Informal Mentoring of Adolescents about Computing: Relationships, Roles, Qualities, and Impact

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ABSTRACT

Influencing adolescent interest in computing is key to engaging diverse teens in computer science learning. Prior work suggests that informal mentorship may be a powerful way to trigger and maintain interest in computing, but we still know little about how mentoring relationships form, how mentors trigger and maintain interest, or what qualities adolescents value in informal mentors. In a 3-week career exploration class with 18 teens from underrepresented groups, we had students write extensively about their informal computing mentors. In analyzing their writing, we found that most teens had informal computing mentors, that mentors were typically teachers, friends, and older siblings (and not parents or school counselors), and that what teens desired most were informal mentors that were patient, helpful, inspiring, and knowledgeable. These findings suggest that computing mentors can come in many forms, that they must be patient, helpful, and inspiring, but that they also require content knowledge about computing to be meaningful. Future work might explore what knowledge of computing is sufficient to empower teachers, parents, peers, and family to be effective computing mentors.

KEYWORDS

Informal mentorship; interest development; adolescence.

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1 INTRODUCTION

Computing has become an integral part of society, increasing the importance of future generations learning about computing. In most places in the world, whether an adolescent engages in computing education is a decision based partly on their *interest* in computing as a subject [25, 26]. As a psychological and motivational construct, interest can be viewed as a predisposition to reengage with certain ideas over time, shaped by the interaction between a learner and their environment over time, and evolving from something that is external and situational to something personal and individual [14].

Unfortunately, prior work has shown that many adolescents are either not interested, or actively disinterested in learning computing, viewing it as boring, antisocial, irrelevant, male, and competitive (e.g., [6, 24, 25]). Changing these adolescents' interests is hard. Theoretically, interest must be both triggered and maintained *situationally* before it becomes internalized enough to drive further learning [14]. Both triggering and maintenance require ongoing effort by both the adolescent and also by people in an adolescent's life. For example, adolescents might become interested because someone fosters pleasure in learning about a subject, concern about a problem related to the subject, identity around knowledge of the subject, or curiosity about the subject [4, 11]. Interest can also be fostered through social means, such as becoming part of a social group, or meeting some social obligation [11]. The maintenance of deeply engaged interest development is rarely about a particular domain of interest, but rather a constellation of concerns, domains, values, goals, practices, and communities that make practice of an interest meaningful along different time scales [2]. In the context of computing, this general literature on interest development suggests that an Hour of Code experience might *trigger* an interest in computing, but adolescents will need a strong social and "multitopical" component over time to develop an individual interest [2].

One way to facilitate this exploration is through *mentoring* relationships [20]. Mentors can be "intimate strangers," in that the student may not know a mentor as a person, but the mentor nevertheless offers sustained help in accomplishing an authentic task that youth have chosen to work on [13]. Mentors can be people like teachers, community members volunteering at a coding summer camp, or even classmates, siblings or parents [3]. The educational paradigm of connected learning views these mentoring relationships as not just helpful to developing interest, but central to embedding youth in social networks and communities of interest that they can call on for support and encouragement [18, 19]. A recent national survey of interest in computing reinforces this view, finding strong correlations between interest and the confidence and encouragement that mentors can provide [38].

Most research on mentoring has focused on *formal* mentoring programs, in settings such as the workplace [16, 17] or in educational contexts (e.g., [28, 33, 35, 39]), in which mentors are assigned or matched as part of a structured program. This focus on formal mentoring is also true of research on computing mentoring. This work has found that strong communication skills and an appropriate personality are key [29, 31, 32, 37], mirroring general research

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on formal mentoring [12, 20, 33]. By following these practices, CS faculty can influence enrollment decisions [36], increase retention [7], and produce more effective learning [10]. Formal *peer* mentoring, in contrast, poses challenges that may do more harm than good [15], but can improve learners' sense of community [9].

