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CULTURAL DIFFERENCES IN CHILDREN'S PAIR COLLABORATION: ENGAGING FLUIDLY VERSUS MANAGING INDIVIDUAL AGENDAS IN A COMPUTER PROGRAMMING ACTIVITY

A dissertation submitted in partial satisfaction
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

PSYCHOLOGY

by

Omar Ruvalcaba

September 2015

The dissertation of Omar Ruvalcaba is approved:

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Professor Kris Gutiérrez

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Professor Brigid Barron

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Tyrus Miller
Vice Provost and Dean of Graduate Studies

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ABSTRACT

CULTURAL DIFFERENCES IN CHILDREN'S PAIR COLLABORATION: ENGAGING FLUIDLY VERSUS MANAGING INDIVIDUAL AGENDAS IN A COMPUTER PROGRAMMING ACTIVITY

by

Omar Ruvalcaba

This dissertation analyzes cultural aspects of fluidity in children's collaboration during a computer programming activity. Pairs of 8- to- 11-year-old children, 25 U.S. Mexican-heritage and 25 European American, were invited to work on a computer programming activity. Ten minutes of their collaboration were analyzed for cultural differences in how much time the pairs spent collaborating fluidly or working using individual agendas.

Pairs of children from both cultural backgrounds spent substantial time collaborating by building on each other's ideas with proposals. However, U.S. Mexican-heritage pairs spent significantly more time in fluid synchrony, with anticipation of each other's contributions, compared to European American pairs, who spent more time resisting partner contributions, negotiating whose idea should be used, and bossing their partner to implement their plan. Thus, children of both backgrounds collaborated; however, the Mexican-heritage children collaborated more and their collaboration included a particularly fluid, seamless approach that was rare among European American children.

Dedication and Acknowledgements

I dedicate my dissertation to my family, community, and colleagues who supported me through this journey that spans over 25 years of formal schooling. This joint achievement was possible thanks to the support of dozens of individuals and many communities. Thank you all for your continued support and love.

Me gustaría agradecer a mi mamá y papá por todo su esfuerzo y apoyo a través de los años. Gracias mamá por educarnos y siempre querernos. Gracias papá por trabajar tantas horas sin descanso y por todo tu amor. Los dos fueron mi inspiración. Sacrificaron estar cercas de sus familias en México para darnos una vida mejor. Todo lo que yo y mis hermanos hemos logrado es por sus esfuerzos. Estoy orgulloso de ser Ruvalcaba, Esparza, y de Amoxochitl. Los amo a los dos con todo mi corazón.

A mis hermanos, los quiero mucho. Juntos hemos logrado lo inimaginable. Cuando yo estaba en la universidad sentí que tenía que ser un ejemplo para ustedes. Después de empezar mis estudios de postgrado, ustedes fueron mi ejemplo de lo que es ser familia. Los tres me apoyaron, me visitaron, y me recordaban que mi esfuerzo sí valía la pena.

To my love, my wife, te amo, I love you, te adoro. You showed me how to be patient and what it means to give yourself completely to another. Through thick and thin, we’ve stuck together and learned to love each other more than I imagined possible.

To my daughter, I love you. I hope that I can be a good example for you and that my actions and research show you the importance to respect, love, and support the individuals you will meet in your life.

To my lab, Angelica, Andrew, Lucia, Katie, Andy, and Amy, thank you for your continued support. We celebrated each other's achievements and supported each other through each milestone. You all inspire me to continue doing my best work. Edith, thank you for helping me survive my first year of graduate school. I wouldn't have been able to do this without your friendship. Paul, our work sessions, that sometimes turned into hang out sessions, helped me stay centered. Thank you all for your friendship.

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I give my thanks to all my mentors for your guidance and support through this long journey. Thank you Kris for your support in applying to this PhD program and for helping me see the implications of my work in education settings. Thank you Maureen for your continued support and faith in my abilities as a researcher. Jill, you were always available to meet and valued my input as a professional. Linda, you helped me bridge my interests in computer science education research and multicultural research.

Miguel Enriquez, Miguel Nava, Ernie, Jon-Erik, and Cynthia, you all have been there for me throughout life. We've been through bad and good times together, but you continue to be in my life and as we grow and transition through life. Thank you for your friendship and support. Tam, thank you for inspiring me to do research that helps others. You impacted so many in your life. I hope to carry your spirit in my work.

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Danny, Ian, Cliff, Jean, Cueponcaxochitl, Ursula, Rigoberto, and Mary, thank you for adopting me while attending AERA. Your scholarship and friendship inspire me to move my research beyond the confines of psychology. Although our meetings were often too brief, I always felt re-energized after our conversations. Thank you Danny and Ian, you two always checked in and helped me feel connected while working on those long nights. I look forward to our potential future collaborations.

Last, but not least, I thank Inez, Jackie, Jacque, and Imelda for being the best research assistants ever. I could not have finished without all your help, support, and inspiration.

Cultural Differences in Children's Pair Collaboration: Engaging Fluidly Versus Managing Individual Agendas in a Computer Programming Activity

> As I searched for a computer science context to analyze cultural variance in collaborative fluidity, my brother, a software engineer, shared his experience working with two school groups of 6- to- 8-year-old children who visited his college for 'Robotics Day.'
>
> > *In the White group, one child took control of the robot the entire time while the other kids watched. The Latino and African American group, they shared the controller with multiple kids holding it at the same time, switching who had access as a new kid had a new idea, and those not on the controls offered suggestions and strategies the whole time. (Eduardo Ruvalcaba, Personal communication, August 6, 2009)*

The present research study focuses on fluid synchrony in U.S. Mexican-heritage and European American children's collaboration during a computer programming activity. I specifically examine whether Mexican-heritage children collaborate more, in two ways: *fluid synchrony* by anticipating their partner's contributions and *proposal-building* by building on each other's contributions and directions with explicit proposals. I also examine whether European American children more often divide contributions into individual agendas.

Understanding cultural differences in collaboration is important considering that this is a much sought-after 21st century skill in academia and the workplace. Benefits of collaboration include that it encourages individuals to persevere in difficult tasks such as learning math and computer science and may help produce better quality work than those who work alone (McDowell, Werner, & Bullock, 2006; Nussbaum et al., 2009; Werner, Hanks, & McDowell, 2004; Zurita, Nussbaum, & Shaples, 2003). Collaboration itself is a skilled process where children periodically evaluate their partner's knowledge in relation to their own knowledge, work to understand a shared common goal, and negotiate how to join others in working towards a goal (Alcala & Rogoff, 2015; Barron, 2003; Dill & Boykin, 2000; Roschelle & Teasley, 1995; Scott, Mandryk, & Inkpen, 2003; Werner et al., 2004).

The present study breaks new ground by distinguishing between two ways of collaborating that involve flexibility in roles and spontaneity: *fluid synchrony* when collaborators move forward in sync, anticipating their partner's efforts towards a mutually shared goal, and *proposal-building* when collaborators build on each other's contributions by making and responding to explicit verbal or nonverbal proposals regarding their direction.

This introduction first describes research findings that children from Mexican- and Indigenous-heritage communities collaborate at home and in their communities more than European American children. Then it examines the closest research and a theoretical model, which deal with the flexible organization of roles in collaboration and the fluidity of collaboration. The present study builds on these two related lines of research and the theoretical model by distinguishing *fluid synchrony* and *proposal-building*. The proposal also connects with some research in computer science that examines the process of collaboration, without attention to cultural variation.

Extensive Collaboration in Mexican- and Indigenous-heritage Communities

In Mexican-heritage and Indigenous communities of the Americas, children show initiative to participate in collaborative family and community work where they are guided and supported by parents and other children (Alcala, Rogoff, Mejía-Arauz, Coppens, & Dexter, 2014; Coppens, Alcala, Mejía-Arauz, & Rogoff, 2014). For example, in Tepoztlán, Mexico, both boys and girls eagerly collaborated skillfully in the annual community-wide Tepozteco ceremony (Corona, 2001).

U.S. Mexican-heritage and Mexican-Indigenous children even collaborate in school settings despite being discouraged from doing so. Mexican Indigenous-heritage schoolchildren allowed partners to see their work, answered classmate's questions, repeated instructions, translated for peers, stood up to look at other children's classwork, and wrote on each other's papers (Delgado-Gaitan & Trueba, 1985; Paradise, 1996; Paradise & de Haan, 2001).

Mexican-heritage cultural values, such as *respeto* and being *acomedido*, remind children of the importance of collaboration and emphasize mutual consideration even when there are asymmetries in leadership roles (Lorente y Fernández, 2006; López et al., 2015; Ruvalcaba, Rogoff, López, Correa-Chávez, & Gutiérrez, 2015; Valdes, 1996). For example, Mexican-heritage children asking for help from an adult to build a toy more often avoided interrupting the adult's activity than European American children (Ruvalcaba & Rogoff, 2015).

