Cracking Her Codes: An Interaction Analysis of Participation and Status in an All-Girls Informal Learning Environment

Abstract: Computer-supported collaborative learning environments provide opportunities for students to engage in complex problem-solving tasks that require collaboration around technology resources. However, we have limited understanding of the ways issues of status and participation are negotiated among students in informal CSCL learning environments. Situated in an all-girls cryptography summer camp, this comparative-case study used interaction analysis methods to investigate adolescent collaborations around shared technologies within a CSCL learning environment. Our analysis showed that interactions around technology reified uneven participation patterns, unequal status orderings, and an imbalance of power in both of the comparison cases, although the effects of these power dynamics had differential effects on productivity. Our results illustrate the consequences of these dynamics on student opportunities to learn, with implications for developing observational measures and designing intervention strategies that can better support equitable participation in CSCL environments.

Learning is a continuous, context-cutting process that happens across a variety of formal and informal settings (Dierking et al., 2003). Just as formal learning experiences can catalyze student pursuit of their own interests outside of school, informal learning experiences can leverage student engagement and educational gains in formal schooling environments (Barron, 2006; Greenhow & Robelia, 2009; Hirsch, 2007). In other words, learning does not occur in one setting, but both formally and informally throughout one's daily experiences (Dierking et al., 2003). Research supports a positive relationship between a learner's ability to connect learning in formal and informal learning settings through the use of technology (Barron, 2006; Hirsch, 2007;

Lai et al., 2013), which underscores the critical mediating role technology plays across settings in terms of *what* students learn and *how* they learn it (Sinha et al., 2015). As argued by Zurita and Nussbaum (2004), technological tools may provide students with “at hand” and even mobile support to participate and collaborate in learning activities.

Computer-Supported Collaborative Learning (CSCL) environments, for example, have been shown to foster deep engagement in key concepts and scientific habits of mind such as argumentation and self-regulated learning (Järvelä & Salovaara, 2004; Krejins et al., 2002; Renninger & Shumar, 2002, 2004; Stahl et al., 2006). Despite the potential for high-leverage learning, peer collaboration in CSCL settings is not a fail-safe strategy (Azevedo et al., 2004; Chavez & Romero, 2012; Sinha, 2016; Winters & Alexander, 2011). For instance, Winters and Alexander (2011) reported that students in their study experienced varying degrees of success, even when the given tasks and instructions explicitly encouraged collaboration within a computer learning environment. Gains in student learning were more often experienced among pairs of students who negotiated a shared understanding and engaged in active processing strategies such as reading notes as opposed to engaging in off-task behaviors and questioning their partner for procedural understanding. This example illustrates how “[i]n CSCL settings, the extent to which collaboration is productive in ways that lead to conceptual understanding depends on high quality engagement in shared activity” (Sinha et al., 2015, p. 274).

As such, scholars argue a need for research to continue examining the quality and nature of group interactions, participation, and engagement within CSCL environments (Barron, 2003; Dillenbourg et al., 2009; Prinsen et al., 2007; Sinha et al., 2015) with a particular focus on verbal and non-verbal conversation dynamics developed among students as they work together (Barron, 2003). As a research team, we questioned how issues of status and participation are negotiated and maintained among students in informal CSCL learning environments, because as research in CSCL formal classroom environments suggests, issues of status (i.e., high versus low; Cohen & Lotan, 1995) affect participation and patterns of interactions (e.g., Bento & Schuster, 2003), which may affect learning gains (e.g., Barron, 2003; Shaw, 2013; Wang & Lin, 2007). Similar research in informal learning environments, particularly those involving learning through the use of computers and hand-held devices, is more limited. Accordingly, our research questions were: (1) What do adolescent interactions around shared technologies within a complex problem-solving context reveal about partner participation and status in an all-girls informal CSCL environment? (2) How do these interactions influence partner productivity? We further contend that the presence or absence of partner productivity shapes the manner in which learning unfolds (or not) within a CSCL environment (e.g., Cohen, 1994; Kapur & Kinzer, 2007).

This article begins by situating the study in literature on collaborative interactions in CSCL environments, followed by a description of the conceptual framework that informed our understanding of this study. We then provide an account of the study context and research design, establishing our study as a case of student participation in a technology-rich, collaborative mathematics classroom more generally. Next, we explain our research methods, including a full account of the interaction analysis methods we employed. Two cases of student partner interactions are then presented and closely analyzed. The article concludes with a summary of the findings and discussion of the educational implications.

Literature review

Computer-supported collaborative learning (CSCL) environments are broadly defined as the use of technology in either a face-to-face (e.g., shared computer) or online (e.g., discussion board) context to support and enhance learning activities through collaboration, or the sharing and distribution of knowledge through interacting with others (Arvaja et al., 2008; Barros-Castro et al., 2014; Dillenbourg, 1999; Lipponen, 2001). Additionally, it is assumed that collaboration, as opposed to cooperation, requires each member of the group to contribute and be engaged in a coordinated effort to solve a shared problem or attend to meeting shared goals (Arvaja et al., 2008; Webb et al., 2006).

Research on the effectiveness of CSCL environments is inconclusive, as the essential features that make them powerful also limit their capacity. Benefits include exchange of positive and supportive comments (Janssen et al., 2007), responsive to and respectful of group member's ideas (Sinha et al., 2015), higher-level cognitive problem-solving strategies and shared content knowledge building (Barros-Castro et al., 2014; Hakkarainen & Palonen, 2003; Kapur & Kinzer, 2007; Salovaara, 2005; Shell et al., 2005), gains in learning performance (Salomon et al., 1989; Shaw, 2013), and a perception of collaboration as positive (Barros-Castro et al., 2014; Shell et al., 2005). For example, Sinha and colleagues (2015) examined the quality of engagement of ten collaborative groups as they utilized simulations, modeling tools, and hypermedia in a unit on aquatic ecosystems. Based on their analysis, group members who were highly engaged exhibited on-task behavior, a shared workspace in which the majority of members contributed and respected one another's ideas, and made connections to content and unit objectives.

That said, existing problems in CSCL environments noted in extant literature include perpetuation of misconceptions in content knowledge (Barros-Castro et al., 2014; Janssen et al., 2007), negative judgments and comments toward others (Janssen et al., 2007), and short discussion threads in online work (Lipponen et al., 2003). Continuing with the study by Sinha and colleagues (2015), some "collaborative" groups exhibited low levels of engagement, off-task behaviors, completing tasks individually, ignoring each other's ideas, and consistent use of "I" language. Similar discrepancies in student participation and engagement in computer-based, cooperative small group settings have also been documented by others (Baker et al., 2012; Kapur & Kinzer, 2007; Salovaara, 2005; Winters & Alexander, 2011).