While there has been substantial prior work on formal mentoring relationships both inside and out of computer science education, we still know little about the *informal* mentoring relationships that develop organically, particularly among adolescents [20]. Recent efforts to define mentorship primarily focus on formally designed mentoring interventions, decomposing models along dimensions such as relative seniority, tie strength, mentee selection, training, monitoring, and policy [8]. Informal mentoring relationships have some of these features, but lack any intentionality in their qualities. A recent definition (and the one we use in this paper) defines informal mentoring relationships as determined not by the setting a learner is in, but rather as relationships that developed as extensions to existing social support structures, developing gradually over time [1, 21]. By this definition, prior work shows that many adolescents have informal mentors in their lives: one national survey of U.S. teens found that more than 4 out of 5 adolescents identified informal mentors that they obtained through their social networks [27]. Another study of Los Angeles teens showed that more than half of adolescents had informal mentors, viewing key mentor attributes as showing respect, offering someone to talk to, and supporting social and learning activities [5].

Only recently have researchers begun to investigate informal mentoring of adolescents about *computing*. This work has found that many students mention the importance of mentors in deepening their interest in computing [22], that interest is associated with having and gaining an informal mentor [23] and that informal mentors included friends, siblings, parents, neighbors, cousins, and teachers. What makes informal computing mentorship notable is just how strongly predictive it is of interest: in a recent study [23], having an informal mentor predicted more than 25% of the variation in self-reported interest in learning computing, an order of magnitude more than gender or socioeconomic status.

While this work shows the importance of mentorship, it leaves open several questions about mentoring relationships:

- What kinds of informal mentoring relationships form?
- What do mentors do to trigger and maintain interest?
- What qualities do youth value in their mentors?
- What impact do youth believe their mentors have?

Our approach to answering these questions was to teach a small group of 18 low-income, racially diverse teens from the city of Seattle, Washington, USA, and have them write about their interests and informal mentoring relationships. We hoped a longitudinal encounter with a trusted teacher and among trusted peers would be more revealing than brief interviews or surveys, while also acknowledging teens' active and evolving sense of identity and interest.

2 METHOD

Our method engaged students both retrospectively and prospectively, relying partly on their memories of current and recent mentoring relationships, but also their active engagement in developing academic interests. We devised a 10-hour class to elicit these perspectives, split across ten days of 1-hour sessions over three weeks. We offered the class as part of our university's Upward Bound program. The class sought to introduce students to careers in web design by engaging them with the experiences that led to their interests and by helping them to develop these interests.

Upward Bound (UB) is a U.S. federally-funded college preparation program that helps high school students who are low-income and/or have no parent or guardian with a bachelor's degree. There are currently 826 programs in the U.S., many of which have existed since the 1964 Economic Opportunity Act that founded them. The program we worked with serves three urban south Seattle public high schools and reaches about 125 students per year. The program is free; students receive lunch money and a stipend to attend. In 2017, 79% were both low-income and first-generation immigrants, 50% identified as female, 35% as South Asian, 19% as African, 16% as Asian, 14% as Hispanic/Latino, 10% as Black, 4% as two or more races, and 2% as White. The program's high school graduation rate is 98% and its college graduation rate is consistently above 60%.

The UB program offers a 6-week summer curriculum. We offered a three-week course titled "Web Design" as part of a six-week "Career Exploration" course, the other half of which introduced students to careers in architecture. Our course description was:

> *Love the Internet? Want to learn more about how to create content and experiences for it? In this course, you'll learn these things and more, learning modern technologies for web design and the big ideas in computing that make the Internet work. You'll create real websites that people in your life can visit and work together with your classmates to make them great. We'll also spend time helping you develop plans for further learning, discussing classes, degrees, and careers related to computing and the web.*

Program administrators solicited student preferences and then randomly assigned students to their 1st and 2nd choices, ensuring a balance along racial and gender lines; however, administrators also encouraged students to focus on classes that would satisfy graduation requirements, which biased enrollment against our course.

We aimed to provide a course that was genuinely helpful in teaching students about computing education and careers, while doing so in a way that generated data useful for answering our research questions. The premise of the course, as conveyed to students, was that "computing is everywhere," and that computing had some connection to their interests. To help them find these connections, we asked students, over the course of the three weeks, to create a site using the Google Sites platform, spanning five pages:

- An "About" landing page that gave context to who the student was and what their interests were.
- An "Interests" page, which provided a narrative about the student's general academic interests and their thoughts on computing, including details about the people in their life that contributed to those interests and disinterests.
- A "Mentor" page, which elaborated on one of the people in their narrative, giving detail about how they came to be mentored by the person and how that person contributed to their interests (computing or otherwise).
- A "Goals" page, in which students expressed the activities they wanted to engage in to further their interests.
- A "Who Can Help" page, which described qualities of their ideal mentor and listed people who could match their ideal.