Several comparative studies find that Mexican-heritage and Indigenous-heritage children collaborate more than European American children. For instance, children who had more experience with Indigenous practices in Mexico and Guatemala collaborated more while working on origami figures and 3d puzzles than Indigenous-heritage, Mexican-heritage, and European American children whose families had extensive schooling experience (López, Correa-Chávez, Rogoff, &

Gutiérrez, 2010; Mejía-Arauz et al., 2007; Rogoff, Najafi, & Mejía-Arauz, 2014). Children of Mexican heritage collaborated more often during board games by making moves that benefited the other players than European American children, who often made moves to win against the other player (Kagan, 1984; Kagan & Madsen, 1971; Knight & Kagan, 1977; Knight, Nelson, Kagan, & Gumbiner, 1982). In one study, European American children even sacrificed their rewards if they could make their opponents lose, and did so more often than Mexican-American and African-American children (Madsen & Shapira, 1970).

Flexible roles in Collaboration in Mexican- and Indigenous-heritage Communities

Flexibility may be a common aspect of collaboration in Mexican- and Indigenous-heritage communities of Mesoamerica and in North American Indigenous groups. In this section, I review studies in several Mexican and Indigenous communities to illustrate that flexible approaches are common across these communities.

Mayan parents and children from families that had extensive experience with Indigenous practices organized work on a three-dimensional totem pole puzzle in horizontal ways where all participants were able to contribute as they saw opportunities to help. Mayan parents who had extensive experience with western schooling more often divided the activity by assigning roles to each individual child, separated the task into smaller sub-tasks, and took a hierarchical leader approach (Chavajay & Rogoff, 2002).

Mazahua Indigenous children in Mexico flexibly exchanged roles, in "complementary role taking," smoothly and spontaneously. They collaborated with peers and adults flexibly with little discussion or separation of roles (Paradise & de Haan, 2009).

Pairs of Navajo children teaching a child to play a game exchanged the lead teaching role while both remained engaged and ready to help regardless of who was taking the lead. This contrasts with approaches by some European American children who became sidetracked when not leading the activity (Ellis & Gauvain, 1992).

Warm Springs Native American children in Oregon collaborated on classwork smoothly, often sharing roles, and easily came to a shared direction. In contrast, European American children often disputed turns, who would lead, and how to carry out the task, and as a result had difficulty completing the task (Philips, 1983).

U.S. Mexican-heritage siblings who explored a museum exhibit coordinated their participation with few interruptions of each other and seldom engaged in turn taking, compared to European American children who employed turn taking twice as much (Angelillo & Rogoff, 2005).

Collaborative Process in Learning by Observing and Pitching In

Collaborating in *fluid synchrony* is hypothesized to fit into a larger cultural system of related practices, especially in communities with Indigenous American histories, as described by a theoretical model known as Learning by Observing and Pitching In (LOPI) (Rogoff, 2014). This model describes practices, values, and approaches that involve children's fluid integration into valued family and community practices. The third facet of LOPI outlines social organization of working groups that involves fluid coordination with others in a joint direction:

> The social organization of endeavors involves *collaborative engagement as an ensemble*, with *flexible leadership* as the people involved coordinate fluidly with each other. Learners are trusted to take *initiative* along with the others as everyone fluidly blends their ideas and agendas at a calm mutual pace. (Rogoff, 2014, p. 74).

Mexican and Indigenous-heritage communities of the Americas appear to share a number of similar cultural practices due to the Indigenous past of many Mexican-heritage communities (López, Najafi, Rogoff, & Mejía-Arauz, 2012; López, Ruvalcaba, & Rogoff, 2015). Some Mexican-heritage communities that no longer identify as Indigenous often still participate in practices related to an Indigenous-heritage (Bonfil Batalla, 1996).

In accordance with the fluid collaboration aspect of LOPI, research has found that Mexican-heritage US children took initiative to help adults without being asked to do so more often than did middle-class European-American children (López et al., 2015). In an Indigenous community of Canada, community members were observed using fluid collaboration in organizinag community events. They understood tasks that needed to be completed and pitched in without being directed to do so (Pelletier, 1970). There was no boss and no division of labor; the roles were flexible. When someone could help, they simply did so. When a European American visitor to this community tried to organize an event based on assigning roles and division of labor, the clash of organizational approaches led to failure to put on the event.

In a research task, Mexican Indigenous Mazahua parents integrated children as equal contributors and gave them space to contribute to the ongoing activity.

Children in turn took initiative to contribute by fluidly coordinating their efforts with the adult and other children. The children (and adults) did not wait to be told what to do next; they contributed when they saw an opportunity. In contrast to the parents, teachers doing the same activity took a boss-like role with the children by assigning tasks (Paradise & de Haan, 2001). Similarly, Mexican-heritage children constructing a bee puzzle more often collaborated fluidly by moving in and out of helping, with little negotiation of individual agendas compared to European American children (Mejía-Arauz et al., 2007).

In several studies of collaboration, Indigenous Mayan children coordinated their participation fluidly without turn taking or division of labor (Chavajay, 2006, 2008; Chavajay & Rogoff, 2002 Paradise & de Haan, 2009). When Mayan children worked on a three-dimensional totem pole puzzle with an adult, for example, Mayan children whose mothers had more experience with Indigenous cultural practices more often coordinated smoothly with other members than children whose mothers had more experience with Western schooling practice (Chavajay & Rogoff, 2002).

The study most closely related to the present study focused on children fluidly making contributions that built on partner's efforts. U.S. Mexican-heritage pairs spent twice as much time *collaborating as a fluid ensemble* than European American middle-class children while planning a route to pick up items in a model grocery store (Alcala & Rogoff, 2015). Not surprisingly, children who spent more time collaborating as a fluid ensemble were also more likely to be involved with collaborative work at home.

Although there is research on flexible roles and some studies have noted that children and adults skillfully integrate themselves into joint work as an ensemble, no study has distinguished *fluid synchrony* where children anticipate a partner's needs from *proposal-building* collaboration where children build on a partner's contributions through explicit proposals. Alcalá and Rogoff's (2015) study of collaboration as a fluid ensemble, comparing US Mexican-heritage and European American siblings, did not distinguish these two approaches.

Collaboration and Learning with Computers

The present study brings together the research on cultural variation in collaboration with research on processes of collaboration in using computers. Several studies have looked at the role of collaboration in classroom organization (Tudge, 1992) and at collaboration using technology (McDowell et al., 2006; Nussbaum, 2007; Nussbaum et al., 2009; Suthers, Toth, & Winer, 1997). No studies, however, compare collaborative approaches between cultural backgrounds during computer programming.

Emerging computer science research suggests collaboration is a more effective way to learn with computers than individual computer use (Scott, Mandryk, & Inkpen, 2003; Zurita & Nussbaum, 2004; Zurita, Nussbaum, & Salinas, 2005). Collaborative learning with computers may hold benefits that include helping children come to the same understanding of a shared problem when learning (Roschelle, 1992). Case studies have shown that collaboration computer software can remind students to check whether they have a mutual understanding of a problem with their partner (Roschelle, 1988; 1992).

Ethnographic research reveals that children use technology collaboratively in their home. Children of various cultural communities sometimes collaborate with their siblings when using video game software designed for one user (DiSalvo et al., 2008; Stevens, Satwiz, & McCarthy, 2008). For example, an older brother in his teens helped his younger sister with a portal video game by completing the activity she could not complete on her own (DiSalvo et al., 2008). British parents have also been observed facilitating their children's interaction with digital media (Greenfield 1984), but no attention has been given to how children of culturally diverse backgrounds collaborate during pair programming.

Computer science education research points to benefits of collaboratively learning computer science at the university level (McDowell et al., 2006; Nussbaum et al., 2009; Werner et al., 2013), but pair programming studies have not examined cultural variance in processes of collaboration. Understanding cross-cultural approaches to collaboration in computer programming may help educators broaden their perspectives on possible ways of collaborating and of supporting collaborative learning.

The Present Study

The present study extends aspects of collaboration noted in the theoretical model of Learning by Observing and Pitching In by taking a more fine-grained analysis to distinguish two approaches to fluid collaboration during a computer programming activity. This is the first study to distinguish *fluid synchrony* and *proposal-building* collaborative approaches and to look at differences in use of these approaches in U.S. Mexican-heritage and European American children's collaboration. This dissertation seeks to answer 3 research questions:

1. Do U.S. Mexican-heritage children spend more time collaborating with fluid synchrony, anticipating their partner's direction and contributions in a computer programming activity, than European American children from families that have extensive schooling experience?
2. Do U.S. Mexican-heritage children also spend more time collaborating by building on their partner's ideas with explicit proposals?
3. Do European American children from families that have extensive schooling experience spend more time focusing on individual agendas by resisting their partners' contributions, pushing for their own ideas, telling their partner what to do step by step, or ignoring their partner, than U.S. Mexican-heritage children?

Method

Children were invited to work in pairs on Scratch, a computer programming application, after school. After watching a brief demo, they worked on an animation with three characters; two were preprogrammed and one character was not programmed in advance. After the computer activity, children participated in a brief interview regarding their experience with technology and with collaborating with their partner. Parents were given a demographic questionnaire regarding parental schooling and background.