Issues of status and power, which may be evidenced by dominating interaction patterns, are often ignored in collaborative settings (Barron, 2003; Chavez & Romero, 2012; Cohen & Lotan, 1995; Salomon & Globerson, 1989), which may impede group productivity and student performance (Cohen, 1994). In addition, students may take on and maintain certain roles and become characters within particular hierarchical structures (Correll & Ridgeway, 2006; Salomon & Globerson, 1989). This may be dictated by status characteristics or "attributes on which people differ (e.g., gender, computer expertise) and for which there are widely held beliefs in the culture associating greater social worthiness and competence with one category of the attribute (men, computer expertise) than another (women, computer novice)" (Correll & Ridgeway, 2006, p. 32). Further, this may be delineated by how students perceive their academic competence in relation to other group members; in other words, how students position themselves and one another based on perceived differences in ability in a particular subject area or skill (Cohen & Lotan, 1995; Correll & Ridgeway, 2006; Salomon & Globerson, 1989). For instance, Salomon and Globerson (1989) discussed the "free rider" effect in which a group member is known for her or his competence and eventually takes on the majority of work as other members feel less able and put forth less effort. Or consider the effect of one or two members expending more effort due to interest or value in a task; therefore, not pooling the efforts of every group member. These behaviors have the potential to become self-fulfilling prophecies, difficult to eradicate.

Although the goal of CSCL environments is to promote student learning through collaboration, these environments may suffer similar problems with status and power as those documented in similar technology settings (Hakkarainen & Palonen, 2003; Kapur & Kinzer, 2007; Janssen et al., 2007; Prinsen et al., 2007; White, 2006). For example, Kapur and Kinzer (2007) examined student participation in solving ill-structured problems in a text-only chat format. These researchers concluded that solving these type of problems, meaning problems which are not clearly defined and allow for multiple entry points and non-routine solutions, led to inequitable groups in which one or two members dominated the discussion and problem-solving space. This inequitable participation pattern occurred early in the task, and was maintained until completion of the task. This affected the quality of the discussion as it became one-sided and difficult for all members to make a meaningful contribution. As another example, White (2006) concluded that even though the utilization of a device network provided students with shared objects to supplement verbal forms of participation, issues of status still existed such as who provided and who received or followed instructions.

We agree with Lipponen and colleagues (2003) that more research is needed on the particulars of effective CSCL environments. For the majority of these studies, it is not clear how the technological tools themselves fostered participation and engagement among individuals in this collaborative group (see White, 2006 and Janssen et al., 2007 for exceptions). One potential reason for this is because of the "limited understanding of the quality of engagement fostered in these contexts, in part due to the narrowness of engagement measures" (Sinha et al., 2015, p. 273). On the other hand, researchers seemed to consider the mediating effect of other variables such as problem type (Kapur & Kinzer, 2007), group size (Shaw, 2013), self-efficacy (Wang & Lin, 2007), and assignment of group roles (Strijbos et al., 2007). Furthermore, there seems to be an overwhelming reliance on verbal interactions as indication of participation as opposed to considering the potential effects of both verbal and non-verbal communicative acts (see White, 2006 for an exception). Additionally, students' performance in CSCL environments is typically assessed through pre-post measurements as opposed to transfer of knowledge and conceptual understanding through the collaboration itself. Lastly, the majority of CSCL research is conducted in formal learning settings as opposed to informal learning settings. It is not that informal learning environments do not utilize computers and hand-held devices, but that the aim of some of these informal settings is not on opportunities for learning *through collaboration*. The present study aims to fill this void.

Conceptual framework

We draw upon the framework of figured worlds (Holland et al., 1998) to conceptualize our investigation of partner interactions around shared technologies within a complex problem-solving task. Figured worlds are defined as "socially and culturally constructed realm[s] of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (Holland et al., 1998, p. 52). In mathematics classrooms, for instance, students continually negotiate their roles, behaviors, participation, and discourse while interacting with one another such as in small group interactions (e.g., Bishop, 2012; Esmonde & Langer-Osuna, 2013; Jurow, 2005; Langer-Osuna, 2014). For example, through the discourse interactions of two 7th grade students, Bishop (2012) noted how one student was jointly positioned as mathematically inferior, or the "dumb one," while the other was jointly positioned as the mathematically superior, or the "smart one."

Discursive actions and acts of participation such as using an authoritarian voice and controlling problem-solving strategies seemed to be assigned more value than other discursive actions and acts of participation such as asking the teacher for help and providing "inferior" information that was not taken up in the ongoing interaction. Through such negotiations, as the one just described, students have an opportunity to co-construct and shift between figured worlds that may allow them to try on and/or uptake different roles within figured worlds (Esmonde & Langer-Osuna, 2013; Jurow, 2005; Langer-Osuna, 2014). In the analysis of a group of three students working together over a three-week period, Esmonde and Langer-Osuna (2013) noted how these students shifted within and between a figured world of learning and a figured world of social relations, friendship and romance. Movement between and within these figured worlds afforded one African-American female student to discursively position herself in a position of power as she continually challenged and criticized another group member's statements and further prevented him from joining in conversations on hair, make-up, and dating.

As illustrated in these examples, within the figured worlds framework, power and status are given attention (Holland et al., 1998; Holland & Leander, 2004). Individuals and groups are socially positioned as a type of individual or group through co-constructed interactions with others, through ongoing verbal and non-verbal communication, such as eye gazing and orientation of body to another (Leander, 2002a). Likewise, individuals and groups are socially positioned through material artifacts, tools, physical and social spaces. Leander (2002b), for instance, provides a detailed account of how one African American female student, Latanya, was positioned as "ghetto" by her classmates. This was accomplished through multimodal means (i.e., discursive and embodied actions), a classroom discussion around a banner containing derogatory terms associated with particular groups and through the co-construction and maintenance of a "Black community" as a social space or figured world within the classroom. This article will add to this current body of literature by illustrating two cases or figured worlds in which two pairs of female students, who only met one another through voluntary attendance in an all-girls summer camp, negotiated participation and status through solving mathematical tasks as part of a team.

Methods

Our study is broadly situated in an all-girls one-week Science, Technology, Engineering, and Mathematics (STEM) summer camp for rising high school freshman and sophomores (n = 22) at a university located within the southeastern region of the United States. The camp aimed to combat the gender disparity of females who pursue and maintain a STEM career (National Science Foundation, 2015) through boosting their mathematics skills and increasing their confidence and awareness of career opportunities in STEM. Camp participants engaged in a variety of daily sessions, such as robotics and dance. Our study was conducted during campers' mathematics sessions, which leveraged technological tools as a means to foster pair engagement and student understanding in solving complex cryptography-focused tasks. Campers worked in partner teams of two on mathematical tasks that required computational tools such as Wolfram|Alpha (2016), ciphering applications on laptops, and text messaging applications on iPod Touch handheld devices. We consider it a strength that we were in a camp setting and not bounded by the same constraints we experience in everyday formal classrooms, such as time, grading and performance evaluations, and content constraints.

Prior to the beginning of the study, two members of the research team attended the welcoming session attended by parents and the camp attendees to discuss the research study, highlight activities for the cryptography sessions, and gain parental consent and participant assent. The primary data source for this study was video recordings of the mathematics sessions. We videotaped each session continuously using five cameras that were positioned to capture partner interactions at every student table, yielding about 25 hours of video recordings.