Students created these five pages across the ten days, with the guidance and help of the first and second authors. To help students understand the genre of content and the level of detail we were seeking, the second author, an undergraduate student studying information science, created a site of her own, as an exemplar. Additionally, each evening after class, the second author also read each page, embedding clarifying questions, both to help students reflect on their past and future, but also to ensure sufficient detail in the content for our research goals.

Additionally, at the beginning of the course, we administered a brief survey of age, racial identity, gender identity, grade level, language fluency, and reasons for enrolling in the class. We also coarsely measured prior knowledge by having students self-report what technology classes they had taken at their school and what programming languages they had used at least once. We measured interest in computing education by adapting an existing validated scale for STEM education [30].

At the end of the course, students presented their sites at an end of summer ceremony to their parents, siblings, and other teachers. After their final edits, we archived their pages for analysis.

Because students in Upward Bound engage in both their third and fourth years of high school, the class did have 4 students whom the first author had taught the year prior to this study. Therefore, there was some potential that those students would write about the first author as an informal mentor. The first author explicitly raised this as a possibility and encouraged students to focus broadly on everyone who had impacted their interests, and that they should be honest about the limited impact that the first author might have had on their interests, so he could improve his efforts in future years. Of course, these students may have censored some of their more negative thoughts about the first author's mentorship, since he held power over their grades in the summer course.

The first two authors, as the instructors of the course, also engaged in mentoring best practices, writing individual feedback to each student's homework assignments and web pages that guided their lives outside of school, providing encouragement and guidance in class, and offering mentorship after the class was over.

2.1 Participants

The class ultimately enrolled 18 students, 8 female-identified, between the ages of 16 and 18 years. Students lived in a dozen distinct neighborhoods of south Seattle, and all were entering their junior or senior year of high school. Only 7 students spoke English at home, with the rest of the students speaking a range of languages, including Spanish, Vietnamese, Chinese, Amharic, Oromo, Kiswahili, and Somali at home. Nine students identified as Asian (of these, six as Vietnamese), 4 as Hispanic, 4 as Black, and 1 as Native Pacific Islander. Only one student had a parent who had finished more than some college; this student's father had recently finished college and started a job as a software engineer. The majority of the remaining students had parents or guardians who had finished no more than some high school. The students' reported parent occupations including nurse, janitor, barber, construction manager, gardener, and waitstaff, or listed unemployed or retired.

We asked students for their reasons for enrolling. Eight reported being explicitly interested in learning about programming and web design, five mentioned being interested in the architecture portion of the career exploration elective, 3 reported being forced to take it because they either did not want to take the other electives or their preferred elective was full, and 2 mentioned taking it because they enjoyed taking the first author's class in the previous year. All but one student was aware of a computing course at their high school or community college, but only 8 mentioned having taken it or an Upward Bound computing course. Six students reported not having ever used a programming language, and the others reported languages such as Java, JavaScript, Scratch, and Excel. On an aggregate scale measuring interest in learning about computing, interest was positive for 10 of the students, and neutral or negative for the other 8. On their websites, students explicitly described academic interests in health, medicine, math, law, business, art, science, music, sports, environment science, biomedical engineering, and aerospace engineering. None mentioned interests related to computing, despite the class's explicit focus on computing.

2.2 Analysis

Our unit of analysis was an *informal mentoring relationship*. To analyze relationships, we systematically read each student's homework submissions and web pages, extracting all sentences referring to an informal mentor. We extracted and categorized four types of information: the *relationship* the student had to the mentor, *actions* the mentor performed in their role as a mentor, *qualities* the student described their mentor having, and *perceived impact* from the mentoring relationship. Our process for coding mentor statements began with open coding of the set of statements that concerned a mentor to generate categories consistent with the content of the sentences. Then, we performed axial coding of the entire set of sentences for each mentor, systematically assigning categories from open coding to each mentoring relationship. Given the small, non-representative sample, we did not seek to quantify the frequency of categories. Our results are therefore the categories themselves, inferred from students' writing.