Participants

Participants were recruited from schools in the central coast area of California with the help of teachers who distributed flyers to children and their parents. The study included 100 8- to 11-year-old children, in pairs of the same gender and cultural background:

25 pairs of *U.S. Mexican-heritage* children (13 boy pairs and 12 girl pairs, *M* age = 9 years 8 months) and

25 pairs of *European American children from families with Extensive Schooling Experience (ESE;* 16 boy pairs and 9 girl pairs, *M* age = 9 years 2 months)

Children were invited to participate in a computer programming activity with a schoolmate, in a spare room after school. The first child who was recruited was asked to choose a partner (to encourage that pairs get along), but if children did not have someone in mind (or if that child had not turned in a parental consent form), we suggested a classmate who had turned in a consent form. Children were agreeable with the partner suggested by the researchers, when this occurred, suggesting comfort with the arrangement. (Of the 25 US Mexican-heritage pairs, 20 were friend pairs chosen by the first child and 5 were classmate pairs suggested by the researchers; 21 European American ESE pairs were friends and 6 were classmates).

U.S. Mexican-heritage children's background. U.S. Mexican-heritage children's mothers averaged 7 years of schooling (ranging from 5 to 12 years) and fathers averaged 8.2 years of schooling (ranging from 3 to 12 years). Over 50% of the parents attended school mostly in small towns or in rural areas in Mexico, usually Michoacán, Guanajuato, and Jalisco. Only 5 of the 50 children had a parent who went to school in the United States or a large metropolitan city in Mexico. Most of the U.S. Mexican-heritage children's grandparents (78%) had no experience with Western schooling; those who did attend school all had less than 6 years.

U.S. Mexican-heritage mothers' occupations included agricultural work, service jobs, and homemaking. One mother worked as a sales representative and another as a medical assistant. Fathers' occupations included agricultural work and service jobs (e.g., painter and parking attendant). Two U.S. Mexican-heritage fathers worked in skilled labor (fumigator and electrician).

U.S. Mexican-heritage parents predominantly reported speaking Spanish at home. The most common reported language for grandparents was Spanish. Four families reported an Indigenous language spoken by a grandparent (Maya, Chatino, and Zapoteco).

European American ESE children's background. European American ESE parents' and grandparents' schooling indicated a family history of extensive formal schooling across several generations. All European American ESE children's parents had at least 12 years of schooling. Most had at least a Bachelor's degree (only 3 fathers and 4 mothers did not). All but one grandparent had at least 12 years of schooling; 60% had at least an associate's degree.

European American ESE mothers' occupations included artist, manager, sales, homemaker and jobs that required a professional degree (e.g., registered nurse, lawyer, teacher, medical assistant, engineer); 3 reported working in service jobs (e.g., waitress). In most cases, European American ESE fathers' occupations required an advanced degree; those that did not require advanced education included an artist, farmer, landscaper, and dispatcher.

English was the most common language spoken at home, but two parents reported knowledge of other Western European languages. Grandparents' spoken languages predominantly included English, but also included French, Polish, Slavic, German, and Portuguese.

Children's Schools and Experience with Programming and Digital Technology

The children from the two cultural backgrounds attended different schools, for the most part, in line with the commonly occurring segregation of backgrounds in the US. Unfortunately, it is often the case that children of these two cultural backgrounds live in different communities and attend different schools. U.S. Mexican-heritage participants were recruited from a school in a rural agricultural community serving predominantly Mexican-heritage immigrant families (16 pairs) and a school located in a predominantly European American neighborhood attended by both European American and Latino children (9 pairs). Most of the European American ESE children attended a school predominantly serving children whose families are middle to upper middle class; 4 pairs came from a school where families are predominantly working to middle-class. There were no significant differences between children of the same cultural background who attended different schools.

Although attendance at different schools opens the possibility that differences between the two cultural backgrounds stem from differences in their schools, in general, US schools serving middle-class children tend to be organized in a more collaborative manner than schools serving children from families with fewer economic resources, which tend to be more authoritarian and individualistic in organization. Thus the differences between the children's schools are likely to give them experience in the opposite direction than the preditions of the current study.

Children's experience with technology was assessed when the research assistant asked the children to use a computer mouse during their introduction to the computer activity and during individual interviews at the end. All children demonstrated that they could operate the computer mouse, which was the minimum skill required to use Scratch, the computer programming application.

All children reported having at least some access to computers: 40 U.S. Mexican-heritage children and 43 European American ESE children reported moderate to daily use at home; the rest of the children reported only having access at school (10 U.S. Mexican-heritage children and 7 European American ESE children). All four schools only provided basic computer experience for children, where children mostly practiced typing and worked on worksheets on the computer.

Children of both cultural backgrounds reported similar purposes for using computer software: Creative purposes were reported by 33 U.S. Mexican-heritage children and 30 European American ESE children; using software designed for entertainment (e.g. video games and Netflix) was the next most common use reported, by 16 U.S. Mexican-heritage and 14 European American ESE children. Few children reported regularly using computer-programming software, but it was more common among European-heritage children (6 European-heritage ESE children and 1 Mexican-heritage child).

Most children had no experience with Scratch (46 Mexican-heritage children and 36 European-heritage children). Only 3 Mexican-heritage children had previously tried Scratch and 1 had heard about it, compared with 8 and 6 European-heritage children respectively. Children who had some experience with Scratch or computer programming followed similar patterns in their collaboration and their projects as pairs of their same cultural background who had no exposure to Scratch.

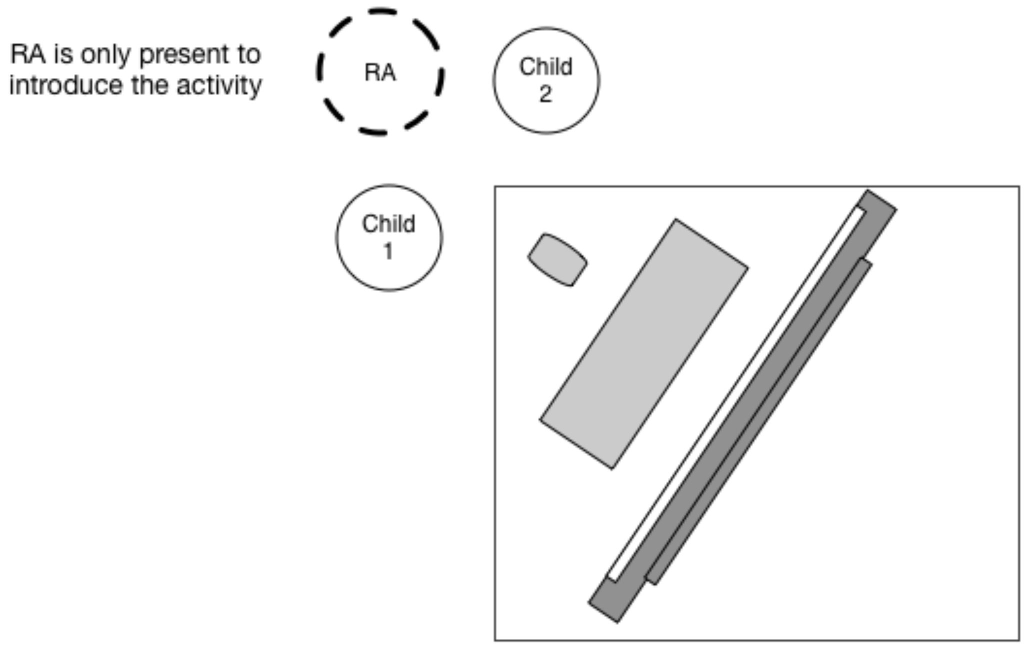
Design of the Computer Programming Activity

The software used for the computer science activity is Scratch, designed by the Lifelong Kindergarten Group at the MIT Media Lab to teach children basic computer programming concepts. (Scratch is available free from http://Scratch.mit.edu). Scratch is designed to teach computer science concepts using interchangeable and modifiable blocks of commands to animate characters and other objects. As seen in the screenshot of Scratch in Figure 2, there is an area on the left with commands, a workplace area in the middle to place the commands, and a theater area on the right where children view the outcome of their programming.

During piloting, the entire procedure was tested and refined to make sure that children would be interested in the activity and that the brief demo would be enough to get them started. A single mouse and single keyboard were placed between the children to encourage interactions between them. To give the children an open-ended project with a starting idea in common across the pairs, the pairs were given a project involving 3 characters — 2 that were already programmed to do a few things that the pair could reference for ideas and one character not programmed to do anything. This gave all pairs a task in common that could be accomplished in many ways — to get the unprogrammed character to do something interesting.

Procedure

The research assistant asked the children whether they would like to proceed in English or Spanish. All chose to proceed in English, although some of the U.S. Mexican-heritage pairs spoke in both Spanish and English while working with their partner. Children sat next to each other at a table facing the screen (see Figure 1). The mouse and keyboard were placed between the two children to give each child equal access to the mouse. The research assistant sat behind the participants as she introduced them to the activity, inviting them to make a digital animation on the computer with their partner. The researcher stood off to the side at a distance, pretending to be busy.