We began our analysis with a data reduction. We omitted video footage of work that did not require collaboration, such as listening to the instructor or reflective writing. We also eliminated video footage with inaudible sound. Author A made a content log of the remaining footage (Jordan & Henderson, 1995), which included an *in vivo* summary of events, annotations of partner interactions, and memos regarding verbal and non-verbal communication. With our research questions in mind, this work guided our selection of two emergent contrasting partner cases—Jasmine & Becky and Sasha & Lily—to analyze in greater depth. Through video reduction, the total length of the video clips analyzed for this study was approximately 24 minutes for Jasmine and Becky and approximately 13 minutes for Sasha and Lily. Information on these participants is displayed in Table 1.

<INSERT TABLE 1 HERE>

We utilized *interaction analysis* methods (Jordan & Henderson, 1995) to empirically investigate partner interactions within the emergent contrast cases because of our interest in understanding relationships between camper interactions around shared technologies required for a complex problem-solving task. In Phase I of the analysis, the research team viewed videos together silently in two-minute increments. After each 2-minute segment, we discussed our observations using evidence from the video. Hypotheses about the activities observed were posed at the conclusion of the first step of the process. These mini-discussions were audio-recorded and later transcribed, creating metadata for the next phase of our analysis. In Phase 2, our goal was to look for confirming and/or disconfirming evidence of our hypotheses (Erikson, 1986). Two members of the research team (Author A and Author B) watched the videos again silently in five-minute increments while recording jottings (Emerson et al., 1995) to discuss at the end of each clip (audio-recorded and transcribed). At this point we revised our original hypotheses for clarity, trustworthiness, and accuracy, which we proposed to Author C as our findings. To increase validity, Author C re-watched the videos with these proposed findings and again looked for confirming/disconfirming evidence for our proposed findings.

In addition, each of the video clips were transcribed verbatim in a six-column format including both verbal and non-verbal cues for each participant pair, as well as for other individuals such as counselors and educators (Ochs, 1979). Verbal and non-verbal behaviors were included, because they, at times, occurred simultaneously and potentially carried varying communicative acts (Leander, 2002a, 2002b; Ochs, 1979). Verbal and non-verbal cues were numbered to indicate actions that occurred at the same time. Refer to Table 2 in the Appendix for an example.

Results

Our fine-grained interaction analysis of the contrast cases that emerged from our data reduction yielded evidence of a fragmented figured world and a connected figured world. We established that adolescent interactions around technology tools within a collaborative, complex problem-solving task reified power and status positions within the figured worlds they negotiated in the CSCL learning environment. Our analysis revealed that interactions around shared technologies reified uneven participation patterns, unequal status orderings, and an imbalance of power in both of the comparison cases, although the effects of these power dynamics had differential effects on productivity. These interactions, which were predominantly non-verbal, affected partner productivity in relation to the quality and quantity of time spent engaging in problem-solving tasks and potential for gaining conceptual understanding.

In what follows, we present the two contrasting cases by providing a description of the setting and mathematical task. We then discuss the results of our analysis using representative examples from the data. We end each case with brief summary statements as well as our conclusions about partner productivity related to the mathematical task.

Fragmented figured world (individual work spaces): The case of Becky and Jasmine

The case of Becky and Jasmine took place on Day 4 of the mathematics sessions. Partner teams explored the process of enciphering and deciphering messages using the RSA cryptosystem (Rivest, Shamir, & Adleman, 1978), which was designed to engage campers in mathematical processes that are used to keep private information secure. Partner teams were challenged to decipher a message sent to them by the end of the session. This challenge *required* the use of an iPod and a laptop. Becky and Jasmine needed the iPod so that they could receive a text message with a string of numbers comprising an enciphered message. They also needed a laptop so that they could use Wolfram|Alpha (2016) to perform computations that would help them decipher the message. The laptop was initially situated between Becky (sitting on the right) and Jasmine (sitting on the left) and the iPod Touch was located in the middle of the circular table.

Jasmine assumed the role of gatekeeper over the “shared” technological tools mere seconds after the lead instructor verbally communicated the task directions, evidenced by her grabbing the laptop and orienting it in her direction without any need to use it at the time. As Jasmine quickly seized the opportunity to assert ownership of the laptop, Becky appeared very busy as she searched through her bag for her session packet. When Jasmine reached the part of the task that required the iPod she grabbed it from the center of the table, scrolled to find the encrypted message, and placed it on the base of the laptop once she finished using it. Again, with her back toward Jasmine, Becky appeared to be very busy with the task of thumbing through the packet for the appropriate page and drinking water from her canteen taking approximately 1 minutes 15 seconds to consume what we assumed was a small amount of water. This situation is illustrated in Figure 1.

<INSERT FIGURE 1 HERE>

It is of interest to our analysis that Jasmine returned the iPod to a space where she had already staked a claim. We interpret Jasmine's subtle interactions with the laptop and iPod as moves of power. Whether or not Jasmine intended them as such is debatable. In addition to the difficulty created by putting the materials out of Becky's reach, Becky was then positioned to ask Jasmine for permission to use essential technology tools that no longer belonged to the collective. Jasmine's interactions with the shared technology resources thus reified her asserted dominance over Becky. Furthermore, we interpret Becky's preoccupation with "acting busy" as a coping strategy for dealing with Jasmine's moves of power and status. Becky temporarily avoided a need to interact with Jasmine or the shared technology resources by disconnecting from the cryptography challenge, shielding herself from additional rejection and lowered status.

Jasmine's early assertion of dominance and subsequent unequal status rankings within their figured world was reified by fragmented interactions around the "shared" technology resources. Jasmine and Becky rarely made eye contact or spoke to one another for the majority of their interactions; negotiations within their figured world occurred almost entirely through non-verbal communication. Interactions between Jasmine and Becky were fractured, power-laden, and devoid of collaboration, which impacted their productivity and potential for learning as a consequence.

Jasmine worked far ahead of Becky – which is easier to do when you control all of the essential resources – which further amplified the division between the pair and left Jasmine without a partner to consult when she hit a roadblock. Becky showed motivation and curiosity in the task – characteristics not uncommon for low-status students (Cohen, 1994) – evidenced by repeated attempts to complete it and figure out what was going on despite being unable to make genuine progress due to lack of access to the technological tools. Although she kept her distance, we observed Becky craning her neck to see what was on the iPod screen as well as transferring numerical information from Jasmine's handout to her own. However, we contend that these numbers were incorrect because Jasmine's handout was open to a different page than the one Becky was on. While it is possible that the page mismatch was accidental and unnoticed by Becky, our analysis supports the conclusion that Becky was "hiding in plain sight" and only pretended to engage and collaborate with Jasmine. Although some might view Becky's actions as cheating or even laziness, we think that Becky tried to make the best of a situation that was perhaps hostile for her. Taken together, these interactions provide evidence of decreased productivity of collaboration between Jasmine and Becky. An imbalance of productivity and opportunities to learn emerged from these interactions, where Jasmine moved forward with the cryptography challenge while Becky sat silently in wait.

