Talk, Tech, and Togetherness: Ethnographic Insights into Siding in Introductory Undergraduate Computer Science

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Abstract

Due to large enrollments, undergraduate computer science (CS) courses often incorporate lectures that can scale to many students. However, there is strong evidence that students learn best through active meaning-making, particularly in collaboration with others. In this paper, we explore how students seek out opportunities to learn collaboratively during class time in a large introductory CS (CS1) course and how pedagogical decisions can create opportunities for such collaboration. We use an ethnographic approach to observe natural student interactions in a CS1 class, contributing to limited research exploring CS classroom activity through ethnographic observation. We find that students engage in frequent siding (i.e., side-talk and other backchanneling during class) to address their in-the-moment learning needs for clarification, tutoring, and support with debugging, as well as to co-construct new understandings and connect with others. We also find that students can meet some of these needs by siding with digital tools. From this, we introduce the concept of digital siding, in which a student turns to the Internet or AI to achieve a goal rather than a peer, and discuss benefits and drawbacks of peer and digital siding. Our data shows that siding happens often and serves important learning needs, providing a way for students to actively engage in learning despite the large scale of CS1. Therefore, we argue that instructors should not view siding purely as a distraction and provide design recommendations to help instructors promote siding in ways that support learning.

CCS Concepts

• **Social and professional topics → CS1**.

Keywords

CS1, ethnography, classroom discourse, classroom collaboration

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1 Introduction

Collaboration is an important part of professional computer science (CS) work, which has made incorporating collaborative learning opportunities a goal for CS education [26, 29]. Yet, this can be challenging to accomplish in undergraduate CS courses, where lecture is often a primary method of instruction [18] and large enrollments may make managing collaborations difficult [53]. To better understand how to design for collaboration in CS classes with these attributes, we can learn from how students naturally collaborate when their interactions are not actively orchestrated by an instructor.

One example of this phenomenon is *siding* [31], or side conversations that happen in parallel to an instructor's talk. Siding is sometimes framed as unconnected to and potentially disruptive of CS learning (e.g., [21]). However, while siding is sometimes off-task, research that focuses explicitly on siding has found that it is an integral part of classrooms [31] and can be supportive of learning, since it creates opportunities for students to bring abstract academic content to a more personal level [2] and spread disciplinary ideas [45]. Siding has also been found to foster classroom community [4, 31]. In this way, students' self-directed siding can provide a unique window into the kinds of collaborative support students need at the time it is needed. Further, as using digital tools is a key part CS learning, it will be important to understand the role these tools play in these student interactions, especially as new tools like generative AI (GenAI) may be impacting students' collaboration patterns [23]. Understanding how CS students side and which aspects of a course's design afford particular siding interactions can help us understand if and how to design CS learning environments that support siding as a way of integrating collaboration into lectures.

Although siding can help us understand how, when, and why students seek additional collaborative interactions, studying it is methodologically challenging, which may partly explain why it has received limited scholarly attention. Some researchers have asked students to self-report their siding (e.g., [2]), but students may not remember or wish to disclose the frequency and contents of their side conversations, since side-talk is, by nature, private and not officially allowed. Other researchers have used audio and video recording to capture rich descriptions of siding in naturalistic settings (e.g., [4, 27, 45]), though it can still be difficult to capture whispered conversations with audio recorders [27]. Siding has not been directly studied in the undergraduate CS context, which is surprising since CS courses often include lecture-based components that could make siding significant "as an outlet for other voices" [2]. While research has characterized students' activity in an undergraduate CS class (e.g., [5]), this work often centers on students' overt participation, or "remarks or questions directed toward the instructor" [63].

To address these gaps, we report on ethnographic observations of 14, 50-minute sessions of an introductory, undergraduate CS course (CS1) and associated field notes. The research question guiding these observations was: "How do students collaboratively learn in CS1?" Our ethnographic approach enabled us to capture students' informal classroom interactions and, through our analysis, identify and focus on siding as a core activity in CS1. In this paper, we (1) present a typology of seven types of siding activities, (2) examine how these different types of siding support collaborative learning and community, and (3) explore how the design of classroom structures creates conditions for siding to emerge. Our analysis shows that students engage in similar types of siding with digital tools as with their peers, leading us to offer the concept of *digital siding*, our term for students' interactions with digital tools like GenAI and the Internet to the side of a main class activity. We also found that peer and digital siding led to qualitatively different learning experiences, which helps us understand what collaborations might be better served by peers, technology, or both. In the discussion, we argue that siding should be taken seriously as a site of generative, collaborative learning. Doing so can give us a broader understanding of how students actively make meaning during a CS class, helping us see students' participation beyond activities like raising their hands and asking questions. Finally, we point to concrete ways instructors and designers of digital tools might enable siding in ways that minimize disruptions to others and support learning.

2 Background and Related Works

2.1 Collaborative Learning in CS

Though collaborative learning is difficult to define, we might start from broadly understanding it as "a *situation* in which *two or more* people *learn* or attempt to learn something *together*" [11]. Evidence shows that collaborative learning can be particularly useful for helping students learn to program [34], a finding that aligns with foundational education research theorizing that knowledge is created among groups of learners through interaction and communication [46, 60]. Beyond the cognitive benefits, integrating collaborative learning into classrooms has also been found to support more equal student participation by helping shift competitive class cultures toward being more mutually supportive [55].