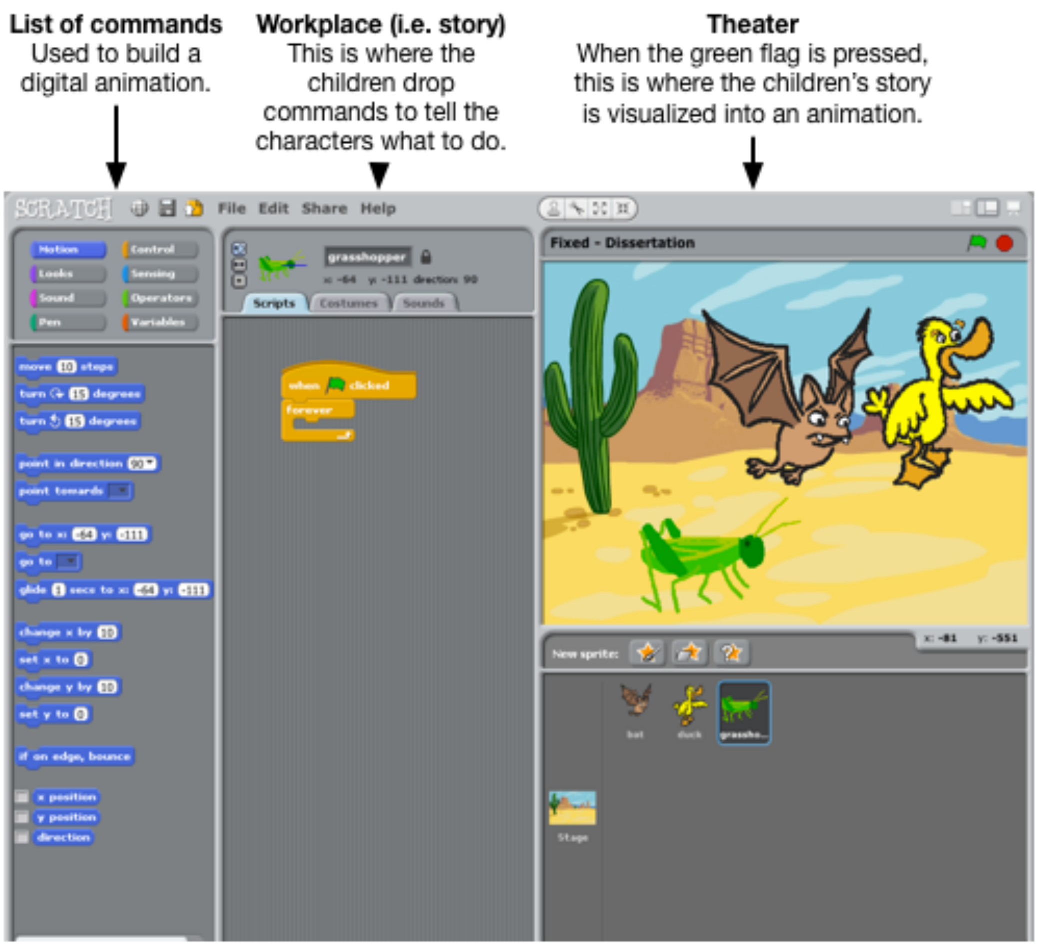
[Figure 1. The children sat adjacent to each other with the keyboard and mouse between them.]

The research assistant introduced a 3-minute tutorial video, “Now I will show you a video that will show you how to use Scratch. After the video you’ll get to work together to make 3 characters do fun stuff.” The tutorial video was carefully created to ensure that the approach to teaching Scratch was engaging and the same for all pairs. The piloting process ensured that the video maintained children’s attention and that it gave enough information to help the pairs start their project in Scratch. The tutorial video explained the basic commands and how to see the outcome of their programmed commands in the theater. Once the children had viewed the tutorial video, the research assistant showed them how they could return to it while working on their project if they had questions, as well as how to play, pause, and rewind the tutorial.

The research assistant then introduced the children to the project that was started for them, explaining, “This is the project you will be working on (pointing at the screen showing what you see in Figure 2). You can do whatever you want with these 3 characters. This project has a bat, duck, and grasshopper. Some of the characters already do something.” She demonstrated the Scratch project that was prepared for them and what the characters could do. The bat was programmed to chase the duck and the duck was programmed to change colors and evade the bat. The grasshopper was only programmed with a ‘start’ command and a ‘loop’ command as a starting point (the 2 commands in the middle column of Figure 2). The research assistant pointed out, “The grasshopper isn’t doing anything yet, but I bet you can figure out something interesting for the grasshopper to do.”

After explaining the task, the research assistant explained that the pair had 30 minutes to work on their digital animation while she went to do some work with the researcher at a table on the opposite side of the room. She explained again, "If you have any questions, try looking back at the video or see if you can figure it out on your own." The children then worked together for 30 minutes while the research assistant and researcher kept busy reading paperwork. If the children had any questions, the research assistant reminded them to review the video.

Almost all of the pairs took the whole 30 minutes; a few checked in with the research assistant at about 25 minutes, but continued when the research assistant told them that they still had time. Pairs of both backgrounds spent almost no time off task, averaging less than 7 seconds off-task on average, out of the 10 minutes that we coded (Mexican-heritage $M = 6$ secs, $SD = 13$ secs, European-American children $M = 0$, $SD = 2$ secs) and there was no difference based on cultural background, $t(25) = 2.41$, ns. After 30 minutes, the research assistant returned and asked both children, “What can the characters do now?” The children then explained their changes in their program.



[Figure 2. Scratch work areas and the set-up for the children’s project.]

Interview. The children were individually interviewed about their experience with the programming activity and their evaluation of working with their partner: whether they liked working with this partner, if they thought having a partner was helpful, and if they felt their and their partner's contributions were balanced during their session. We also asked if they liked working on Scratch and if they would like to use Scratch again. All children said they liked working on Scratch and would like to use it again, which was supported by the fact that the children spent little time off-task. While one child was interviewed the other child sat at a separate desk and worked on a distraction activity (i.e., a new Scratch project on a laptop) while they listened to music through earphones to prevent them from overhearing the partner's interview responses. After one child participated in the interview, the children switched places.

Coding

Two bilingual research assistants, blind to the hypotheses of this study, coded the data. The analysis focused on 10 minutes of the pairs' work on their digital animation, using the pairs' interactions as the unit of analysis. Coding started when the pairs made their first change to any character's commands, approximately 5 minutes into the 30-minute video after the pairs had had time to become comfortable with the tools and setting. The overall stream of behavior was divided into 10-second intervals because most of the interactions of interest took less than 10 seconds and included only one coded category. This segmentation of the video yielded 60 coded intervals per pair. Intervals interrupted by an adult or outside distractions were excluded from the analysis.

Based on the research questions and extensive ethnographic review of the video data, I developed three coding categories involving collaboration and four categories that emphasized individual agendas, plus one that coded children's observation of their partner. I distinguished between two forms of collaboration (*fluid synchrony* and *proposal-building*) based on observations during piloting and related research on fluid agendas (Alcala & Rogoff, 2015) and synchrony in collaboration (Dayton & Rogoff, 2014).

Three Categories for Collaboration

Fluid synchrony. Both children actively contribute to the project with coordinated joint action and attention as they focus on accomplishing the immediate shared goal. The children seemed to anticipate each other's contributions and smoothly moved forward in the same direction, in sync. This approach includes no evidence of any new proposals or discussion of direction.

In one example of *fluid synchrony*, a child took the mouse and clicked on the duck's word bubble followed by their partner typing in "Hey bat, leave me alone!" All this occurred with no proposals or requests for help from either partner. The child with the mouse seemed to anticipate the partner's direction and took action. Verbal discussion can occur as the pair figures out how to move in their joint direction, but it does not involve proposals and responses.

Proposal-building. Children build on each other's ideas with explicit proposals, with either child suggesting a new idea or direction in the activity (a proposal) and the other child responding. For example, in one European American ESE pair, a child suggested, "Wait, why don't we make the grasshopper have a moustache?" The partner nodded and began to implement the suggestion. As demonstrated by this example, explicit evidence of a proposal and a response defines this approach.

Discuss which idea. The pair pauses and discusses what to do in their project for several turns (more than two back-and-forth exchanges) before moving forward with their project. They *discuss which idea* they want to implement next or they *discuss which idea* would be best (not whose idea is best). For example, a pair of European American ESE girls stopped programming to discuss whether to add a moustache to the grasshopper or to make it go in circles.

Four Coding Categories for Individual Agendas

Resistance. Children resist the partner's contribution of ideas by ignoring suggestions or restricting the partner's mouse and keyboard access. For example, a child might block their partner's access to the mouse with their body or verbally resist the partner's access (e.g., "No wait, don't touch that yet"). Resistance also includes unproductive arguments between both partners and mutual conflict, such as snatching the mouse away from each other.

Whose idea. The children jockey for *whose idea* to use in their project, insisting on their own idea (e.g., "I want to," "My turn," and "You already had a turn to decide, now it's my turn."). This category differs from collaborative *discussion of which idea* might work best, in its use of egocentric negotiation. The children eventually do reach an agreement or one partner goes along with the partner's proposal (otherwise it would be coded as resistance).