Once Jasmine successfully transferred the encrypted message from the iPod to her handout, she relinquished control of the technological device, stating "I'm done." Becky was finally able to gain access to the iPod while Jasmine maintained her position as gatekeeper of the laptop. However, Jasmine realized that she did not know how to input pertinent information on the laptop, prompting Jasmine to ask Becky for help (see Lines 1-7, Excerpt 1). This is the first verbal interaction between the two in regards to the mathematical task.

<INSERT EXCERPT 1 HERE>

In this excerpt, Jasmine briefly relinquished her dominance of higher status to request help from Becky as she could not remember what keys were needed to insert the karat key (^) into

Wolfram|Alpha. Up until this point, Becky had yet to gain access to this tool. She also had not experienced the need to use the laptop because of where she was in the complex task. In fact, this is the only time in which Becky gained access to the laptop – to show the location of two keys. Jasmine asked Becky for help four times before getting a response from Becky. It could be argued that Becky simply did not hear Jasmine. On the other hand, given their physical proximity, it is more likely that Becky did hear Jasmine, but chose not to acknowledge her. As it takes concentrated effort not to respond to or look at a person who speaks to you directly, we claim that Becky intentionally ignored Jasmine's question. This interpretation seems reasonable because of the likelihood that Becky would not want to engage with Jasmine.

In the excerpt, Jasmine appeared comfortable when asking Becky a question about how to use the computer. However, when Jasmine had a question about the mathematics, she did not ask Becky for help and instead turned to adult "experts" in the room. These observations confirmed Jasmine's perspective and position of power and may be an indicator that Jasmine does not believe that Becky had anything to contribute intellectually. To elaborate on one such instance, Jasmine requested help from the lead instructor. "I typed in 697 and I got too large a number." Her intuition told her that not getting a number between 0-25 was wrong because these numbers corresponded to letters in the English alphabet. As she and the lead instructor continued to brainstorm, Becky at first looked on quietly, but then continued the task of transferring numbers from the iPod to the handout. Rightly so, Becky is not at a point in the complex task to be a contributing member. We argue this is yet another example of Jasmine reifying her position of dominance, lowering Becky's status to that of an onlooker.

As the negotiations within the fragmented figured world continued, Becky eventually indicated to Jasmine that she is in need of the laptop to continue forward with the task. Jasmine took this opportunity to give Becky directions in how to proceed. Jasmine instructed Becky to *type* in the second row of numbers into the laptop and write down the corresponding letter in the third row. Despite these instructions, Jasmine turns her attention back to the laptop and continued with her work. Becky is denied the very technological tool that Jasmine explicitly told her she needed to move forward with the cryptography challenge. We interpreted this as additional verbal confirmation that Jasmine is in a dominant position of power, having made territorial claims over the "shared" technology resources and withholding access to them from her partner. We see this behavior again in Excerpt 2.

<INSERT EXCERPT 2 HERE>

We found corroborating evidence of Jasmine assuming a dominant, high-status role within the team when she asserted herself as the expert member of the team. For example, Jasmine reached across Becky and pointed to errors on Becky's paper, followed by unsolicited advice for making corrections (see Figure 2). We interpret this move as an invasion of Becky's learning space. Becky had her elbows positioned up on the table. Therefore, we argue Becky did not invite Jasmine to enter her personal space, which is noticeable given Jasmine's prior territorial behaviors. Having said that, it is possible that Jasmine perceived her actions more nobly, instead believing her actions to be helpful to Becky. While we are not able to make claims about Jasmine's intentions, we leave open the possibility that Jasmine was woefully unaware of her affect. We do claim that she treated Becky as an incompetent, inferior team member as opposed to an equal peer with the ability to make intellectual contributions to a collaborative, complex task (Esmonde and Langer-Osuna 2013).

<INSERT FIGURE 2 HERE>

Becky and Jasmine continued their reticence and independence on the cryptography challenge for the remainder of the camp session that day. Becky continued possession of the iPod and Jasmine maintained possession of the laptop. Near the end of the session, the lead instructor challenged the class to decipher one more message, creating a need for Jasmine to use the iPod again. Jasmine unabashedly took the iPod out of Becky's hands not once – but twice – without checking in with Becky in any way before grabbing it for her own use (see Lines 2 and 22 in Excerpt 3).

<INSERT EXCERPT 3 HERE>

This brazen move of dominance reified Jasmine's ownership of "shared" resources, denied Becky access to essential tools, and limited Becky's ability to participate fully in the cryptography challenge. We claim that the deeply problematic, power and status-laden interactions between Jasmine and Becky created a fragmented figured world between them, limiting both girls' opportunities to learn and engage meaningfully in a complex task.

Connected figured world (shared intellectual space): The case of Lily and Sasha

The case of Lily and Sasha took place on Day 2 of the cryptography sessions, where they were challenged to use Caesar's Cipher to encipher and decipher messages. This task required the use of a laptop and an online tool—"Crack a Caesar Cipher" (Crypto Club Project & Eduweb, n.d.)—to decipher secret messages. The laptop was situated between Lily (sitting on the left) and Sasha (sitting on the right) as they engaged in their work (see Figure 3).

<INSERT FIGURE 3 HERE>

The task and laptop were positioned between Lily and Sasha throughout the video footage that was analyzed. The laptop was in the middle of the table and was directed so that both girls could see the screen. We found that the position and directionality of the laptop reified

Lily and Sasha's shared collaborative problem-solving space about the Caesar Cipher. Excerpt 4 provides a representative example of their verbal and non-verbal communicative acts around the online tool and deciphering task.

<INSERT EXCERPT 4 HERE>

In this example, Sasha and Lily were observed pointing to the screen at different moments, as well as sharing their thinking and comments out loud with one another. Neither seemed hesitant to speak up and the laptop was a tool utilized by both in completing the task. As these communicative acts were observed across the video footage, we contend that Lily and Sasha used the laptop as a joint thinking tool within an inviting, shared intellectual space that emerged from their collaborative work. As implied by the acts of happiness and gratitude that we observed in the footage (Lines 11-13), Lily and Sasha appeared to appreciate one another's contributions in cracking one of the enciphered messages. Yet, as evidenced next, this space was not void of power negotiations and subtle moves of dominance.

Although Lily and Sasha collaborated on the Caesar Cipher within an inviting, shared intellectual space, we found evidence of Sasha positioning herself as team captain. As verified in Excerpt 4 and in Excerpt 5, Sasha maintained control of the laptop through her non-verbal communicative acts, namely being the only one to input information for their team into the laptop. By assuming the participatory role of team captain (Cohen, 1994), Sasha was able to manage the intellectual workspace by privileging her own ideas as "correct" and taking up Lily's suggestions for deciphering messages as she deemed appropriate. For example, Lily suggested changing the C to S in the Caesar Cipher. But before she could get her ideas out, Sasha interrupted Lily's think-aloud to make the change she deemed appropriate (Line 7, Excerpt 4).