However, the term collaborative learning can encompass many types of interactions. We draw on Dillenbourg's work to attend to how learning collaborations vary along dimensions like (1) scale, in terms of group size and time span, (2) the "learning" that happens, from situations involving collaborative learners (e.g. sharing course assignments) to joint problem solving to development in a community of practice, and (3) what is referred to as "collaboration," or the degree of symmetry between participants, degree of interactivity, learning mechanisms, and effects of the collaboration [11]. Collaborations can also vary by the actors involved, including as human collaborators incorporate digital tools [11]. There is also a large precedent of work in human-computer interaction that understands how humans can meaningfully interact with digital tools (e.g. [43]), and more recent work in human-AI interaction has sought to understand the possibility of collaborations existing between a human and these tools (e.g. [62]). Investigating these elements helps us understand how different interactions between students and with digital tools might support collaborative learning.

Much of what we know about collaborative learning in CS comes from studying structured collaborations, especially pair programming [53]. Pair programming is a process where students take turns programming on a single computer, switching between "driver" and "navigator" roles, and is one of the most commonly used methods of structuring collaborations in CS classrooms [54]. Research on pair programming has found positive effects on students' performance [20, 57], sense of belonging [67], and self-confidence in their programming abilities [9, 19, 20]. Collaboration has also been studied in CS through process oriented guided inquiry learning (POGIL), in which students collaboratively solve problems. Students pass POGIL courses at higher rates [61] and self-report increased learning and collaborative skills [66]. However, research has found that collaboration in CS classrooms often happens in informal and unstructured ways [37, 53]. Despite this, researchers have pointed to a gap in work examining informal and unstructured collaborative learning in CS [37]. Understanding these informal collaborations is important, as "effective learning is more likely to occur when learning environments are designed to align with how people learn in everyday and informal settings" [40].

Although there are many reported benefits to collaborative learning, large enrollments in introductory classes at the university level often lead to lecture being used as the primary mode of instruction [18]. Even in CS courses where collaboration is integrated and collaborative learning is an active instructional goal, collaborations often take the form of group time to work on problems interspersed with lecture [37]. Instructors also often encounter practical barriers when implementing collaborative learning, like difficulties in managing students' interpersonal interactions and ensuring students have opportunities to learn [53]. Given this reality, we suggest that looking at how students already self-direct their collaborations in CS classes can be a lightweight way to integrate more collaboration into large classes that use lectures.

2.2 In-Class Interactions and Siding

2.2.1 *Students' In-Class Interactions with Other Students.*

Our focus on students' self-directed interactions stems from sociocultural theories of learning, which have long been used by learning scientists to understand learning as a process that is essentially communicative and that happens through a learner's interaction with the people and environment around them [44, 60]. We particularly draw on the sociocultural theory of communities of practice [64], which understands that the community in which learning is situated shapes *what* is learned and *how*. This helps us to understand each student in a CS classroom as contributing to a *negotiation of meaning*, where as they participate by interacting with other members of the classroom community, these interactions are also shaped by things like the organization of the classroom, what the instructor is saying, and what students have worked on before. While studies on the role of communication in classroom learning often focus on teacher-led or structured group interactions [27], student-led forms of communication, like "off-task talk," have been a site of rich understanding for socioculturally-oriented learning sciences researchers (e.g., [30]).

In this paper, we focus on the student-led discourses that emerge when students interact with one another in parallel to the main learning activity. In the research that exists on this kind of communication, it has been called many things, including side-talk, backchanneling [4], covert interaction [45], parallel activities [27], and siding [2, 31]. Importantly, none of this research has taken place in a CS context. We will use the term siding in this paper, aligning ourselves with other researchers who intend for this term to include the many kinds of interactions that happen "to the side" of a main learning activity, like side talk, passing notes, and gestures [2]. As with Antia, we use the term siding to convey the "idea of an unauthorized or discreet practice… [without] assumptions of topical (ir)relevence" [2].

Across the research that focuses directly on siding, benefits for student learning have been found. While acknowledging that siding can be a distraction and that "students do not always use good judgment in deciding when they must say something" [31], Lemke argues that forbidding siding would foreclose opportunities for students to engage and practice using disciplinary language. Others also found that siding helped students try out disciplinary ideas and spread them among their peers during whole class discussions [45] and connect their lived experiences with abstract academic content [2]. Siding also helps to develop learning communities at the K-12 [31] and university level [4].

Studies have also identified a few mechanisms through which siding emerges. In a study on siding that happens in a different language than the language of instruction, intricate chains of antecedents shaped how and when students sided, including concern for discretion and relationships between students [2]. Further, students have been found to maintain an orientation around the main activity of the class across a variety of "parallel activities" [27]. Still, there has been less detailed study of how a teacher might set up a class to allow space for siding, particularly at the undergraduate level where siding may be an important way for students to share their voices [2].

2.2.2 Students' In-Class Interactions with Digital Tools. As digital tools are increasingly integrated into classrooms, it is important to understand how students' interactions with these tools shape their learning. Students' in-class technology use is often understood to be a distraction, particularly as research has found that students who multitask on laptops perform worse on recall tasks (e.g. [22, 38]). However, recognizing that classroom technology is integral to university-level CS learning and that digital tools will remain in these classes, we instead seek to better understand *how* students use these tools during class. Siding may be a useful lens to apply to study this phenomenon; similar to students' classroom technology use, siding is also commonly thought of as a distraction—yet, a closer look reveals that siding has many functions, many of which enable students to participate in classroom learning [27].

