have to really think about it before you start doing anything. . . . I like a challenge . . . I like challenges . . . I don't like anything that is my level or lower." In this context and in gaming, Andres preferred tinkering to tutorials when it came to learning, noting that when it came to computers, he trusted himself to figure things out on his own.

Andres was not without significant sources of support in his pursuit of challenges with respect to technology. Andres relied on staff and tools available to him at the local Computer Clubhouse, an affiliate of a program run at the Boston Museum of Science that provides access to powerful technology tools in community technology centers, primarily in low-income neighborhoods. The clubhouse is a drop-in setting, with guides available to help young people learn new technologies and occasional workshops; its approach to promoting learning is based on the constructionist ideas of Seymour Papert (1993), which emphasize using computers as tools for young people to explore their own interests and develop knowledge (Resnick & Rusk, 1996). Andres was a regular at his local clubhouse, and he had taken every workshop the coordinators had given. He consulted with them on most of his projects, relying on their help and expertise to assist him with game design.

Andres's family and church life provided him with occasions to help others use technology to achieve their goals in ways that linked his technological fluency development to meeting family and community members' needs. For example, Andres was the primary computer coach for his mother. He helped her learn to set up online bill-paying accounts, and he taught her to use the mouse and keyboard and how to find and organize her documents within folders. His expertise with computers had also been called upon at church. He was asked to help create support to the congregation for singing novel songs. He used Adobe to create a song guide that scrolled song lyrics projected on a large screen. School offered few opportunities to extend Andres's production activity. In fact, at school, he primarily used a computer to complete standardized assessments of his literacy and math skills. The one computing class his middle school offered focused on basic operations and typing, skills that he had surpassed through his clubhouse experience.

WHAT THE CONTRASTING CASES REVEAL ABOUT POTENTIAL DIFFERENCES IN DEVELOPMENTAL TRAJECTORIES OF ENGAGEMENT WITH TECHNOLOGY

Comparing Jonathon's and Andres's trajectories of engagement and supports along the way reveal some important ways that trajectories differ, as well as commonalties that might be looked for in research to inform the writing of portraits of other youth. On the one hand, the particular kinds of technology interests that these two boys have pursued have been different, but both boys' engagement could be described as deep and sustained over longer time spans and settings. Both lines of activity (Azevedo, 2006) involved making digital environments and required imagination, continual learning, and resourcefulness. Both boys adapted available tools to meet their own or their community's needs. Further, although the contexts that supported their engagement were quite different from one another, neither was without support, and both boys' skills and experiences became intertwined deeply into the lives of their families, such that it is hard to imagine what the family life of either boy would look like without their interests and activities.

The differences in the composition and dynamics of the social networks that support these boys' development illuminate ways that the links among settings of development can shape possibilities for learning. Jonathon's path toward expertise in programming started early and was guided by his father, a practicing programmer and systems designer. Long before middle school, he had access to both formal and informal learning resources. When he reached middle school, he was able to take technology-focused electives like industrial technology and Web design. Teachers at school recognized his expertise by calling on him to troubleshoot technology breakdowns, both in the classroom and in their own homes. With resources provided by his family, and in collaboration with partners, he started small businesses that further motivated his learning. Jonathon's social network provided him with access to knowledgeable experts but also provided him with the opportunity to become an authentic member of the larger Silicon Valley community that values innovation. By age 13, Jonathon saw himself as someone who could improve existing systems and create new tools.

Andres was equally enthusiastic about new technologies, but his opportunities for expertise development were dramatically different. The mentors at the clubhouse provided access to tools and encouragement for game creation, and they offered workshops to introduce new tools; however, neither mentor held a degree in computer science, and programming was not a focal activity of clubhouse participants. Andres's middle school did not offer many opportunities for him to learn about or with technology. The contrasting school-based learning opportunities offered to Andres and Jonathon were consistent with other studies that documented socioeconomic-status-linked differences in computing electives (Margolis, 2008). At home, Andres was given encouragement, and he was recognized as the resident expert, an important role that marked his competence and gave him opportunities to learn as he consulted with his mother. However, in contrast to Jonathon, Andres did not have a more expert parent who could provide him with specialized knowledge, explain advanced concepts, or make connections with a broader social network. Thus, whereas Jonathon is already on the fast track for a career in computing, Andres's opportunities for expertise development will likely be limited by what he can explore on his own and the courses his high school may offer.