3 RESULTS

Throughout, we quote students anonymously. All spelling and grammar issues in quotes are students' own, and are due to many of them recently learning English.

3.1 What kinds of informal mentoring occur?

The 18 students we taught mentioned 47 informal mentoring relationships that influenced their interest in learning computing. Students mentioned anywhere from 1 to 7 relationships, with a median of 2. All relationships emerged from social contexts not originally intended to produce mentorship. Many of the students mentioned the first two authors who taught the course as mentors, and so we include students' perspectives on us as well.

Students wrote in widely varying detail about their mentors, but there was sufficient information to classify each according to well-defined social role. By far the most common role was *teacher*, which was 25 (50%) of the relationships mentioned. By "teacher," however, students were not referring to the role of managing a classroom, providing instruction, and administering tests, but rather the mentoring role of providing guidance and encouragement to

them individually and often outside of class, beyond the boundaries of what students viewed as teachers normally providing. We will therefore call these teachers *teacher-mentors*.

There were two types of teacher-mentors. The most common was Upward Bound teachers, which 9 students mentioned. These mentors included six distinct people, including the first two authors of the paper, and other past instructors of computing courses, two of whom were doctoral students. All of these teacher-mentors developed relationships with each individual student and viewed their role as guiding students to and through college.

Nine students also mentioned teacher-mentors from their public schools who individually encouraged interest in computing:

> *One of my mentors that shaped my interest in computing was my 8th grade tech teacher, [–]. He is also the school's Spanish teacher and librarian. Our previous librarian had retired and it was [–]'s first year at the school. We became acquainted since I usually visit the library often during recess. I was surprised to hear that he was going to teach the brand new tech course. (F, African, 17)*

Students described these teachers as interacting directly with them and providing them meaningful attention outside of class.

Nine students mentioned a *sibling* or *cousin*. For example:

> *...my older sister by 21 months. She is the smartest person I know, or at least one of the smartest. When I was little and before I met a lot of people, she is the person that I would say is the smartest besides my dad... I live with her so I can just barge into her room whenever I need help. But she's going to college so she'll probably not have time for me. (M, Asian, 16)*

Not all sibling relationships were constructive. One older brother encouraged a student to take AP CS, but offered little support:

> *Sometimes, he would yell at me for my troubling grade in the class but he could not able to listen to me looking out for support... Also, he do not spent much time with me to be able to understand my problem in the class or unable to help me on it... Throughout, the AP class I would cried myself to sleep in silent without letting my older brother know my struggle in class... (M, Asian, 17)*

Six students described *friends* as informal mentors. In all but one case, these were friends in the students' schools with whom they interacted regularly. The nature of these relationships was quite diverse. Some were acquaintances that students met through classes, clubs, or their community and shared their knowledge. Others were best friends who had some computing knowledge:

> *Later on my best friend [–], who was a year younger, introduced me to the concept of coding and web design after she took a class at school sophomore year. (F, Hispanic, 17)*

One student mentioned an online friendship that emerged from starting a Minecraft server. A high school student in Canada that was one year older decided to help him set it up, teaching him over the course of a year how to run and configure a server, learning how to write Java in the process. The Canadian student spent multiple hours on Skype, helping the student solve programming problems and providing him guidance on how to run the online community.

Only three students described *parents* as informal mentors (two mothers and two fathers) and one mentioned an employer. Students provided almost no detail about these relationships with adults, mentioning only superficial guidance.

3.2 What do informal computing mentors do?

Next we discuss what actions these mentors took that triggered students' interests. Students shared three types of actions.

First was simply *teaching a skill*. Whether the mentor was a teacher-mentor, a sibling, a friend, or a parent, teaching a skill was by far the most common form of mentorship, mentioned as a critical role in 37 of the 47 relationships. The skills mentors taught ranged from basic computer skills such as how to use the internet, to programming and debugging in various platforms. For example, one student described how her friend shared the knowledge she was learning in class:

> *One day, she told me how her friend was making a game for her AP Computer Science class and that she was asked to design the characters and the visuals. During the rest of the school year would kept on show me the progress that she made and would even work on it during homeroom. (F, Asian, 17)*

In describing their teacher-mentor's efforts, students highlighted the importance of their teachers helping with problems they encountered in school and out of class activities, and providing feedback and guidance on learning these skills.