Understanding students' interactions with digital tools as siding has some precedence. Siding has been understood to be inclusive of non-verbal behavior [27], establishing that siding is not restricted to peer-to-peer *talk*. Research on siding has also included passing notes written on paper [2] or digital screens [2, 8], showing how digital tools can facilitate peer interactions that allow students to extend class discussions [8]. Students' smartphone use also opens new forms of parallel participation by enabling them to integrate digital tools into their side talk with peers by referring to digital content and to interact with people who are not physically co-present in the classroom [52]. However, these works focus on digital tools as communication channels that enable peer siding, or as shaping the conversational subject of peer siding. In other words, a single student interacting with a technology to do something other than communicating with another human has not yet explicitly been understood as a form of siding. However, in a field like CS where interactions with digital tools are a key part of learning, and as new tools like GenAI increasingly take on interactive and possibly collaborative roles [62], we argue that it can be valuable to take this perspective.

2.3 Ethnographic Observation Methods in CS Education Research

Ethnographic observation is a method that is not often used in CS education research, though it does have precedence. Of the ethnographic observation studies that do employ this method in the context of CS, it has been applied at various scopes: understanding structural barriers to equitable participation in CS [36], teaching practices [14, 50], and student engagement and process in organized class activities and projects [24, 51, 65]. These studies richly illustrate the experiences of students and teachers in CS learning environments that can shape students' CS trajectories.

More closely related to the aims of the present work, one study employed ethnographic observation to explore classroom discourse, focusing on how students' overt participation contributes to classroom climate in CS [5]. This method enabled the researchers to document and analyze classroom comments and questions to help other instructors recognize potentially problematic dynamics in their own classrooms. They were also able to surface ways instructors could reshape these dynamics by attending to the role of broader structures, like course organization and implicit norms, in shaping classroom climate. Another study focused on how students' experiences across the CS learning environment, from lecture to small-group settings, promote or limit their sense of belonging [49]. Through ethnographic observations, the authors were able to illustrate how inequities captured in existing quantitative data infrastructures were reflected in the nuanced, day-to-day realities of students' engagement with instructional decisions and intricate social dynamics in small-group collaborations. However, while these studies have explored students' overt participation in the CS classroom and in small, collaborative groups, there has been less focus on interactions that are not organized by the instructor. In this paper, we use an ethnographic approach to study student collaboration during class, allowing us to observe the phenomenon of siding which would otherwise have been difficult to study.

3 Methods

3.1 Ethnographic Inquiry

Ethnographic inquiry through analysis of field notes is a well-established approach in learning sciences research that prioritizes looking closely at learning as it happens (e.g. [42, 59]). In conducting such an inquiry, an ethnographer seeks to write down, "in regular, systematic ways what she observes and learns while participating in the daily rounds of the lives of others" [13]. In this study, we sought particularly to understand CS students' collaborative classroom activities. Using ethnographic observation methods allowed us to directly observe these activities as they occurred, while also better understanding how they operated within the broader context of the classroom learning environment.

Ultimately, the goal of ethnographic research is to develop a nuanced, insider's perspective on a particular community [6, 12], which can help us see different avenues to support student learning (e.g. [49]). This means that while the findings from an ethnography are specific, rather than generalizable, they are still useful by analogy, as they can be applied "in other settings only when the reader sees similarities between the essential features of the description provided and his or her own experiences and situation" [5]. It also means that research questions begin broad, but emerge and gain specificity from grounding in the data [13]. In our case, we narrowed our focus from trying to understand collaboration generally to asking: "How do students engage in and learn from side interactions in CS1?"

Finally, as taking field notes encompasses aspects of both observation and the writing of an ethnography, it is crucial to acknowledge how a researcher's positionality and approach shape data collection and analysis [10]. The credibility of the findings can be enhanced through member-checks, or interviews with participants that help an observer understand the meaning of particular activities [6], as a way of triangulating observations with participants' own understandings.

3.2 Research Context

To collect data for this study, the first author regularly attended lectures for a course typically taken by CS majors in their first year at a highly-selective university in the United States. The first author sat among the students in their classroom—the largest lecture hall on campus, with rows of auditorium seats and pull-out tray tables—choosing a new seat every class. 100 to 150 students regularly attended, and attendance was part of students' grades. The course was taught in Racket, a functional programming language. By choosing this language, course designers intended to "level the playing field" for students entering with different prior programming experiences, since it would be new to everyone.

Because departmental policies limited out-of-class collaboration to discourage copying, the instructor ran her course as a "flipped classroom" so she could set aside time for students to collaborate during class meetings and deliver most lecture content through videos assigned as homework. At the start of the academic term, the instructor, who has taught this course for over 10 years and holds a leadership role in the department, invited students to fill out a survey about who they knew in the class and their interests. Using this, she placed students in groups and designated areas of the lecture hall where they could find one another each class. While many students sat with their groups throughout the quarter, others seemingly sat alone, especially as time went on. Classes lasted 50 minutes and often involved the instructor directly instructing about a concept from the stage at the front of the classroom, giving students time to collaboratively work on related exercises, and then explaining her solutions. While interactions between students were the initial observational focus, more attention was paid to students' interactions with technology as the term progressed, particularly as a way of understanding the activities of students who did not seem to have a peer group.