Boss-implement. One child commands their partner what to do, one step at a time. The partner simply implements the instructions without making their own contributions.

Ignore-off–task. One child takes over and does not incorporate the partner, who is off-task for the interval (e.g., staring away from the monitor). The off-task child shows signs of boredom or distraction, but not resistance.

Observation

One child manages the activity for the whole interval while the other child remains engaged by observing but makes no direct contributions. The observing child shows signs of readiness to contribute and attentiveness to the leading child, who shows openness to her partner's participation and may describe what she is doing.

Coding Reliability

Two bilingual research assistants, unaware of the hypotheses, coded 40% of the data for reliability. Disagreements were resolved by consensus. Each research assistant coded half of the remaining data individually. Inter-observer agreement, assessed using Pearson correlations, was good (Hartmann, 1977): *fluid synchrony* (r =.85), *proposal-building* (r =.83), *discuss which idea* (r =.80), *explicit resistance* (r =.87), *whose idea* (r =.83), *boss-implement* (r =.81), *ignore-off-task* (r =.91), and *observation* (r =.85).

Interview Questions

Children's responses to interview questions were used to code whether the child liked collaborating with a partner, whether they found working with their partner helpful, and whether they felt the collaboration was balanced.

Children's general appreciation of working with a partner was categorized into three categories: they liked working with a partner, they had mixed feelings about working with a partner, or they explicitly stated they did not like working with a partner. This code was based on the child's response to the following interview questions:

Did you like working with a partner or would you have preferred to work alone? Why?

What would you have done differently if you worked alone?

Why couldn't you do that with your partner?

Perceptions of collaboration as helpful were categorized into indicating that the collaboration with their partner was helpful, both helpful and not, or not helpful, based on the following interview questions:

Did you help each other? How?

Do you think kids can work better if they work alone or together? Why?

What would you have done differently if you worked alone?

Why couldn't you do that with your partner?

Did you do something with your partner that you couldn't have done on your own?

Children's responses regarding balance were coded as indicating that the children felt they both contributed, they felt one child took a slight lead during their collaboration, or they felt they or their partner controlled the activity most of the time, based on the following interview questions:

What parts of your project did you do together?

Did one of you do more? (Probe for contribution of ideas as well as amount of time and access to equipment.)

Whose ideas were used for the project?

Did you get to use the mouse or keyboard?

Results

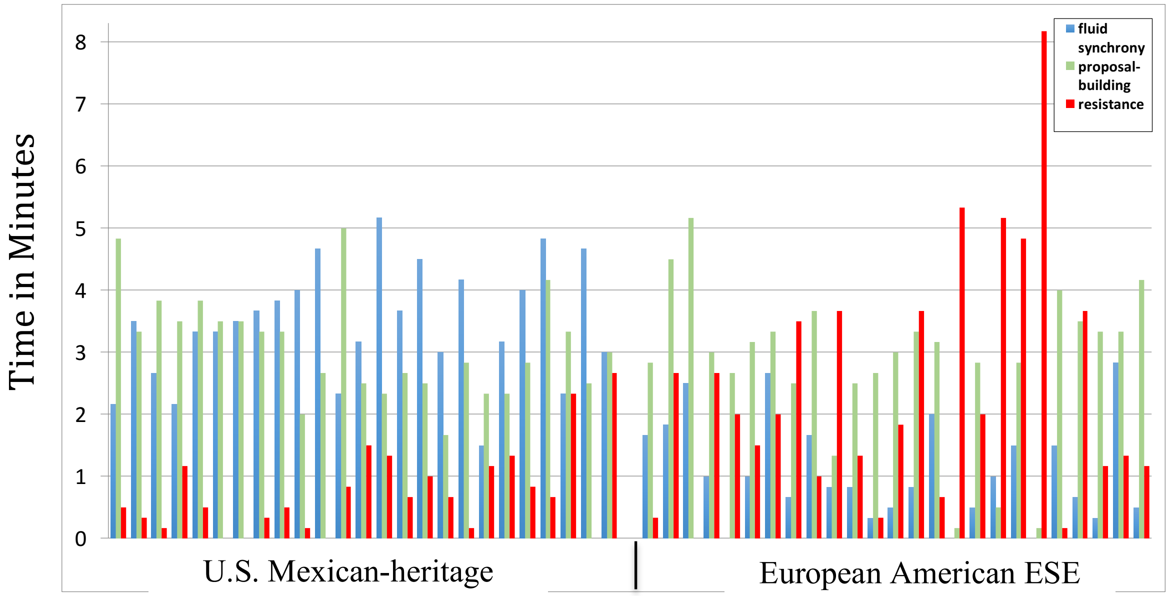
The results examined the pairs' collaboration versus the use of individual agendas, first by descriptive analysis using casegraphs and then by statistical comparisons of cultural differences in collaboration. I then discuss children's reflections on the collaboration process. There were no gender differences and no interaction between cultural background and gender.

I checked for differences among U.S. Mexican-heritage pairs with different levels of maternal schooling. Children were not paired based on extent of maternal schooling, but in my sampling, it worked out that in some pairs of children, one child's mother had low experience with Western schooling and one child's mother had extensive experience with Western schooling (12 years or more). In the other pairs both children had mothers with low Western schooling experience (less than 12 years). Comparison of these two groups showed no difference based on maternal schooling in the time spent on any of the coded approaches.

Descriptive Casegraph Analysis

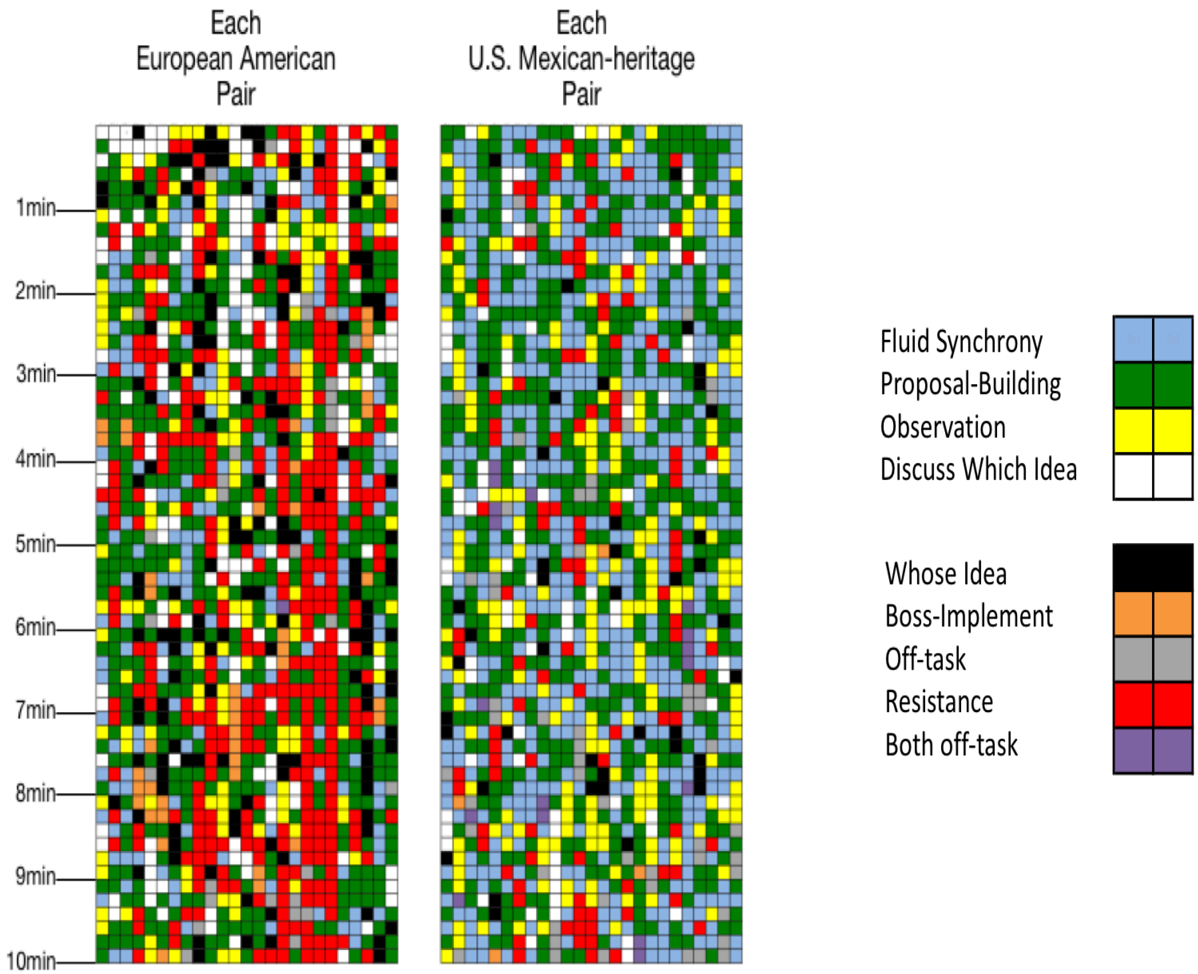
I began the analysis of the data by reviewing casegraphs of total time spent on each approach to examine variation within the two cultural backgrounds and differences between them. *Figure 3* shows casegraphs for the 3 most common approaches. (The analysis actually included all 9 approaches in casegraphs.)