Six students also described the impact of mentors sharing *new perspectives*. For example, writing about the first author, one student wrote:

> *During one of his brief lectures one day, [–] explained to the entire class how computing happens everywhere, not just with people who major in computer science. He then showed us a list of careers that utilize computing. Aerospace engineering, a career I am interested in was on that list! That moment changed my views of computer science because it plays a large role in the field of engineering. After this day I became more open minded with computing as the class was very enjoyable. (M, Asian, 16)*

Only three students mentioned their mentors offering *encouragement*. A few mentioned parents playing this role superficially:

> *Dad really wanted me to have a career in computing becasue it's 'easy' and has a good pay. Good Impact. (M, Asian, 17)*

> *My mom has always expressed some of her desire for me to pursue computer science as a career because she heard that it is a very popular field in this day and age. She would always try to persuade me to take computers classes in school which I had no desire to take... This slight pressure actually had the opposite affect and made me not want to go into this field. (F, Asian, 17)*

In both of these cases, students perceived the encouragement to be unrelated to the student's interests.

Aside from skills, perspectives, and encouragement, students did not mention other elements of mentoring described in prior studies, including goal setting or psychological support.

3.3 What qualities do adolescents value?

In creating their "Mentor" page, we explicitly prompted students to describe what they valued about their mentors, and in our effort to help them develop goals and plans, also asked them to characterize the qualities of an "ideal" mentor. We analyzed these statements and found a range of mentor qualities.

A small number of adjectives and phrases dominated youths' descriptions. Table 1 shows the most frequent qualities described more than once, including *patient*, *helpful*, *inspiring*, and *supportive*.

These manifested in similar ways across each role. For example, students characterized teachers as focused on helping students build confidence, identity, and skills:

> *Ms. [–] was caring person and very inspirational. Due to the fact that she was an African American woman into computer engineering, she really inspired me that anything thing can be done and that if you gain enough interest into computing you can use that skills to build skills that will make you successful. She did not want me to discourage myself and assume I was not good with computer. She was caring enough to work with me alone to help me build my skills with computer so that I don't become left out from the class. (F, African American, 17)*

Table 1: Frequency of qualities students used to describe their informal mentors (left) and their ideal mentors (right).

patient	||||||||	patient	||||||||||
helpful	||||||||	expert	|||||||||
inspiring	|||||	older	||||||
supportive	||||	similar age	||||
fun	|||	easy to talk to	||||
interactive	|||	understanding	||||
kind	||	comfortable	|||
caring	||	kind	|||
clear	||	positive	|||
encouraging	||	encouraging	|||
humble	||	fun	||
African American	||	open-minded	||

Students described their friends and siblings in similar terms, emphasizing how comfortable and supported they felt:

[–] is easy to work with because he is very humble and laid back as well as supportive and patient. He also has a good sense of humor and is only a year older than me so it is easy for us to talk and relate. (M, Asian, 17)

What's most important about my sister is that she even until this very day she puts me first in everything. I was lucky to have a sister who is humble and caring. (F, Hispanic, 17)

In their "Who can help" page, students described their ideal mentors, and people in their lives who might fit those ideals. The qualities they described (also shown in Table 1) mirrored those of their past and current informal mentors:

The most important quality I would value in a mentor is motivation. I think as a mentor it is very important to encourage your mentee to do better at anything in there life, and especially to be able to bring them up and empower them when something happens that brings them down. (F, African American, 17)

My ideal mentor would be someone who I'm comfortable around. This is probably the most important trait. I have this fear of messing up in front of other people and it causes me to just malfunction. When I'm alone, I can just laugh over my mistake and move on but in front of others I just can't. (F, Hispanic, 17)

Patient. So they can put up with my shit. (M, Asian, 17)

While students mentioned a desire to be close to their mentors, they also mentioned the importance of mentors having wisdom and genuine expertise in computing:

Someone who has a lot of experience in my interests. They will be able to tell me what kind of experience I need, what classes to take, and so forth. I could go to this person for advice and ask for help. (F, Pacific Islander, 16)

I would like my mentor to be an expert because I want to be able to learn a lot and achieve my goal... I prefer mentors who interactive, fun, outgoing, easy to talk to, and flexible. My mentor's age doesn't matter much to me because friends can be mentors too... (M, Asian, 17)

In reflecting on who in their life might fit these ideals, most students wrote about existing mentors already in their life, with whom they were already comfortable speaking. Several, however, described people they already knew who might be able to support them, including teachers they admired but never talked to, siblings with whom they had never shared their interests, and friends who knew about computing but had never shared their knowledge:

A person who would fit my ideal mentor would be my sister [–]. She is very understanding and patient. Though she does not know a lot about any of my interest, she will be able to teach some of it. (F, Pacific Islander, 16)

Few students mentioned their parents, lamenting that they did not have the knowledge to guide them in their academic interests.