FUTURE DIRECTIONS FOR RESEARCH ON LIFELONG, LIFE-WIDE ENGAGEMENT

Longitudinal case study research focusing on biographies of learning has the potential to expand our theorizing about learning and may help teachers, parents, policy makers, and informal educators imagine new ways to support development. By documenting learning across both time and setting, a richer portrait of individual learning emerges as supported by guides and resources in both formal and informal learning settings inside and outside of school. By contrast, it is hard to imagine that a researcher who evaluated these boys' technology fluency on the basis of what they were learning in school would fully appreciate the significance of technology for each boy or his trajectory of skill development.

Future research may extend this work in a number of ways. First, although we acknowledge the importance of demographic correlates of patterns of engagement, there is a significant need to move beyond studies that simply document associations with demographic variables in order to provide more nuanced understanding of the nature of co-learning practices and how and why they vary within and across communities (Lee, 2008). The portraits presented in this chapter cast differences in access to opportunity to learn in terms of differences in the adolescents' personal networks and characteristics of the settings where they use and learn about technology. At the same time, they also show the potential for community-based resources to be generative. It is possible for schools and communities to make spaces where access to ideas, conversations, tools, and new social networks leads to very similar levels of interest development and pursuit of learning, even when parents are not able to play direct roles within activity. Erickson (2002) suggested that we begin to recognize that all learners belong to multiple communities of practice and that a productive approach to developing a more nuanced understanding of how these communities do or do not interact synergistically is to expand our units of analysis to include the "daily round" of a learner as he or she moves in and out of life settings (see also Mørck, 2010. this volume). Explicit attention to sampling and studying youth over time who have access to generative learning environments created to bridge equity gaps across communities will contribute to a human sciences research agenda that will be generative for design and provide better accounts of human learning. Studies of outstanding classrooms (e.g., Scardamalia & Bereiter, 1994) and community center programs in other subject areas also give us models (Heath, Soep, & Roach, 1998) to follow, especially where adults are positioned as guides to support learner engagement.

Another important direction for future research involves documenting the varied ways that learners exert agency to advance their own learning and the conditions under which the resources they develop sustain engagement. Seeking out online resources, forming ongoing mentorship relationships, creating a small business, or deciding to take a course are examples of choices that learners make that allow them to keep learning. Charting these kinds of moves can help designers begin to see how to create resources that are more easily taken up by interested learners.

Third, although longitudinal case studies are useful, other methods of research might be fruitfully brought to bear on the question of how to best recognize, nurture, and sustain engagement. Design research can help to create and test tools to help adults track interests across time and settings so that youths' interests do not fall through the cracks or go ignored by people who could help them. A direction we are pursuing as part of the LIFE Center involves developing representations that help other researchers or adults who support young people's development notice young people's engagement in interest-driven activities over time. Our timeline visualizations of the learning activities of young media producers represent age along the horizontal axis. The settings of home, school, and community are represented along the vertical axis. Learning activities are mapped, and connections between them are marked visually. This kind of representation has allowed my research group to notice the varied origins of engagement in production-related projects, the distribution of activities across settings and their evolution across time and setting, and the collaborative partners involved. We imagine that this tool could help parents, teachers, or mentors identify potential activities and resources for learners that might extend their learning.

In closing, in this chapter, I have argued for research that captures the dynamics of learning across setting and time and that goes beyond a focus on knowledge to also address interest as a driver of continued engagement. Formative assessments that focus on choice, interest, and engagement can provide an essential complement to the typical focus on short-term knowledge gains. We believe that tools that make visible engagement in learning provide an example of a "human sciences" approach to intervention, which emphasizes "tools for action" or "equipment for living" (Burke, 1938) over black-box interventions—that is, resources that help researchers and adult guides in learning situations help young people pursue and develop skills and knowledge they value and about which they are passionate.

Acknowledgments

This material is based in part on work supported by the National Science Foundation (REC-238524, REC-354453) through the LIFE center (http://life-slc.org/) and by a grant to the author from the John D. and Catherine T. MacArthur Foundation. Any opinions, findings, and conclusions expressed are those of the author and do not necessarily reflect the views of the sponsoring agencies. I am grateful for the participation of the families involved and the contributions of the YouthLab research group, particularly the contributions of Caitlin Kennedy Martin, Lori Takeuchi, and Susie Wise to data collection and case study preparation.

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