<INSERT EXCERPT 5 HERE>

Excerpt 5 corroborates this claim, offering evidence of Sasha negotiating her position of power by instructing Lily to write down letters from the screen—as if Lily were her secretary—while she continued the intellectual work of deciphering a message (Line 7). Lily assumed the role of secretary as a response, acting as scribe by writing down team responses in the task packet (see Excerpt 6).

<INSERT EXCERPT 6 HERE>

Lily assumed the intellectual role of questioner (Herrenkohl, 2006) in addition to her participatory role as secretary. As an onlooker to Sasha's control of the input, Lily asked Sasha a steady stream of questions, or comments that functioned as questions, which kept the team moving forward productively with the task. In contrast, Sasha—continuing to act as team captain— consistently interrupted Lily when she was speaking (e.g., Line 7, Excerpt 4). It happens again in Excerpt 7 when the instructor asked the team to explain how they cracked one of the enciphered messages. Lily made an utterance that suggested she wanted to respond. Before she could say anything of substance, Sasha interrupted Lilly by attributing their success to "brains" (Line 3, Excerpt 7).

<INSERT EXCERPT 7 HERE>

It is reasonable to think that Sasha meant *her* brains, as we found evidence of her consistent use of "I" language. In so doing, Sasha positioned herself singularly as the one who moved the pair forward with the Caesar Cipher. Phrases like "I'll do it again" (Line 3, Excerpt 5) or "Let me try that one now" (Line 9, Excerpt 5) or "I need to change that." (Line 7, Excerpt 4) show continued evidence of Sasha's assumed role of team captain and of her control of the joint thinking tool. As with our interpretation of Jasmine's interactions toward Becky, we remain cautious about overstating Sasha's intentions and do not claim that Sasha was aware of her subtle power moves of dominance. Nevertheless Sasha's verbal and non-verbal communicative acts of power indicated that Lily had lower status in the group. In the case of Lily and Sasha, analyses showed that Sasha was the dominant partner and often assumed higher intellectual status within her team, also reified by her control of the team's laptop. Sasha's benign dominance, however, did not have noticeable effects on the team's productivity and mutual intellectual engagement in the task at hand.

Summary of Findings

Taken together, our analysis of the cases of Becky & Jasmine and Lily & Sasha showed how their partner interactions around technology tools during the Cryptography Challenge reified fragmented and connected figured worlds, respectively. The ways in which the campers interacted around the laptops and iPod devices reified their participation patterns and status orderings within their partner team. These predominantly non-verbal interactions impacted their productivity and opportunities for learning. In the fragmented figured world, one female used the technological tools to reify her position as the dominant member. This resulted in the pair working individually to complete the assigned mathematical task and seemed to limit the knowledge gained from engaging with the task. In the connected figured world, the technological devices became joint thinking tools. Although evidence of a status imbalance was present, it did not negatively impact their collaborative engagement and learning.

Discussion

The purpose of our study was to examine partner interactions around "shared" technological devices in an all-girls CSCL informal environment, and what these interactions disclosed about partner participation, status, and productivity (e.g, Leander, 2002a, 2002b). We conceptualized our cases using figured worlds (Holland et. al, 1998) because of our interest in linking these findings to partner productivity, which has direct implications on student access to learning mathematics in CSCL environments (Jurow, 2005). Camper interactions around the laptop and iPod device reified partner participation, status, and productivity, highlighting shared technology resources as an important mediating factor on participation and status. This insight extends scholarship regarding factors that matter for learning mathematics such as the task (Kapur & Kinzer, 2007) or assignment of group roles (Strijbos et al., 2007). In what follows, we summarize the cases of Becky & Jasmine and Lily & Sasha, and then discuss how participation and status issues around the shared technological devices provided each girl with an opportunity for learning about mathematics – or not.

Summary: the case of Becky and Jasmine

We used the term "fragmented" to depict how Jasmine and Becky negotiated a figured world in which they completed work individually despite expectations for collaboration and sharing technology resources required for the cryptography challenge. This was evidenced in part by the way Jasmine reified her dominant position through establishing herself as gatekeeper of the laptop and iPod—creating a boundary and positioning the technological resources toward her, away from Becky's line of sight, and storing them out of Becky's reach when not in use. This was further evidenced by Jasmine's positioning herself as the expert within the pair and by the ease with which she invaded Becky's personal space. These findings illustrate the effects of student status (Cohen & Lotan, 1995)—the unspoken pecking order regarding whose ideas are most valued within the group—on student engagement in complex problem-solving tasks. Jasmine's dominance and "uninviting" behaviors crippled the pair's productivity and Becky's participation as a contributing member or problem solver of the complex mathematical task.

We find it imperative to directly acknowledge the strong likelihood that race, a well-documented, known diffuse status characteristic, contributed to Jasmine and Becky's fragmented figured world (e.g., Cohen & Lotan, 1995, Esmonde & Langer-Osuna, 2013; Reyes & Stanic, 1988). Following Danny Martin's (2006) lead, "race is viewed here as socially, politically, and relationally constructed so that issues of marginalization, power, dominance, and devalued social status assume prominence" (p. 198). It is not our intention to ignore this factor or hide its salience. We agree with scholarly work that conceptualizes learning and participation, especially within the disciplinary context of mathematics, as racialized forms of experience (Martin, 2006; 2009). In fact, we believe that the findings from our analysis of this case—that the pair's "shared" technology resources reified the CSCL environment as a racialized form of experience (Martin, 2006; 2009)—negatively impacted Jasmine and Becky's participation and productivity, thereby adding corroborating evidence to this large body of influential research. Neither our research questions, nor the data we collected and analyzed, allow us to make definitive claims in this arena, although the emergent importance of race on our findings is compelling.

Summary: the case of Lily and Sasha

We used the term "connected" to depict how Lily and Sasha negotiated a figured world in which they negotiated a shared collaborative problem-solving space around the Caesar Cipher task. Although Lily and Sasha's interactions appeared genuinely positive, their figured world was not void of power negotiations and subtle moves of dominance. Lily and Sasha assumed participatory and intellectual roles within the group, with Lily as scribe and questioner and Sasha as team captain. The positioning and collaborative use of the laptop reified their imbalance of power, although in absence of fine-grained interaction analysis this finding may have been overlooked given the subtlety of their negotiations and outward appearances of productivity and collegiality. These findings again illustrate the effects of student status (Cohen & Lotan, 1995) on student engagement in complex problem-solving tasks, serving as an important reminder that negotiations of power and status are always at play. These findings suggest that observed interactions around shared technology resources may act as indicators for power dynamics and status orderings within the group, which is especially helpful in cases where uneven differences are less obvious.

Opportunities for Learning

Learning mathematics in technology-rich, CSCL environments has the capacity to strengthen students' sense-making, reasoning, communication, and collaboration skills, thereby increasing the cognitive demand of the mathematical work at hand. However, scant attention has been paid to the ways in which students negotiate technology usage in collaborative spaces, leaving room for subtle, predominantly non-verbal enactments of status problems that negatively impact student learning experiences. In this study, we utilized the framework of figured worlds to gain an understanding of the role of status and participation on learning mathematics (Esmonde & Langer-Osuna, 2011; Jurow, 2005).