3.4 What impact do youth perceive?

In describing their mentors' contributions to their lives, many students described how their *identity* shifted:

9th grade summer's Web Design class left me unsure in my coding capabilities and disappointed in myself. On the other hand, 10th grade summer's Web Design class helped me understand the role of coding in life, as well as reaffirm my self-confidence... Thanks in large part to [-]'s teachings, I once again believed that even someone like me can excel at coding with enough practice. (M, Asian, 17)

Going to [-]'s class everyday for the past few weeks has been very eye opening for me. It has made me wondered why I was so disinterested with computing to begin with. Not only has [-] allowed me to learn about the field of computer science, but I have also learned more about myself and what I want to do in the future. (M, Asian, 17)

Others focused on how mentors shifted their *interests*:

He greatly advised me to follow my ambitions in what ever career that caught my attention and never be lured by the income I would be earning. I could tell by just looking at his lifestyle of what kind of ambitions he was advising me about... We have become great friends despite the wide age gap between us. (M, African, 18)

In other cases, mentors shaped students' *perspectives on the world* and their role in it:

All my teachers had a positive impact on me and showed me that code isn't just used for building websites, but showed me that coding is used for almost everything we interact with. (M, Hispanic, 17)

All three of these types of perceived impact centered on helping to *develop* an adolescent by giving them knowledge about computing. This focus on knowledge, and its impact on interest, is consistent with the mutually reinforcing roles of identity, values, and goals in developing interest over time [2].

4 DISCUSSION

Prior work shows that most adolescents have informal mentors from their social network that offer respect, support, and encouragement of their social and learning activities [5, 27]. Our work builds upon these findings in many ways.

First, the types and distribution of informal mentoring relationships we observed reinforce prior work showing that informal mentoring relationships emerge naturally from existing social relationships [1, 21]. Our work extends this to computing, showing that even among students with lower socioeconomic status and without parents who have earned college degrees, attending school that offers computing can indirectly produce informal mentorship about computing.

Our results also show that teachers in *any* subject area can play an instrumental mentorship role in not only teaching computing skills, but offering guidance, encouragement, and perspective on computing. When asked to select a mentor to describe, most chose a teacher, partly because that was the only informal computing mentor they had, but also because of the pivotal role that teachers played in offering individual guidance on the subject.

Unlike prior work showing the role that parents can play in triggering computing interest [3], the adolescents we taught relied more on teachers, siblings, and friends. This might be explained by demographic differences: none of our youth had parents with college degrees, and none of their parents had knowledge of computing. In contrast, Barron et al. studied youth with parents working in Silicon Valley. Another explanation is age: adolescents can be

more interested in developing identity with peers and other adults than with their parents [34].

Finally, students' characterization of qualities of an ideal mentor were strikingly consistent: they sought mentors who would not judge them for their failures, who would inspire them to learn, and who had the expertise to guide them. Students reported that their mentors having sufficient expertise was just as important as having a comfortable relationship with them. These qualities, while often found in great teachers, can also apparently be found in great friends, great older siblings, and even online friends.

These results have many implications. First, these findings point to the need for a deeper understanding of what aspects of adolescents' relationships give them the capacity for informal mentorship. Are there ways of providing peers, parents, and teachers with enough content knowledge about computing to thrive as mentors? Could we teach potential informal mentors this content at scale? What explicit steps might schools take to foster these informal mentoring relationships organically? If we can answer these questions, we may be able to not only trigger more interest in computing, but maintain and develop it over time among more diverse groups.

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REFERENCES

[1] Tammy D. Allen and Lillian T. Eby. 2011. *The Blackwell handbook of mentoring: A multiple perspectives approach.* John Wiley & Sons, USA.