As shown in Figure 3, U.S. Mexican-heritage children mostly collaborated by working together in *fluid synchrony* by anticipating each other's direction and contributions (3min 27s) as well by building on each other's contributions through explicit proposals (*proposal-building*, 3min 6s). In contrast, European American ESE children spent most of their time resisting each other's efforts (*resistance*, 2min 24s) and *proposal-building* (2min 52s). The U.S. Mexican-heritage children spent only 45s on *resistance* and the European American ESE children spent only 1min 5s working in *fluid synchrony*.



[Figure 3. Casegraphs for each pair’s total time spent in the 3 most common approaches: collaborating with *fluid synchrony*, collaborating by *proposal-building*, and in *resistance*. The Y-axis shows 8 of the 10 minutes coded.]

I also examined time casegraphs that arranged the sequence of approaches across all 10-second intervals, to examine possible changes of approach over time. (See Figure 4.) There were no patterns except during the first 30 seconds of the pairs’ programming: European American ESE children seldom built on each other’s contributions fluidly in the same direction (*fluid synchrony*) nor did they build on each other’s ideas with proposals (*proposal-building*). The U.S. Mexican-heritage children used both of these approaches extensively from the start of their programming, proceeding immediately with collaboration while the European American ESE children spent this first half-minute often discussing which or whose idea to use or resisting each other’s efforts.



[Figure 4. Time casegraphs for each pair's approaches across time. Each column represents a pair and each row represents a 10-second interval, beginning at the start of the pair's programming efforts.]

Cultural Differences in Collaboration During Computer Programming

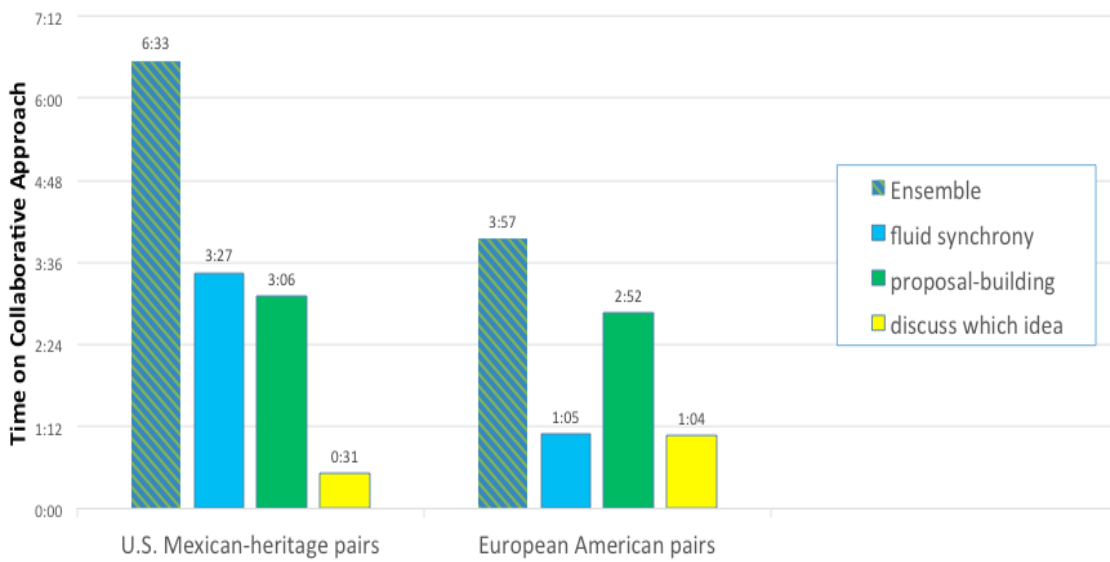
This section provides the results for the three approaches that demonstrate collaboration: *fluid synchrony*, where children coordinate fluidly in the same direction and anticipated each other's direction; *proposal-building*, where children built on each other's contributions with explicit proposals and responses regarding new ideas, and *discuss which idea*, where children stopped their programming to discuss joint decisions for next steps. Bonferroni adjustments were used to adjust the statistics for the total number of comparisons. In addition, the statistics did not assume equality of variance. See Table 1 for means and standard deviations.

U.S. Mexican-heritage children collaborated with *fluid synchrony* three times as long as European American ESE pairs (*Ms* = 3min 27s versus 1min 5s; *SDs* = 56s and 49s). This is a significant difference, $t\,(47.2) = 9.49$, $p < .001$, $d = 2.7$. The U.S. Mexican-heritage children averaged 2min 22s longer collaborating with *fluid synchrony* than European American ESE children (95% CI [1min 51s, 2min 52s]). In fact, 24 of the 25 U.S. Mexican-heritage pairs spent at least 2 minutes collaborating with *fluid synchrony* compared to only 4 of the 25 European American ESE pairs (as shown in Figure 3). For example, one U.S. Mexican-heritage pair worked together smoothly, with one child controlling the mouse and the other using the keyboard. They often overlapped their hands while working on the same idea, often anticipating each other's next steps. In another pair, the child in control of the mouse clicked on the text command in anticipation of the partner typing something into the word bubble.

U.S. Mexican-heritage and European American ESE children did not differ in how much time they spent collaborating via *proposal-building* (*Ms* = 3min 6s vs. 2min 52s, *SDs* = 49s and 1min 13s), $t\,(41.9) = .81$, ns. Almost all U.S. Mexican-heritage pairs and European American ESE pairs spent at least 2 minutes in *proposal-building* (24 of 25 and 21 of 25, respectively).

Children of the two cultural backgrounds also did not differ significantly in extent of time spent *discussing which idea* to use (*Ms* = 31s vs. 1min 4s; *SDs* = 24 and 58s), t (32.5) = 2.62, p = .013.

The coding of collaboration in the present study takes a more fine-grained approach than prior studies by distinguishing collaborating in *fluid synchrony* from *proposal-building*. To compare my findings with prior research on cultural differences in children's collaboration, I combined time spent in *fluid synchrony* and *proposal-building* to create a variable corresponding to *collaborating as a fluid ensemble*, which was the main coding category used by Alcala and Rogoff (2015). Alcala and Rogoff found that U.S. Mexican-heritage pairs spent twice as much time *collaborating as a fluid ensemble* as European American ESE children. In line with Alcala and Rogoff's findings, as seen in Figure 5, U.S. Mexican-heritage pairs in the current study spent almost twice as much time *collaborating as a fluid ensemble* as European American ESE pairs (*Ms* = 6 min 33s vs. 3min 57s, respectively, *SDs* = 1min 1s and 1min 47s). This is a significant difference, t (38.3) = 6.29, $p < .001$, d = 1.8. U.S. Mexican-heritage children spent 2min 36s longer *collaborating as a fluid ensemble* than European American ESE children (95% [1min 46s, 3min 26s]).



[Figure 5. Average amount time pairs of each cultural background spent on each collaborative approach. Time spent in *fluid synchrony* and *proposal-building* was combined to create *collaborating as a fluid ensemble*.]

Cultural Differences in Time Spent on Individual Agendas

Four approaches focused on the partners' attempts to prioritize their own individual agendas: *resistance* of partner's involvement; a focus on *whose idea* to use; one child tells their partner what to do step-by-step (*boss-implement*); and one partner ignored the other, who did not focus on the activity (*ignore-off-task*). See Table 1 for means and standard deviations.

European American ESE pairs spent significantly more time in *resistance* when compared to U.S. Mexican-heritage children, t (29.9) = 3.96, $p < .001$, $d = 1.1$. The European American ESE pairs spent 24% of their time in *resistance*, four times as much as U.S. Mexican-heritage pairs (*Ms* = 2min 24s vs. 45s; *SDs* = 1min 57s and

41s). European American ESE children averaged 1min 39s longer in *resistance* than U.S. Mexican-heritage children (95% CI [48s, 2min 30]). In fact, 13 of the 25 European American ESE pairs spent at least 2 minutes in *resistance*, whereas only 2 of 25 U.S. Mexican-heritage pairs did so. In one European American ESE pair, for example, a boy made 13 bids to participate by reaching for the mouse and saying things like, “Maybe I can try it now? I can probably do something cool if you let me try.” Each time, the partner who was controlling the mouse blocked this boy by grabbing his hand away, saying, “Let’s do that later,” or by simply ignoring him.

European American ESE pairs spent significantly more time negotiating *whose ideas* to use than U.S. Mexican-heritage children did—approximately five times as much (*Ms* = 1min 1s vs. 17s; *SDs* = 47s and 16s), t (29.9) = 4.35, $p < .001$, d =1.3. The European American ESE children on average spent 44 more seconds negotiating *whose idea* to use than the U.S. Mexican-heritage children did (95 % CI [23s, 1min 4s]). In one European American ESE pair, one boy interrupted his partner’s insistence on making the grasshopper change colors: “No, but you’ve had a turn. Now *I* want the duck to move towards the grasshopper and say ‘Hi.’” The partner responded, “No, watch, let me show you. We should make the grasshopper change colors.”