3.3 Data Collection

The first author observed 14, 50-minute class sessions in the winter of 2025, accounting for over half the instructional days of the academic quarter. Observations began in the third week of classes and continued to the end of the quarter. The main source of data informing this paper is over 100 pages of written field notes. The goal of these observations was to understand students' in-class collaborations. However, capturing natural, unstructured collaborations, like siding, is difficult since students often think they are not allowed. As a result, students may have fewer unstructured collaborations if they know they are being observed. To have a lesser effect on student behavior, the first author did not introduce herself as a researcher to students before observing. This opens a question of whether it is ethical to record observations of students' behavior without their knowing. While students in a classroom are in a public space where their actions are visible to others, students could reasonably assume that those other people are fellow students or instructors. In order to navigate data collection ethically, no directly identifiable information about students was ever captured in field notes. Before data collection, we also made plans to never record field notes containing potentially sensitive information, and to destroy any sensitive information unintentionally included. Perhaps the most important step taken to conduct this work ethically was that the first author was transparent about her role as a researcher with all students she spoke to after class, explaining the purpose of the field notes and adding students' reflections to the analysis with their consent. This procedure was approved by the university's Institutional Review Board (IRB).

To produce the field notes, the first author began by recording observations in typed jottings while in the class, then expanded them into full field notes immediately following each class to preserve as much detail as possible. Initially, observations focused on the interactions that could be directly observed and overheard between nearby students, so the first author chose to sit in areas of the classroom with at least one group of students sitting directly next to each other who she had not observed before. However, as the observational focus expanded to include what students who were seemingly alone were doing as the quarter progressed, the first author more often chose to sit near students who had no nearby peers and record their interactions with digital tools. This process of theoretical sampling [56] allowed for observations to surface a wide variety of interactions.

To supplement the field notes, the first author conducted member checks [6] by interviewing students whose activity was included in the field notes after class to triangulate observations with students' own perspectives. The first author conducted six such interviews, each after a different class, approaching students based on analytic interest, proximity, and students' availability to talk. The first author either obtained students' consent to audio record or made a voice memo immediately after speaking with them to preserve as much detail as possible. These member-checking interviews centered on students' overall impressions of the class, their group's dynamics, and their explanations of what was happening during particular interactions that stood out to the observer. The first author also spoke around once weekly with the instructor to understand her perspective on the class, her pedagogical decisions, and what she was interested in understanding about her class through this research. The first author made voice memos immediately after these conversations. The analysis was regularly revised in response to these conversations and interviews.

3.4 Data Analysis

To analyze the field notes, the first author first content-logged [25] them, inductively assigning descriptive codes like "peer-to-peer talk" and "laptop screen" to each sentence. This helped manage and document the large volume of field note data by categorizing observations of similar types into the same code group for ease of reference. The first author also incorporated in-process memo writing [13] to capture impressions of the data as it was being collected, separate from the observational field notes. This allowed ongoing interpretation to sensitize the first author to emerging patterns and activities to look for in her observations [56], while also maintaining the field notes as a minimally interpretive record. Throughout data collection, the first author also wrote about excerpts from the field notes and elaborated some of these memos into structured excerpt commentary units [13] to develop analytic topics. These structured writings were shared with learning sciences researchers who were are not authors on this paper as part of a course on field methods to sharpen the analytic focus, ensure claims followed from the data, and guide future data collection. For example, while the original research question focused on collaborative learning, these conversations prompted the first author to also attend to the negative case of students who did not seem to be interacting with peers in her observations.

After completing data collection, moments when students interacted with each other *while the instructor was teaching* began to stand out as potentially important. To guide the identification of these moments in the field notes, the first and fourth authors created a qualitative code definition for siding, drawing on existing literature on siding and perspectives from human-computer interaction, discussing until we reached consensus. Specifically, we define an activity as siding if it meets the following criteria: (1) it happens in a context that is to the side of (i.e., running in parallel with) the main classroom activity, and (2) it is interactive, meaning that more than one party is involved and those parties respond to one another. Furthermore, we define a siding activity as "peer siding" if it happens between two or more students, and as "digital siding" if it happens between a student and a digital tool. These definitions were not mutually exclusive (i.e., some activities could be classified as both peer *and* digital siding).

Using these definitions, the first and second authors each separately conducted a second, deductive round of content logging by applying "siding" and "digital siding" codes to all instances of student interactions that fit the above definitions, and resolved any disagreements through discussion. The first and second authors then examined overlaps between these codes and inductive codes from the initial content logging (e.g., "peer to peer question" and "debugging") to establish seven types of siding, (see Table 1), discussing any disagreements until consensus was reached. The identified types of siding guide the structure of the findings.

While analyzing the data, it was often unclear what students were doing to the side. These cases were labeled *Unclear*, and the prevalence of these unclear side interactions in the field notes can be seen in Table 2. In many cases, it was difficult to hear exactly what students were saying to one another, especially if they sat in front of the observer (as their voices would not carry as well), if they kept their voices low, and if there was other noise in the classroom. Similarly, it could be hard to see what students were doing with digital tools, especially on small phone screens or if they sat behind the observer. In this way, the observer's physical position in the classroom shaped the kinds of observations that were recorded and analyzed. Other aspects of the authors' positionalities are addressed in the following section.

3.5 Positionality

The field notes and analyses shared through this paper are shaped by the authors' positionalities, as is all qualitative research [39]. As the person conducting observations and writing field notes, the first author's identities as a learning scientist, as a cis white woman who took CS classes as an undergraduate, and as someone who had to rely on digital tools for social connection when she was critically ill as a teen shaped what she was sensitized to in the data collection. The analysis was further shaped by the other authors' distinct positionalities and expertise in human-computer interaction, CS education, and the learning sciences.