[2] Flávio S Azevedo. 2013. The tailored practice of hobbies and its implication for the design of interest-driven learning environments. *J. of the Learning Sciences* 22, 3 (2013), 462–510.

[3] Brigid Barron, Caitlin K. Martin, Lori Takeuchi, and Rachel Fithian. 2009. Parents as learning partners in the development of technological fluency. *Int'l J. of Learning and Media* 1, 2 (2009), 55–77.

[4] Sreyashi Jhumki Basu and Angela Calabrese Barton. 2007. Developing a sustained interest in science among urban minority youth. *J. of Research in Science Teaching* 44, 3 (2007), 466–489.

[5] Margaret R Beam, Chuansheng Chen, and Ellen Greenberger. 2002. The nature of adolescents' relationships with their "very important" non-parental adults. *American J. of Community Psychology* 30, 2 (2002), 305–325.

[6] Sapna Cheryan, Benjamin J Drury, and Marissa Vichayapai. 2013. Enduring influence of stereotypical computer science role models on women's academic aspirations. *Psychology of Women Quarterly* 37, 1 (2013), 72–79.

[7] Gloria Crisp and Irene Cruz. 2009. Mentoring college students: A critical review of the literature between 1990 and 2007. *Research in Higher Education* 50, 6 (2009), 525–545.

[8] Phillip Dawson. 2014. Beyond a definition: Toward a framework for designing and specifying mentoring models. *Educational Researcher* 43, 3 (2014), 137–145.

[9] Peggy Doerschuk. 2004. A research and mentoring program for undergraduate women in computer science. In *Frontiers in Education*. IEEE, IEEE, New York, NY, S2H–7–12.

[10] Daryl D'Souza, Margaret Hamilton, James Harland, Peter Muir, Charles Thevathayan, and Cecily Walker. 2008. Transforming learning of programming: a mentoring project. In *Conf. on Australasian Computing Education*. Australian Computer Society, Inc., Australian Computer Society, Inc., Australia, 75–84.

[11] Daniel C. Edelson and Diana M. Joseph. 2004. The interest-driven learning design framework: motivating learning through usefulness. In *Int'l Conf. on Learning Sciences*. Int'l Society of the Learning Sciences, ICLS, ICLS, 166–173.

[12] John C. Hall. 2003. *Mentoring and Young People: A Literature Review.* ERIC, New York.

[13] Shirley Brice Heath. 2012. Seeing our way into learning science in informal environments. In *Research on schools, neighborhoods, and communities: Toward civic responsibility*, William F. Tate (Ed.). American Educational Research Association, New York, Chapter 13, 249–267.

[14] Suzanne Hidi and K Ann Renninger. 2006. The four-phase model of interest development. *Educational psychologist* 41, 2 (2006), 111–127.

[15] Mark A Holliday and David R Luginbuhl. 2004. Peer-centered service learning. In *Frontiers in Education*. IEEE, IEEE, New York, F3E–1–6.

[16] Beth K Humberd and Elizabeth D Rouse. 2016. Seeing you in me and me in you: Personal identification in the phases of mentoring relationships. *Academy of Management Review* 41, 3 (2016), 435–455.

[17] David M. Hunt and Carol Michael. 1983. Mentorship: A career training and development tool. *Academy of management Review* 8, 3 (1983), 475–485.

[18] Mizuko Ito, Sonja Baumer, Matteo Bittanti, Rachel Cody, Becky Herr Stephenson, Heather A Horst, Patricia G Lange, Dilan Mahendran, Katynka Z Martínez, CJ Pascoe, et al. 2009. *Hanging out, messing around, and geeking out: Kids living and learning with new media.* MIT press, Cambridge, MA.

[19] Mizuko Ito, Kris Gutiérrez, Sonia Livingstone, Bill Penuel, Jean Rhodes, Katie Salen, Juliet Schor, Julian Sefton-Green, and S Craig Watkins. 2013. *Connected learning: An agenda for research and design.* BookBaby, Pennsauken, NJ.

[20] Thomas E. Keller. 2005. The stages and development of mentoring relationships. *Handbook of youth mentoring* 1 (2005), 82–99.