Within the fragmented figured world, we contend that Jasmine's use of the technological tools to establish and maintain her position of power created a boundary to the mathematics within the fragmented figured world. We are convinced that Becky did not make progress on the cryptography challenge because Jasmine withheld necessary resources from her; Becky was not able to decipher the message because the only tool Jasmine "shared" was the iPod, which was only useful for copying down the string of numbers in the message. We remain unconvinced that Becky learned important mathematics by copying letters and numbers from Jasmine's handout. On the other hand, there is some evidence that Jasmine may have met the intended learning goals from the cryptography challenge, such as in her interactions with adult "experts" about the mathematics of the task and her attempts to use her "expert knowledge" to help Becky. As a result, Jasmine's assertion of status and dominance over Becky afforded her with more resources and opportunities to learn (Cobb & Hodge, 2002; Esmonde & Langer-Osuna, 2013; Reyes & Stanic, 1988).

Within the "connected" figured world, we claim that through the shared intellectual space, both Lily and Sasha exhibited indicators of learning as they pushed each other forward in meeting the intended goal of the task. This was in spite of Sasha's asserted position as team captain. For Lily, we believe that she would be able to decipher an encrypted message using the online tool on her own. She was observed posing questions, analyzing mistakes, and providing suggestions to Sasha regarding output on the laptop. Sasha, on the other hand, was the driver of input and commonly vocalized her thoughts and conjectures regarding the task. Moreover, we have evidence of Sasha explaining to the lead instructor the possible number of Caesar Cipher keys, as well as how there are only two letters that can be a single letter, namely I and A.

Implications for design and instruction

With the increase of computer science and maker-related (e.g., Kalelioğlu, 2015Peppler et al., 2014) programs, this study has implications for the design and implementation of informal programs with a focus on collaborative learning around various technological tools. Additionally, the insight from this study has important implications for collaborative work in K-12 and postsecondary schools (Barron, 2006, Hirsch, 2007; Lai et al., 2013) given the rise of bring your own device initiatives (e.g., Song, 2014) and one-to-one classrooms (e.g., Lei & Zhao, 2008; Penuel, 2006). These findings suggest that observed interactions around shared technology resources may act as indicators for power dynamics and status orderings within the group, giving educators a window into mediating factors that impact individual student learning within the collaborative group setting.

While designed interventions in a CSCL environment were beyond the scope of this study, we find that research on complex instruction (CI) offers helpful conceptual and practical intervention strategies because CI explicitly attends issues of power and status in collaborative settings (Cohen, 1994, Featherstone, Crespo, Jilk, Oslund, Parks, & Wood, 2011; Horn, 2012; Nasir, Cabana, Shreve, Woodbury, & Louie, 2014). As an example, while circulating around the room, educators are encouraged to assign competence to low-status students whose contributions are not being heard by their partner or group members (Cohen & Lotan, 1995, 1997). In assigning competence, educators publicly acknowledge the genuinely intellectual contribution made by the student that was relevant to the task at hand. An instructor might say, "I noticed you experimenting with different number and letter combinations for the deciphering challenge. The way you organized your ideas on paper is going to help the group notice a pattern so that you can crack the code. Team, take a look at the way she experimented with these combinations and use that to help you with the next part of the task." Another powerful strategy documented in the CI literature involves a multiple-ability orientation, where educators point out the abilities that will be needed in the task—e.g., experimenting, tinkering, using computers as dynamic thinking tools—followed by a public statement that no one will be good at everything but everyone will be good at something and be able to contribute to the task (Cohen, Lotan, Scarloss, & Arellano, 1999). Lastly, educators should attend to the position of the technological devices and tools and take an active role in shifting devices and tools to the center of the intellectual workspace. In doing so, educators are using their power as an evaluator to catalyze productive shifts in power within the small group (Cohen, 1994).

Future research

Our findings corroborate existing claims that providing students with technological devices to utilize as collaborative tools is a necessary but insufficient condition for generating productive academic learning environments (e.g., Chavez & Romero, 2012; Järvelä & Hadwin, 2013; Sinha et al., 2015). Given increasing expectations for student collaboration in CSCL learning environments, our field would benefit from studies that investigate relationships between observed interactions around shared technology resources and issues of power, status orderings, participation, and learning. Studies of this nature, for example, could generate observation instruments that can be used to make issues of power, status, and participation more visible and to test different classroom intervention strategies that minimize the effects of status on productivity on learning.

Next, the diffuse status characteristic of race emerged as important for analyzing the fragmented figured world case, and our findings were limited by not having data that allowed us to respond to this issue with our analysis. We mean to suggest that the "shared" technology resources in this case reified the CSCL environment as a racialized form of experience (Martin, 2006; 2009), which has major implications for equitable student learning in CSCL environments. It is urgent that future research directly attends to issues of race so that honest accountings of marginalization, dominance, and power become an explicit part of the conversation in extant literature.

Conclusion

The purpose of our study was to examine partner interactions around "shared" technological devices in an all-girls CSCL informal environment, and what these interactions disclosed about partner participation, status, and productivity (e.g, Leander, 2002a, 2002b). We conceptualized our cases using figured worlds (Holland et. al, 1998) because of our interest in linking these findings to partner productivity, which has direct implications on student access to learning mathematics in these spaces (Jurow, 2005). Camper interactions around the laptop and iPod device reified partner participation, status, and productivity, highlighting shared technology resources as an important mediating factor on participation and status, extending scholarship about factors that matter for learning (e.g., mathematical task (Kapur & Kinzer, 2007), assignment of group roles (Strijbos et al., 2007)). Our analysis showed that interactions around technology reified uneven participation patterns, unequal status orderings, and an imbalance of power in both of the comparison cases, although the effects of these power dynamics had differential effects on productivity. Our results therefore have direct implications for student opportunities to learn in CSCL learning environments, as questions remain about the converse of our findings. Race emerged as a diffuse status characteristic in our analysis, which suggests a need for research that investigates CSCL environments as racialized forms of experience. Rather than avoiding issues of power, understanding the complexity of race on small group dynamics in CSCL environments is key.

Appendix

<INSERT TABLE 2 HERE>

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References

Arvaja, M., Häkkinen, P., & Kankaanranta, M. (2008). Collaborative learning and computer-supported collaborative learning environments. In J Voogt & G. Knezek (Eds.), *International handbook of information technology in primary and secondary education* (pp. 267-279). New York, NY: Springer Science+Business Media, LLC.

Azevedo, H. J., Scalabrin, E. E., Faria, M. D. P., & Manfroi, F. (2004). Implementing agents for a collaborative online learning environment. *Journal of Computer Science & Technology*, *4*(2), 98-104.