4 Findings

Each day in CS1, effectively every student had a laptop out. Typically, the instructor helped students start the day's exercises, which they worked on using their own computers and in their groups. Throughout the class, the instructor would occasionally explain parts of a problem; as she spoke, students frequently whispered to each other and almost always typed or clicked on their computers. So, we did not have to look far to see siding.

We found three categories to be useful for understanding how students sided in CS1. For ease of exposition, we present them separately, though in practice, students move fluidly between them. The first, "peer siding," are interactions between students that align with previous definitions of siding. The second, "digital siding," refers to when students use their technology in a way that is similar to peer siding in two key ways: the student does something and technology

Type of Siding	Definition	Example
Co-Constructing	Extended interactions that left all parties with changed understandings	See Section 4.3.1 for an example of how Eli and Josh make sense of the instructor's code together.
Soliciting Clarification	Quick question and answer exchanges	*As the instructor described the week ahead, Rob said, "That's good. Two exercises due this week?"*
Tutoring	Extended interactions with one party explaining to the other	See Section 4.3.3 for examples of how Dev and Nina, as well as Will and an AI chat, tutored about code.
Coding	Interactions centered on coded artifacts	*Ann watched as Bo pointed to a line of code on his screen. Bo looked back at Ann, who nodded.*
Connecting	Interactions that seemed, above all, to build relationships	*While the instructor explained a problem, Cat said she wouldn't preregister for classes next quarter.*
Non-CS Task	Interactions not connected to relationship building or course learning	*Opal was working on the New York Times crossword puzzle on her laptop.*
Unclear	Inaudible or otherwise not well-captured interactions	*Tim turned to Joe again and whispered something I couldn't hear, though his voice tipped up at the end. Joe nodded and whispered something back.*

Table 1: The seven types of siding we inductively identified from our field notes, presented with their definitions and an example excerpted from the field notes.

responds (*interactivity*) and this interaction happens in parallel to the main activity of the class (*context*). The third, "sociotechnical siding," is where both digital and peer siding entwine.

In Section 4.1, we introduce a typology of the different siding interactions we observed. Then, in Section 4.2, we show how peer and sociotechnical siding contributed to forming connections between students. In Section 4.3, we explore the similarities, differences, affordances, and limitations of peer, digital, and sociotechnical siding toward collaborative learning. We also argue for the viability of seeing interactions with digital tools as siding. In Section 4.4, we build from our description of the three categories of siding to thickly describe how this expansive range of participation emerged in CS1 and point to conditions that enable siding that is meaningful for students' learning.

4.1 Typology of Siding

Across the three categories, we found seven types of side interactions, which are shown in Table 2, along with how many times each type of siding appeared in the field notes. These frequencies are not intended to represent the typicality of each kind of siding in the classroom, but rather to give context for the contents of the field notes analyzed in this study.

The first four types of siding (*Co-Constructing*, *Soliciting Clarification*, *Tutoring*, and *Coding*) are distinct activities that can be distinguished by their unique mix of collaborative elements, as we will describe in Section 4.3. While there are differences in the characteristics of a particular type of siding across the peer, sociotechnical, and digital categories, often in the degree of symmetry between collaborators and the interactivity of the exchanges, each is still recognizable as holding many of the same characteristics of other interactions within its type. An interaction that falls within a particular cell (e.g. *Soliciting Clarification* through peer siding) may also vary slightly from other interactions in that cell, as any collaborative interaction involves distinct people at particular moments in time. Though absent from our data, we would expect to see sociotechnical sides for *Co-Constructing* and *Tutoring* on further observation. Absences in the cells for *Coding* through peer siding and *Co-constructing* through digital siding are by definition: in our view, coding involves interaction with a computer and co-construction results in collaborators being meaningfully changed in ways that do not currently happen to digital tools through interaction [64].

The final three types of siding (*Connecting*, *Non-CS Task*, and *Unclear*) are concerned more directly with the subject of a side interaction. We see *Non-CS Tasks* and *Connecting* as part of a spectrum: *Connecting* happens between two or more humans engaging in either CS or non-CS tasks with a primary aim of building interpersonal connections, whereas *Non-CS Tasks* are undertaken by students engaging in non-CS oriented tasks with a digital tool. That is, using social media would be a *Non-CS Task*, but sending a post to or looking at posts with other students would be *Connecting*. This explains why there are only observed *Non-CS Task* interactions in the digital siding category and *Connecting* interactions in the peer and sociotechnical siding categories. We distinguish these interactions because relationship building is an important part of classroom community and disciplinary learning [47], though neither of these ends can be achieved through digital siding about things unrelated to CS. We do not discuss *Non-CS Tasks* further in this paper, as students' digital distractions are documented elsewhere (e.g. [22, 38]). For obvious reasons, we also do not report on siding interactions that were *Unclear* to us, since the observations captured about these were not sufficient to draw conclusions from.

4.2 Siding with Peers and Digital Technology to Foster Community

Many of students' siding interactions were oriented toward building connections with peers. For some, peer siding was a way to share the difficulty of learning CS with others. This could be seen as:

> The instructor explained how to code a graphic, saying, "The hard part is the color, of course." June whispered to Mia, "The colors are the hard part for me."