[21] Rhodes Jean E. Klaw, Elena L. and Louise F. Fitzgerald. 2003. Natural mentors in the lives of African American adolescent mothers: Tracking relationships over time. *J. of Youth and Adolescence* 32, 3 (2003), 223–232.

[22] Andrew J Ko. 2009. Attitudes and self-efficacy in young adults' computing autobiographies. In *IEEE Symposium on Visual Languages and Human-Centric Computing*. IEEE, IEEE, New Jersey, 67–74.

[23] Andrew J. Ko and Katie Davis. 2017. Computing mentorship in a software boomtown: Relationships to adolescent interest and beliefs. In *ACM Int'l Computing Education Research Conf.* ACM, ACM, New York, 236–244.

[24] Colleen M Lewis, Ruth E Anderson, and Ken Yasuhara. 2016. I don't code all day: Fitting in computer science when the stereotypes don't fit. In *ACM Int'l Computing Education Research Conf.* ACM, ACM, New York, 23–32.

[25] Jane Margolis, Rachel Estrella, Joanna Goode, Jennifer Jellison Holme, and Kim Nao. 2010. *Stuck in the shallow end: Education, race, and computing.* MIT Press, Cambridge, MA.

[26] Jane Margolis and Allan Fisher. 2003. *Unlocking the clubhouse: Women in computing.* MIT press, Cambridge, MA.

[27] Kathryn T McLearn, Diane Colasanto, Cathy Schoen, and Michele Y Shapiro. 1999. Mentoring matters: A national survey of adults mentoring young people. In *Contemporary Issues in Mentoring*, J. B. Grossman (Ed.). Public/Private Ventures, Philadelphia, 66–83.

[28] Barnes J.C. Miller Holly V. Miller, J.M. and Layla McKinnon. 2013. Exploring the link between mentoring program structure & success rates: Results from a national survey. *American J. of Criminal Justice* 38, 3 (2013), 439–456.

[29] Emma Norling. 1995. Encouraging networking through informal mentoring: a look at a newly-established mentor scheme. In *Second Australasian Women in Engineering Forum*. RMIT, RMIT, Australia.

[30] Youn Joo Oh, Yueming Jia, Mhora Lorentson, and Frank LaBanca. 2013. Development of the educational and career interest scale in science, technology, and mathematics for high school students. *J. of Science Education and Technology* 22, 5 (2013), 780–790.

[31] Kate Philip and Leo B Hendry. 2000. Making sense of mentoring or mentoring making sense? Reflections on the mentoring process by adult mentors with young people. *J. of Community & Applied Social Psychology* 10, 3 (2000), 211–223.

[32] SS Pisimisi and MG Ioannides. 2005. Developing mentoring relationships to support the careers of women in electrical engineering and computer technologies. An analysis on mentors' competencies. *European J. of Engineering Education* 30, 4 (2005), 477–486.

[33] Jean E Rhodes. 2009. *Stand by me: The risks and rewards of mentoring today's youth.* Harvard University Press, Cambridge, MA.

[34] Wendy M Rote and Judith G Smetana. 2015. Parenting, adolescent-parent relationships, and social domain theory: Implications for Identity development. In *The Oxford handbook of identity development.* Oxford University Press, Chapter 27, 437–453.

[35] DÃĪana Aeolani Scipio. 2015. *Developing mentors: Adult participation, practices, and learning in an out-of- school time STEM program.* Ph.D. Dissertation. University of Washington, Seattle.

[36] Amber Settle, Sarah Pieczynski, Liz Friedman, and Nathan Kizior. 2013. Evaluating a prospective student mentoring program. In *Frontiers in Education*. IEEE, IEEE, New York, 1.

[37] Rahman Tashakkori, James T Wilkes, and Edward G Pekarek. 2005. A systemic mentoring model in computer science. In *ACM Southeast Regional Conf.* ACM, ACM, New York, NY, 371–375.

[38] Jennifer Wang, Sepehr Hejazi Moghadam, and Juliet Tiffany-Morales. 2017. Social perceptions in computer science and implications for diverse students. In *ACM Int'l Computing Education Research Conf. (ICER '17)*. ACM, New York, NY, 47–55.

[39] Sarah Wood and Evan Mayo-Wilson. 2012. School-based mentoring for adolescents: A systematic review and meta-analysis. *Research on Social Work Practice* 22, 3 (2012), 257–269.