Baker, M., Bernard, F. X., & Dumez‐Féroc, I. (2012). Integrating computer‐supported collaborative learning into the classroom: The anatomy of a failure. *Journal of Computer Assisted Learning*, *28*(2), 161-176. doi: 10.1111/j.1365-2729.2011.00435.x

Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecology perspective. *Human Development, 49*, 193-224. doi: 10.1159/000094368

Barron, B. (2003). When smart groups fail. *The Journal of the Learning Science, 12*(3), 307-359.

Barros-Castro, R. A., Córdoba-Pachón, J. R., & Pinzón-Salcedo, L. A. (2014). A systemic framework for evaluating computer-supported collaborative learning—mathematical problem-solving (CSCL-MPS) initiatives: Insights from a Colombian case. *Systemic Practice and Action Research*, *27*(3), 265-285. doi: 10.1007/s11213-013-9279-7

Bento, R., & Schuster, C. (2003). Participation: The online challenge. In A. Aggarwal (Ed.), *Web-Based Education: Learning from Experience* (pp. 156-164). Hersey, PA: Information Science Publishing.

Bishop, J. P. (2012). “She’s always been the smart one. I’ve always been the dumb one”: Identities in the mathematics classroom. *Journal for Research in Mathematics Education, 43*(1), 34-74.

Chavez, J., & Romero, M. (2012). Group awareness, learning, and participation in Computer Supported Collaborative Learning (CSCL). *Procedia-Social and Behavioral Sciences*, *46*, 3068-3073.

Cobb, P., & Hodge, L. L. (2002). A relational perspective on issues of cultural diversity and equity as they play out in the mathematics classroom. Mathematical Thinking and Learning, 4(2-3), 249–284. doi:10.1207/S15327833MTL04023_7

Cohen, E. G. (1994). *Status treatments for the classroom* [Video]. New York, NY: Teachers College Press.

Cohen, E. G., & Lotan, R. A. (1995). Producing equal-status interaction in the heterogeneous classroom. *American Educational Research Journal, 32*(1), 99-120.

Cohen, E. G., & Lotan, R. A. (Eds.). (1997). *Working for equity in heterogeneous classrooms: Sociological theory in practice*. New York: Teachers College Press.

Cohen, E. G., Lotan, R. A., Scarloss, B. A., & Arellano, A. R. (1999). Complex Instruction: Equity in cooperative learning classrooms. *Theory Into Practice, 38*(2), 80–86.

Correll, S. J., & Ridgeway, C. L. (2003). Expectation states theory. In J. Delamater (Ed.), *Handbook of Social Psychology* (pp. 29-51). New York, NY: Kluwer Academic.

Crypto Club Project & Eduweb. (n.d.). *Caesar cipher.* Retrieved from www.cryptoclub.org/tools/caesar_cipher.php

Dierking, L. D., Falk, J. H., Rennie, L., Anderson, D., & Ellenbogen, K. (2003). Policy statement of the "informal science education" ad hoc committee. *Journal of Research in Science Teaching*, *40*(2), 108-111. doi: 10.1002/tea.10066

Dillenbourg, P., Järvelä, S., & Fischer, F. (2009). The evolution of research on computer-supported collaborative learning: From design to orchestration. In N. Balacheff, S. Ludvigsen, T. de Jong, A. Laxonder, & S. Barnes (Eds.), *Technology-enhanced learning* (pp. 3-19). Springer Netherlands.

Dillenbourg, P. (1999). What do you mean by 'collaborative learning'? In P. Dillenbourg (Ed.), *Collaborative-learning: Cognitive and Computational Approaches* (pp. 1-19). Oxford: Elsevier.

Emerson, R. M., Fretz, R. I., & Shaw, L. L. (1995). *Writing ethnographic fieldnotes*. Chicago: University of Chicago Press.

Esmonde, I., & Langer-Osuna, J. M. (2013). Power in numbers: Students participation in mathematical discussions in heterogeneous spaces. *Journal for Research in Mathematics Education, 44*(1), 288-315.

Featherstone, H., Crespo, S., Jilk, L. M., Oslund, J. A., Parks, A. N., & Wood, M. B. (2011). *Smarter together! Collaboration and equity in the elementary math classroom*. National Council of Teachers of Mathematics, Reston, VA.

Greenhow, C., & Robelia, B. (2009). Informal learning and identity formation in online social networks. *Learning, Media, and Technology, 34*(2), 119-140. doi: 10.1080/17439880902923580

Hakkarainen, K., & Palonen, T. (2003). Patterns of female and male students' participation in peer interaction in computer-supported learning. *Computers & Education*, *40*(4), 327-342.

Herrenkohl, L. R. (2006). Intellectual role taking: Supporting discussion in heterogeneous elementary science classes. *Theory into Practice*, *45*(1), 47-54.

Hirsch, D. (2007). *Experiences of poverty and educational disadvantage*. Joseph Rowntree Foundation.

Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (1998*). Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.

Holland, D., & Leander, K. (2004). Ethnographic studies of positioning and subjectivity: An introduction. *Ethos, 32*(2), 127-139

Horn, L. (2012). *Strength in numbers: Collaborative learning in secondary mathematics.* Reston, VA: NCTM.

Janssen, J., Erkens, G., Kanselaar, G., & Jaspers, J. (2007). Visualization of participation: Does it contribute to successful computer-supported collaborative learning?. *Computers & Education*, *49*(4), 1037-1065. doi:10.1016/j.compedu.2006.01.004

Järvelä, S., & Hadwin, A. F. (2013). New frontiers: Regulating learning in CSCL. *Educational Psychologist*, *48*(1), 25-39. doi: 10.1080/00461520.2012.748006

Jordan, B., & Henderson, A. (1995). Interaction analysis: foundations and practice. *The Journal of the Learning Sciences, 4*(1), 39-103.

Jurow, A. S. (2005). Shifting engagements in figured worlds: Middle school mathematics students' participation in an architectural design project. *The Journal of the Learning Sciences, 14*(1), 35-67.

Kalelioğlu, F. (2015). A new way of teaching programming skills to K-12 students: Code.org. *Computers in Human Behavior*, *52*, 200-210.

Kapur, M., & Kinzer, C. K. (2007). Examining the effect of problem type in a synchronous computer-supported collaborative learning (CSCL) environment. *Educational Technology Research and Development*, *55*(5), 439-459. doi: 10.1007/s11423-007-9045-6

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in Human Behavior*, *19*(3), 335-353.

Lai, K. W., Khaddage, F., & Knezek, G. (2013). Blending student technology experiences in formal and informal learning. *Journal of Computer Assisted Learning*, *29*(5), 414-425. doi: 10.1111/jcal.12030

Langer-Osuna, J. M. (2015). From getting “fired” to becoming a collaborator: A case of the coconstruction of identity and engagement in a project-based mathematics classroom. *Journal of the Learning Science, 24*(1), 53-92. doi: 10.1080/10508406.2014.944643

Leander, K. M. (2002a). Silencing in classroom interaction: Producing and relating social spaces. *Discourse Processes, 34*(2), 193-235. doi: 10.1207/S15326950DP3402_4

Leander, K. M. (2002b). Locating Layanya: “The situated production of identity artifacts in classroom interaction. *Research in the Teaching of English, 37*(2), 198-250.