	Peer Siding	Sociotechnical Siding	Digital Siding
Co-Constructing	**4** (3 days, 3 groups)	–	–
Soliciting Clarification	**11** (5 days, 6 groups)	**2** (1 day, 1 group)	**3** (2 days, 2 groups)
Tutoring	**6** (3 days, 4 groups)	–	**3** (2 days, 2 groups)
Coding	–	**8** (5 days, 5 groups)	**10** (5 days, 5 groups)
Connecting	**36** (9 days, 13 groups)	**24** (9 days, 13 groups)	–
Non-CS Task	–	–	**49** (10 days, 13 groups)
Unclear	**28** (9 days, 13 groups)	**4** (2 days, 2 groups)	**27** (11 days, 15 groups)

Table 2: Frequencies of each type of siding interaction in the field notes. These are reported as a total number of observed instances, with details about how many days of field notes they were found in, and how many groups of students (determined by proximity and interaction) across those days were observed siding in a particular way.

> June leaned into Mia's side and they both looked at Mia's screen, saying something about "the green" before separating (Day 2).

By siding, June and Mia connected about a challenge June had, creating an opening for her to physically lean on Mia as they made sense of some code. As the instructor first normalized the difficulty, her pedagogy helped make this siding possible, since June only had to agree with her to get a peer's support.

For others, peer siding was also a way to connect about topics beyond the class. While in this paper, we will mostly focus on students' siding when it clearly supported their learning, it was not uncommon for both peer and digital siding to not directly relate to class. For example, *as the instructor discussed functions that would be useful for an assignment, Maya talked with Hope about when she was planning to get to the airport to meet her parents* (Day 2). In this instance, Maya connected with Hope on a purely personal level by sharing information about her family and life outside class.

Although it may be paradoxical for a student to create interpersonal connections with a peer through digital siding alone, these connections were often created in sociotechnical systems. This siding was also not usually directly related to classroom learning. For example:

> As the instructor explained how she would approach a problem using recursion, Olive held out her phone over the empty seat between herself and Leah, showing a photo of an event invite on Instagram. They leaned in close together and exchanged a few words, smiling. (Day 8)

Here, we can see how technology was a conduit that allowed students to interact with the world beyond the classroom [1] while a main activity continued. Still, by sharing this post, Olive and Leah developed a friendly relationship, which can have long-term benefits for learning and belonging [47]. Further, conversations unrelated to course activities have been found to support course-related collaborations by managing attention and engagement with others [30].

4.3 Siding with Peers and with Digital Technology to Support Learning

We begin this section with an example of a type of peer siding that does not have clear analogies to digital siding, but that shows the value of attending to side interactions as a site of collaborative learning. Then, we present the three remaining types of siding and demonstrate how students can serve similar needs across the different categories of siding. In each section that follows, we also interpret the interactions drawing inspiration from Dillenbourg [11] to attend to collaborative dimensions of scale (D1-Scale), learning (D2-Learning), and collaboration (D3-Collaboration).

4.3.1 Co-Construction of Knowledge. Sometimes, peer siding did not have direct parallels to digital siding. One such case was when peer siding enabled students to co-construct conceptual understandings through extended exchanges. Before the following excerpt, Josh had just raised his hand and asked the instructor, "I seem to remember that at one point you talked about Sussman form or lambda form, and I'm wondering how that plays in here."

> The instructor smiled and said there was a phrase that "sounded exactly like" what he just said, but that is not applicable in this case. She explained the difference between the two forms, saying, "For example, if you think that you will not need an entire procedure called square, you could just write it like," then typed: map(lambda(x)(* x x))(list 1 2 3)). Either Josh or Eli said, "Ohhhhhh." One said, in an aside to the other as the instructor kept explaining on the stage, "So you call it and it's on the list and then–" the other continued, "It takes in a procedure and applies it to the list so it just—so list is essentially the input. Or, list every–" and the other cut in "every list is–" and the first finished, "every object." The instructor finished talking, then asked if it made sense. Josh replied, "Yes, thank you." (Day 5)

To attend only to Josh's overt participation would be to miss a rich moment of collective sensemaking to the side. After hearing the start of the instructor's explanation, Eli and Josh made sense of her code independent of and in parallel to her teaching in an interaction that spanned multiple conversational turns, making it long in scale compared to other sides (D1-Scale). This interaction enabled them to jointly problem solve about what the instructor's code was doing (D2-Learning) by building upon each other's sentences to add specificity (D3-Collaboration). For example, one of them reworded "you call it and it's on the list" to include disciplinary language: "It takes in a *procedure* and *applies* it to the list" (emphasis added).

This kind of dialogue, where a student extends another's ideas, is a mechanism that supports learning [3] and shows the instructor's explanation alone did not lead to a concept making sense; rather, her explanation initiated siding through which students co-constructed understanding.

Josh was likely willing to side while the instructor answered his question since he thought CS1 was a "pretty safe environment" per his post-class interview, adding that the large lecture hall made it "easy to blend in." Josh also said he liked his group, showing how the instructors' decision to let students pick their groups contributed to students' willingness to engage with each other. We did not see analogous interactions with technology because of how specific their siding was to the instructors' explanation and since their shared positionality as learners gave them a high degree of symmetry (D3-Collaboration), which allowed them to both legitimately participate in the co-constructive exchange.