Pairs of both backgrounds seldom engaged in *boss-implement*, but European American ESE pairs spent significantly more time using this approach (*Ms* = 17s vs. 1s; *SDs* = 22 and 3s), t (25.4) = 3.48, p = .002, d = 1.01, 95% CI [6s, 24s]. In one instance, a girl reluctantly gave over the mouse to her partner and immediately started dictating steps to that partner. The partner, who now had the mouse, carried out the steps (but only for a few intervals; then she started *resisting* the partner's commands).

Overall, there were very few intervals where one child ignored the other, who spaced out or was not involved in the project (*ignore-off-task*). The few times this happened were brief (less than 25s in both backgrounds). There was no significant difference between groups.

Cultural Differences in Time Spent Observing Partner

One approach, *observing*, was neither a form of collaboration nor a form of focusing on individual agendas. Pairs of both backgrounds spent about a minute *observing* their partner's work without making direct contributions (respectively, *Ms* = 1min 22s and 1min 1s; *SDs* = 1 min 2s and 51s). The cultural backgrounds did not differ significantly from one another, t (46.3) = 1.31, ns.

Table 1

Means (and standard deviations) for each approach

		U.S. Mexican-heritage	European American ESE
Collaboration	fluid synchrony*	3min 27s (56s)	1min 5s (49s)
	proposal-building	3min 6s (49s)	2min 52s (1min 13s)
	discuss which idea	31s (24s)	1min 4s (58s)
Individual Agendas	resistance*	45s (41s)	2min 24s (1min 57s)
	whose idea*	17s (16s)	1min 1s (47s)
	boss implement*	1s (3s)	17s (22s)
	ignore-off-task	21s (16s)	13s (19s)
Observation		1min 22s (1min 2s)	1min 1s (51s)

Note. *= $p < .005$. The approaches sum to approximately 10 min; the remainder is the small amount of time where both children were off task.

Overview of complexity of the children's computer programming. All pairs engaged in some programming. Programming included changing the visual appearance of the characters, adding word bubbles with text to the characters, and changing the characters' movement. Changing a character's movement was the most complex since it required adding several commands to a character. These three approaches were all commonly and approximately equally employed. Children of both backgrounds engaged to a similar extent in these 3 approaches. All pairs did at least one of these types of programming in their project. Given that the U.S. Mexican-heritage children were more collaboratively involved in shared thinking, the individual children of this background spent more of the 10 minutes engaged in collaborative programming, compared with the European American ESE pairs, who more often followed individual agendas in which only one partner at a time was directly involved in programming.

Summary of cultural differences in the children's collaboration. In line with my hypothesis, U.S. Mexican-heritage pairs spent more time collaborating in *fluid synchrony* than the European American ESE pairs, who spent more time on approaches that emphasized individual agendas (*resistance, whose idea*, and *boss-implement*). Contrary to my hypothesis, there were no differences in the amount of time pairs spent collaborating through *proposal-building*; both cultural backgrounds engaged in a great deal of this form of sharing ideas. This pattern suggests that previous findings by Alcalá and Rogoff (2015) that Mexican-heritage partners spent more time *collaborating as a fluid ensemble* than European American ESE partners may be primarily based on their much greater extent of collaborating in *fluid synchrony*; both backgrounds may be generally involved in building on partners' ideas with proposals and responses to a similar extent. Pairs of both backgrounds also spent substantial time *observing* their partner's work.

The present study makes another original contribution by distinguishing children's discussion of *which idea* to use from their negotiations of *whose ideas* to use. Children of both backgrounds engaged in examining ideas for programming together (*which idea*), whereas European American ESE children spent significantly more time claiming that their own individual idea should predominate (negotiating *whose idea*).

This focus on dominance of individuals rather than on value of particular ideas independent of who proposed the idea, among the European American ESE children, fits with their considerably greater time spent in *resistance* to each other's attempts to make decisions and in *bossing* their partner to implement their own plan. All three of these ways of engaging focus on ego, not on sharing or considering ideas together. This difference in emphasis on individual agendas versus shared thinking also shows up in how children described the balance of their contributions, presented below.

Children's Reports about Collaboration

Children's individual interview responses covered 3 aspects of collaboration: whether they liked working with a partner, whether they found working with a partner helpful, and whether they thought the collaboration was balanced.

The majority of individual children of both backgrounds liked working with their partner (41 of 50 U.S. Mexican-heritage and 33 of 50 European American ESE) and reported that they felt collaboration was more helpful than working alone (45 and 34, respectively). Few stated that they would have preferred to work alone (1 Mexican-heritage child and 6 European American ESE children). The responses to these 2 questions did not vary in relation to whether the children spent a lot of time collaborating or in resistance.

About half of the U.S. Mexican-heritage children and European American ESE children reported that they felt collaboration was balanced between them and their partner (22 and 25 children respectively). Another 21 U.S. Mexican-heritage children and 14 European American ESE children felt either they or their partner took a slight lead during the activity. Only 7 U.S. Mexican-heritage children and 11 European American ESE children reported that either they or their partner controlled the activity most of the time.

To look more closely at responses by children on the extremes of collaboration and individual agenda approaches, I examined the reports on balance of contributions by children from the pairs who spent more than 3 minutes on *resistance* (8 European American ESE pairs and 0 U.S. Mexican-heritage pairs) and children from the pairs that spent more than 5 minutes *collaborating as a fluid ensemble* (23 U.S. Mexican-heritage pairs and 7 European American ESE pairs). The European American ESE children from pairs high on *resistance* seemed often to recognize that one child dominated the activity (38% of those children) in comparison to fewer children from pairs high in *collaborating as a fluid ensemble* (only 15% of the U.S. Mexican-heritage children and 14% of the European American ESE children).

A focus on balance in terms of time and turns with the mouse was common among the responses of children from pairs that extensively *resisted* partner participation. For example, when asked if he felt the collaboration between him and his partner was balanced, a European American ESE boy from a pair high in *resistance* focused on a precise count of turns, "We had the same number of turns. Hmm, maybe he had one or more turns than me, so maybe he did a bit more." Another European American ESE boy described balance by dividing his and his partner's contributions,

> "We did the jelly fish, the squid, he did the bottom, I did the top, he did some of the programming, I did some of the programming. I made the fish. He made the duck say 'I'm drowning'."

Some European American ESE children from pairs that did not spend a lot of time on *resistance* also talked in terms of division. When one girl was asked if she felt the collaboration was balanced, she reported, "Yeah, it was pretty balanced. I was looking at my watch [she held her wrist up to show her digital watch] and I think we each had an equal amount of minutes."

Children from pairs who spent the highest amount of time on *collaborating as a fluid ensemble*, especially Mexican-heritage children, often referred to changes in their programming as joint efforts—often using "we" to explain what had gone on in their programming. Although using "we" was not exclusive to children using this approach, it was prevalent in the 4 pairs who spent the most time *collaborating as a fluid ensemble*. For example, when asked about balance, one U.S. Mexican-heritage boy described the process in terms of helping each other rather than divided efforts, “He helped me choose between the colors. He wanted to do the bat, and I wanted to do the duck. So I helped him do the bat first and he helped me do the duck.” His response shows a focus on blending rather than dividing agendas.

Some of the U.S. Mexican-heritage children, from pairs who spent the most time *collaborating as a fluid ensemble*, credited their partner with helping them figure out some parts of their project or said that it would not have been as interesting if they had worked alone. Children from pairs who spent extensive time on *resistance* sometimes gave examples of ideas or steps they would have been able to implement differently if they had been able to work alone.

Summary of children’s responses about collaboration. Almost all children reported that they liked working with their partner, said that it was helpful to work with their partner, and claimed that the collaboration was balanced. However, the children who *resisted* partner contributions most often noted that one partner took the lead and explained balance in terms of dividing the computer activity into turns and time. Mexican-heritage children often described balance in terms of joint effort and working together to meet their goals.

Discussion

As hypothesized in this study, the U.S. Mexican-heritage children spent more time collaborating fluidly in the same direction compared to the European American

ESE children. Children of both cultural backgrounds spent extensive time building on each other's ideas with explicit proposals and discussing ideas to use in their project. The distinction of collaborating in *fluid synchrony* from collaborating with *proposal-building* clarifies the kinds of collaboration common in the two cultural backgrounds. Combining these two approaches shows similar findings to Alcala and Rogoff (2015), but moves beyond these findings by analyzing cross-cultural differences in *fluid synchrony* and *proposal-building*, the results indicate that differences in collaboration are largely due to the Mexican-heritage children spending much more time collaborating in *fluid synchrony*. These findings seem to generalize to other activities considering that the combination of *fluid synchrony* and *proposal-building* mirrored findings by Alcala & Rogoff (2015) in a different context where children physically manipulated a figure through a shopping task with siblings instead of peers.