Lei, J., & Zhao, Y. (2008). One-to-one computing: What does it bring to schools?. *Journal of Educational Computing Research*, *39*(2), 97-122.

Lipponen, L., Rahikainen, M., Lallimo, J., & Hakkarainen, K. (2003). Patterns of participation and discourse in elementary students' computer-supported collaborative learning. *Learning and Instruction*, *13*(5), 487-509. doi:10.1016/S0959-4752(02)00042-7

Martin, D. B. (2006). Mathematics learning and participation as racialized forms of experience: African American parents speak on the struggle for mathematics literacy. *Mathematical Thinking and Learning, 8*(3), 197–229. doi:10.1207/s15327833mtl0803_2.

Martin, D. B. (2009). Liberating the production of knowledge about African American children and mathematics. In D. B. Martin (Ed.), *Mathematics teaching, learning, and liberation in the lives of Black children* (pp. 3–38). London: Routledge.

Nasir, N., Cabana, C., Shreve, B., Woodbury, E., and Louie, N. (2014). *Mathematics for equity: A framework for successful practice*. New York: Teachers College Press.

National Science Foundation [NSF]. (2015). *Women, minorities, and persons with disabilities in science and engineering.* Retrieved from http://www.nsf.gov/statistics/2015/nsf15311/digest/nsf15311-digest.pdf

Ochs, E. (1979). Transcription as theory. In E. Ochs (Ed.), *Developmental Pragmatics* (pp. 43-72). New York, NY: Academic Press.

Olson, J. K., & Clough, M. P. (2013). A cautionary note. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, *75*(1), 8-13. doi: 10.1080/00098650109599225

Penuel, W. R. (2006). Implementation and effects of one-to-one computing initiatives: A research synthesis. *Journal of Research on Technology in Education*, *38*(3), 329-348. doi: 10.1080/15391523.2006.10782463

Peppler, K., Maltese, A., Keune, A., Chang, S., & Regalla, L. (2014). *Survey of Makerspaces, Part II.* Retrieved at http://makered.org/open-portfolios-survey-of-makerspaces-part-ii/

Prinsen, F. R., Volman, M. L. L., & Terwel, J. (2007). Gender-related differences in computer-mediated communication and computer-supported collaborative learning. *Journal of Computer Assisted Learning*, *23*(5), 393-409. doi: 10.1111/j.1365-2729.2007.00224.x

Renninger, K. A., & Shumar, W. (2002). Community building with and for teachers: The Math Forum as a resource for teacher professional development. In K. A. Renninger & W. Shumar (Eds.), *Building virtual communities: Learning and change in cyberspace* (pp. 60–95). New York, NY: Cambridge University Press.

Renninger, K. A., & Shumar, W. (2004). The centrality of culture and community to participant learning at and with the Math Forum. In S. A. Barab, R. Kling, & J. H. Gray (Eds.), *Designing for Virtual Communities in the Service of Learning* (pp. 181–209). New York, NY: Cambridge University Press.

Reyes, L. H., & Stanic, G. M. A. (1988). Race, sex, socioeconomic status, and mathematics. *Journal for Research in Mathematics Education, 19*(1), 26-43.

Rivest, R.; Shamir, A.; Adleman, L. (1978). A method for obtaining digital signatures and public-key cryptosystems. *Communications of the ACM, 21*(2), 120-126.

Salomon, G., & Globerson, T. (1989). When teams do not function the way they ought to. *International Journal of Educational Research*, *13*(1), 89-99.

Salovaara, H. (2005). An exploration of students' strategy use in inquiry-based computer-supported collaborative learning. *Journal of Computer Assisted Learning*, *21*(1), 39-52.

Shaw, R. S. (2013). The relationships among group size, participation, and performance of programming language learning supported with online forums. *Computers & Education*, *62*, 196-207. doi: 10.1016/j.compedu.2012.11.001

Shell, D. F., Husman, J., Turner, J. E., Cliffel, D. M., Nath, I., & Sweany, N. (2005). The impact of computer supported collaborative learning communities on high school students' knowledge building, strategic learning, and perceptions of the classroom. *Journal of Educational Computing Research*, *33*(3), 327-349.

Sinha, S., Rogat, T. K., Adams-Wiggins, K. R., & Hmelo-Silver, C. E. (2015). Collaborative group engagement in a computer-supported inquiry learning environment. *International Journal of Computer-Supported Collaborative Learning*, *10*(3), 273-307. doi: 10.1007/s11412-015-9218-y

Song, Y. (2014). 'Bring your own device (BYOD)' for seamless science inquiry in a primary school. *Computers & Education, 74*, 50–60. doi: 10.1016/j.compedu.2014.01.005

Stahl, G., Koschmann, T., & Suthers, D. (2006). Computer-supported collaborative learning: An historical perspective. In R. K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 409-426). New York, NY: Cambridge University Press.

Strijbos, J. W., Martens, R. L., Jochems, W. M., & Broers, N. J. (2007). The effect of functional roles on perceived group efficiency during computer-supported collaborative learning: a matter of triangulation. *Computers in Human Behavior*, *23*(1), 353-380. doi:10.1016/j.chb.2004.10.016

Waight, N., & Abd-El-Khalick, F. (2007). The impact of technology on the enactment of "inquiry" in a technology enthusiast's sixth grade science classroom. *Journal of Research in Science Teaching*, *44*(1), 154-182. doi: 10.1002/tea.20158

Wang, S. L., & Lin, S. S. (2007). The effects of group composition of self-efficacy and collective efficacy on computer-supported collaborative learning. *Computers in Human Behavior*, *23*(5), 2256-2268.

Webb, N. M., Ing, M., Kersting, N., & Nemer, K. M. (2006). Help seeking in cooperative learning groups. In S. A. Karabenick (Ed.), *Strategic help seeking: Implications for learning and teaching* (pp. 45–115). Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

White, T. (2006). Code talk: Student discourse and participation with networked handhelds. *International Journal of Computer-Supported Collaborative Learning*, *1*(3), 359-382. doi: 10.1007/s11412-006-9658-5

Winters, F. I., & Alexander, P. A. (2011). Peer collaboration: The relation of regulatory behaviors to learning with hypermedia. *Instructional Science*, *39*(4), 407-427.|

Wolfram Alpha LLC. (2016). *Wolfram|Alpha.* Retrieved from www.wolframalpha.com/

Zurita, G., & Nussbaum, M. (2004). Computer supported collaborative learning using wirelessly interconnected handheld computers. *Computers & Education*, *42*(3), 289-314. doi:10.1016/j.compedu.2003.08.005

Legends.

Figure 1. Jasmine controls technology; Becky acts busy.

Figure 2. Invasion of Becky's intellectual space.

Figure 3. Illustration of the shared intellectual space of Lily and Sasha.

Figure 4. Lily as scribe and Sasha as team captain.

Captions.

Table 1 Participant information

Table 2 Example of the five-column format