4.3.2 Soliciting Clarification. Students frequently sided with both peers and digital tools to solicit clarification. For many students, peer siding was a way to get explanations from a student's perspective, as seen in the following:

> The instructor said she would start class with a review of functional programming before moving into imperative programming. Aaliyah asked quietly, "What's imperative programming?" Carlos quickly answered her. (Day 8)

Aaliyah's siding might be seen as a way of "looking up" a definition via her peers that is analogous to searching a term online. In this way, the interaction was small in scale, as it spanned only the two conversational turns of a question and an answer (D1-Scale), and concerned the sharing of declarative knowledge (D2-Learning). There was also less symmetry between the partners, as Carlos was positioned as holding the information Aaliyah sought (D3-Collaboration). Many conditions contextualize Aaliyah's choice to side with her peer, including that they had built rapport from working in the same assigned group for multiple weeks and frequently sided without reprimand. Furthermore, by turning to her peer, Aaliyah got a response from a fellow student, who could give course- and context-specific support.

Another way students sided for clarification was by using technology to search for information. Will sided in this way when:

> While the instructor explained a certain list operation, Will looked at a webpage in the Racket documentation titled "Mutable Pairs and Lists." Then Will typed the word "rest" into a search bar on the page, scrolling through a list of hyperlinks returned by his search before clicking one. (Day 9)

This is an example of digital siding because its interactivity and context were similar to peer siding. First, the *interactivity* of the webpage meant that the technology responded after Will searched for "rest." Since programmers working with a list often need to retrieve the rest of its members, we interpret Will's search as asking: "How do I get the rest of the list?" Second, the *context* of the interaction paralleled the main activity of the class. In both this moment and the previous, a student asked a question and received an answer as the instructor spoke, revealing similarity between digital and peer siding. Additionally, just as Aaliyah's relationship with her peers enabled her to turn to them for clarification, Will also needed familiarity with the domain and documentation to find an answer [68]. Because of this, we consider the collaborative dimensions of this interaction to be very similar to the peer siding example above.

Yet unlike Aaliyah, who received an answer from a peer, Will got a response authored by experts in Racket. This has affordances—in this case, the information was accurate, which would not be guaranteed had he asked a peer or GenAI—and limitations—Will had to filter through options and interpret their contents in terms of his question.

While some clarifying questions can be answered by peers or technology, peer siding benefits from the shared context; in fact, some questions were so specific that only a person in the class could answer them. For example:

> The instructor advised the class on how to approach open response questions on an exam, saying, "If you put down a bunch of answers, you'll get credit for how many are right out of how many total you put down." Kara whispered a question to Eli, who replied, "Because you didn't say the exact thing, you can't describe. . . ." (Day 5)

Here, Eli sided to explain a grading procedure, adding his interpretation of the instructor's reasoning for the policy. Kara could not have turned to web search or GenAI, which lacks this context, for an answer.

4.3.3 Tutoring. Students also sided with peers and digital tools to receive tutoring. Peer siding frequently helped students get personalized support, as the following excerpt shows.

> After the instructor answered Dev's question on brackets, Dev turned to Nina while the instructor continued to answer other students' questions. He said something quietly, holding up his thumb and forefinger in a bracket, catching something on the instructor's screen in the web of his hand. (Day 3)

This side interaction spanned more time than sides for soliciting clarification, a key difference between these interactions (D1-Scale). It was important Dev sided so he could explain the instructor's response while the instructor's screen still showed the lines of code his question was about. He made use of this shared point of reference by embodying the brackets on the screen with his gesture, making the concept more tangible (D2-Learning). After class, Nina explained she took this class since she knew Dev would help her, indicating less symmetry between the two as collaborators (D3-Collaboration). Because they chose to be in the same group, Dev was able to side with Nina to give the context-specific tutoring that made her feel able to take the class.

We observed students digital siding using GenAI to explain and debug code on two different days. However, as we consider interactions where GenAI writes code to fit within the *Coding* type, we focus on an example of a student using GenAI to explain code here. It is easy to see interactions with GenAI as digital siding because of the *interactivity* of chatbots, and the interaction we present below occurred in a *context* parallel to the main activity of working with peers and instructors. Like other siding instances, it was not the intended way for a student to engage in a part of class. In this excerpt, Will sat alone and worked on an assignment, as around 20 students did on any given day, since the instructor did not regroup lone students. Earlier in that day's class, the instructor told the class she had to turn in multiple students for using AI to write code, suggesting that GenAI use may be prevalent even beyond our two observed instances.

> Will ran his code and the terminal went blank before floods of red text filled the console. After a moment, Will switched to an AI chat website (Claude.ai) with "You know the language Racket?" as a header. The rest of the page showed a text exchange, and in the most recent message, Will had written "btw the list will only contain posn, is that ok?" The answer came in word chunk by word chunk of generated text, but not code. He read through the response and typed something back before swiftly pulling up his code and the assignment document in split screen. He wrote a new line of code and ran it again—again, red text filled the screen. (Day 9)

As Will programmed, he received a large amount of error text, which can be hard for students using Racket to decipher [35]. In the absence of a peer group, Will asked GenAI for help understanding his code, like Nina turned to Dev for an explanation of the instructor's code (D2-Learning). The multiple blocks of text returned by the GenAI indicate an interaction that extended in duration similarly to Dev and Nina's interaction, as it took time for Will to read this response (D1-Scale). Also similar to Nina's established tutoring relationship with Dev, the existing conversation when Will opened the tool indicates that he had a pattern of seeking help from it, indicating an asymmetrical relationship (D3-Collaboration). The strength of this pattern is underscored by his choice to ask GenAI to interpret code minutes after the instructor's warnings about using it to generate code, toeing the line of the course's AI policies.