In addition, this study goes beyond past studies by researching cultural variation in children's time spent in synchrony during collaboration while learning to computer program and children's attitudes toward collaboration in this context. Although all children reported that they liked collaborating with their partner and found collaboration helpful and balanced, reflections by the Mexican-heritage children who spent over five minutes *collaborating fluidly as an ensemble* coincide with observations regarding time spent collaborating in *fluid synchrony* and *proposal building* versus dividing the activity into individual contributions. They stated that the project would not have been as good or as interesting if they had worked alone.

Both groups spent a great deal of time collaborating through *proposal-building* (about 3min) indicating that European American children collaborated through the use of proposals that built on partner ideas rather than collaborating in a fluid synchrony. The European American children seldom collaborated in *fluid synchrony*—a specific skilled form of collaborating involving reading each other's signals and moving forward in coordination without discussing new proposals.

European American children spent more time on individual agenda approaches than Mexican-heritage children. The European American children spent more time resisting partner contributions, pushing for their own individual ideas, and one partner bossing the other. Children from pairs that spent more than three minutes in *resistance* to partner contributions often reported that they or their partner did more. These children often spoke of balance in their collaboration in terms that emphasized division of the activity, such as separating the kinds of tasks each child carried out in their description of the collaboration. A few European American children who spent a substantial amount of time building on each other's ideas with proposals similarly described balance in collaboration in terms of dividing the activity into turns and individual task.

Conflict has been noted as an important aspect of learning and collaboration since these sources of tension and disagreement lead participants to re-evaluate their ideas in comparison to collaborator's ideas and it has been found to relate to learning benefits during collaborative computer science work (Tao & Gunstone, 2001; Zimmerman & Blom, 1983). In this study, we focused on time spent in collaboration.

It is a matter of how much they spent time discussing ideas. *Resistance* and *whose idea* did not involve discussion of the merits of the idea – which is the important part of conflict. The important part of conflicts in these previous studies is the discussion of conflicting ideas rather than interpersonal conflict (as capture in the individual agendas coding categories

Connection to LOPI

Learning by Observing and Pitching In may help explain the prevalence of *fluid synchrony* in Mexican-heritage children's collaboration. In Mexican- and Indigenous-heritage communities, practices and values that support coordination within a community may create a shared reference point that supports fluid approaches to collaboration. As describe in the sixth hypothesized facet of LOPI:

> Communication is based on coordination among participants that builds on the *shared reference* available in their mutual endeavors. This involves a balance of *articulate nonverbal conversation and parsimonious verbal means*. When explanation occurs, it is nested within the shared endeavors, providing information to carry out or understand the ongoing or anticipated activity. (Rogoff, 2014, p. 74).

Integration in household work may relate to an ability to fluidly collaborate (Alcala & Rogoff, 2015). This may be because disrupting family work can impact everyone in the family (and in some cases, the livelihood of the family), which contrasts with using chores to encourage collaboration in families with an extensive schooling experience where children primarily participate in self-care (Alcala et al., 2014; Coppens et al. 2014). A coordinated fluid approach may be learned through collaborative participation in family work and may be reinforced through Mexican- and Indigenous-heritage cultural values that promote responsibility towards others in mutual endeavors (López et al., 2012; Ruvalcaba et al., 2015).

Children and adults alike are noted to skillfully integrate themselves into ongoing collaboration with no assigned roles and without dividing the task into discrete responsibilities (Mejía-Arauz et al., 2007). Instead, participants simply aim to help when they see something that needs to be done (López et al., 2015).

Flexible and Improvisational Qualities of Collaborating *in Fluid Synchrony* and *Proposal-building*

As illustrated in the opening example of this research paper, *fluid synchrony* may include children fluidly overlapping their interactions and contributions in a joint direction. The prevalence of *fluid synchrony* in Mexican-heritage pairs suggests that some of these children were more skilled in anticipating other's direction and contributions than European American pairs. Children's contributions were made in the same direction adding to the ongoing direction. This unscripted collaborative approach improvisation as described Sawyer (2000, p. 155) where the direction becomes evident as individuals contribute. Sawyer explains:

> In many ways, every day conversations are also improvised. Especially in casual small talk, we do not speak from a script; our conversation is collectively created, and emerges from the actions of every one present.

Fluid synchrony seemed to reflect a form of skilled improvisation because it included anticipation of partner's direction with no proposals rather than frequently proposing new ideas (as in *proposal-building*). Children who collaborated in *fluid synchrony* in this study often moved in the same direction with few new proposals. Children adjusted quickly and subtly as they moved together as one.

The Mexican-heritage cultural value of being *acomedido* may encourage improvisation in helping others (López, 2015). Being *acomedido* reminds children and adults to anticipate other's needs and to be ready to help. In an activity where children worked with an adult on a science activity, for example, U.S. Mexican-heritage children volunteered their help spontaneously to the adult more often than European American children did (Lopez, 2015; see also Ruvalcaba et al., 2015).

Implications for Schooling

The cultural differences in *fluid synchrony* during computer programming may be of particular interest to educators in computer science fields where Latinos continue to be severely underrepresented (Denner & Rivera, 2011). Latino students are sometimes discouraged by teachers and the perceived level of difficulty of pursuing computer science classes, majors, and careers (Denner & Rivera, 2011; Margolis et al., 2008). Allowing and supporting collaboration where children collaborate through *fluid synchrony* may help create a more welcoming environment for Mexican-heritage students.

Children and youth bring aspects of their cultural experience to learning with technology (including computer science activities) in ways that reflects their experience in their communities (e.g. DiSalvo, Crowley, & Norwood, 2008; Mandryk, Inkpen, Bilezikjian, Klemmer, & Landay, 2001; Smith, 2010). For example, African American youth more often participated in collaborative video game play with family at home than European American children who more often played video games alone (DiSalvo et al., 2008).

It may be the case that *fluid synchrony* is not noticed as collaboration by adults and children that expect equal turns. Creating a space that encourages *fluid synchrony* may help educators develop approaches that allow for more diverse collaborative learning approaches than when using turn taking approaches. Rather than only using turns and time to organize collaboration in school, curriculum designers and educators may consider encourage *fluid synchrony* to help encourage children to help others (not just their partner). As showcased by the findings in this study, children are able to collaborate in more complex ways than educators may expect.

Turns and divided roles are a form of individual agendas, which this study (and several others) finds are more common in European American families and in formal schooling where responsibilities are often divided into specifically outlined individual roles (Rogoff, 2003). Evidence suggests that experience with schooling practices relates to lower rates of flexible collaboration in Indigenous-heritage communities, as well (Chavajay, 2006; 2008).

Children may benefit from collaboration that uses complex and dynamic approaches (as observed in both cultural communities in this study) instead of a one-size-fits-all approach that emphasizes turns and division of labor. Research with triads solving math problems found that children who collaborated in a way that resembled a fluid and proposal-building approach outlined in this study benefited from positive learning outcomes (Barron, 2000; 2003).

Ongoing work with children, youth, and adults working on joint technology activities highlights the importance of understanding the role of gaze and gestures in children's engagement during activities with technology (Vossoughi & Escudé as cited in Garcia, 2015). The researchers highlight the importance of gaze and observation in coordination between teachers and children. Rather than using an approach where they correct the children's work, the researchers found that encouraging awareness of nonverbal communication led to improvements in student and teacher's joint coordination. Rather than the teacher leading and assigning tasks, the teacher and student both contributed ideas as they collaborated to design electronic gadgets.

Integrating Mexican-heritage approaches in school may help create a context that allows students to draw on the diverse experiences children have with collaboration. In a space that allows for multiple collaborative approaches, children may benefit from drawing on each other's experience with diverse approaches to collaboration as they work together to solve a problem (Gutiérrez, López, & Tejeda, 1999). However, as cautioned by researchers advocating for technology in the classroom, children's learning cannot be delegated to new digital technology.

The organization of an activity may help children not familiar with a fluid collaborative approaches coordinate in a way more like *fluid synchrony*. Children (mostly of European American ESE and Asian-heritage ESE backgrounds) collaborating on a digital game with a single mouse often fought over control of the mouse, even when they did not need the mouse (Scott et al., 2003). When the children each had an individual monitor and mouse but a shared virtual screen, they fought less but collaborated infrequently. In contrast, when they worked on one screen with two mice, both children were on task more and spontaneously helped each other more often compared to the other two setups.

Another approach that may help encourage *fluid synchrony*, intrepid exploration, an approach that encourages children use trial and error to figure out complex computer skills (Denner & Bean, 2006). In collaborative programming, intrepid exploration often includes building on partner's approaches and ideas.

Is collaborating in *fluid synchrony* a benefit or disadvantage in the long run? In schooling, it is clear that collaborating in schooling has been discouraged historically (Rogoff, 2003). *Fluid synchrony* may be misunderstood by teachers in school settings where collaboration is often interpreted as cheating. In contrast, *fluid synchrony* may be an advantage in the workplace where skilled coordination with others is seen as taking initiative and working well with others. Collaboration in a workplace setting where individuals contributed equally led to better work than groups where one participant took a leader role (e.g. a boss who designated task) (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010).

Instead of limiting the approaches children can use in school, there may be benefits to create contexts were all children engage in *fluid synchrony* in collaborative learning.

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