Will's choice to use GenAI had benefits and drawbacks. While it likely kept Will from entering the "pattern of disengagement" that can impact CS students when they work on a difficult task without help [32], the value of GenAI in this scenario is precisely its weakness: Will could turn to it instead of a peer. This added friction to Will's learning experience, as he had to assess whether the tool even "knew" Racket in his first message (the page's header) and could only converse with it through text, rather than by using other communicative tools like gesture (D3-Collaboration). This is quite different from how Dev provided Nina with context specific mediation directly in relation to the instructor's screen. Turning to GenAI rather than a peer also had a longer term drawback in that it foreclosed an opportunity for Will to participate in a learning community with his peers, which is important for developing disciplinary identity [7].

4.3.4 Coding. Peer and digital siding were not mutually exclusive in sides that supported learning. Students often sided with both peers and technology in sociotechnical systems, especially when coding, as seen in the following:

> The instructor explained her code, and Ben looked between the instructor's screen and his own, completing a line of code and running it. After a second, he bumped his shoulder into Caroline's. She ran her mouse over her screen, highlighting various lines as Ben watched (Day 4).

All students in CS1 wrote code in an integrated development environment (IDE), which helped them write, test, and debug code. By clicking a button to run his code, Ben solicited and received feedback (*interactivity*) from his IDE in parallel to the instructor's explanation (*context*), making this a case of digital siding. Although testing code is a desired activity during live coding, this interaction is still siding, since it brought the content from the instructor's lecture into a parallel, more local level and gave the Ben access to new kinds of personalized feedback.

We can see how intertwined technology is with peer siding about debugging when Ben immediately turned to Caroline after receiving feedback from the IDE, entering a sociotechnical side with her. This may have helped Ben interpret IDE feedback, which is designed to address issues of syntax, with someone he had a higher degree of symmetry with in understanding the conceptual purpose of the code (D3-Collaboration). From the initial feedback Ben got from his IDE to his interactions with Caroline, this side spanned a few exchanges with multiple parties (D1-Scale). When Caroline drew Ben's attention to parts of her code by highlighting, her computer was a medium through which she communicated with Ben (D2-Learning). Viewing this interaction as a whole helps us see the broader sociotechnical system, where peer siding built on digital siding to support debugging.

Sometimes, students worked on code through digital siding without another human present (i.e. not as a sociotechnical side). In the following excerpt, Seth *interacted* with GenAI in the *context* of class time set aside for students to work on a programming project with help from peers and instructors (not GenAI).

> Seth typed the header for a function named get-scoring-outcome in his IDE. Then he switched to a window with a GenAI chat open for just a moment before opening the course's webpage. He leaned back, yawning. Then, he reopened the GenAI chat. As the prompt, Seth wrote, "Implement quiz scoring reset in Racket. Use imperative programming and…" the chat output forced his prompt off the screen. The GenAI's response began: "If you want to use imperative programming to write a scoring outcome…" then a block of code appeared in the output. Seth looked at this for many seconds before switching back to his IDE, typing code in the get-scoring-outcome function without copying and pasting. Next to each line, he wrote a comment, including one that read "// current max outcome is first outcome" (Day 12).

As Seth programmed, he seemed to get stuck after writing the header for his function and began to look between different windows on his laptop. Though Seth had a peer sitting very near to him, she spent most of the class engaging in non-CS tasks on her laptop. Rather than turning to her, Seth asked the GenAI tool to "implement" part of his program. Here, Seth was solving the problem with the AI, perhaps learning as he read the AI-generated code. He then typed his own version into his IDE with descriptive comments about the purpose of each line (D2-Learning). Yet there was a high degree of asymmetry in this learning interaction; Seth asked the tool for an implementation, which it did instantaneously (D3-Collaboration). This particular interaction only spanned one exchange, though the GenAI output was long and detailed (D1-Scale), and Seth also returned to his chat with the tool two other times throughout the class, indicating a larger pattern of help-seeking from this tool. As with our other example of a student using GenAI, turning to it may have helped Seth meet an in-the-moment learning need while also foreclosing opportunities for learning in community. However, in contrast to the previous case, it is possible that the interaction did not support much learning, since the GenAI directly provided code rather than an explanation or pseudocode Seth could apply himself.

4.4 How One Group's Siding Shifted Across One Day in CS1

To understand how siding unfurled through a rich tapestry of interactions, we follow one group over a single day of class. By following them, we can see how formal class structures interwove with informal communication webs to create consequential opportunities for students to learn together—with each other and with technology.

Our focal group consists of Claire, Daniela, and Ethan, from a larger group of five students. Before class began on Day 1 of my observations and the seventh class meeting of the quarter, the five friends talked in groups of two and three.

4.4.1 Influences of Ambient Noise and Problem Difficulty. Once class began, the instructor explained the learning outcomes and gave the class five minutes for a warm up question. The focal group worked quietly, and the auditorium was hushed, save for the scattered sounds of typing. Ethan did not have a computer and looked between Daniela's screen and the instructor's IDE projected at the front.

As the instructor began to explain her process, the focal students only had one course-related side. This happened when: *a student asked Claire about "signatures" after the instructor described how she "always starts" by writing one. Claire explained in a whisper, holding her hands up like two brackets as she spoke.* This siding echoes an earlier excerpt where Dev gestured as he tutored a peer to bring the course material to a more personal level. The students also sided in less course-related ways when, for example: *Claire looked at a university news website and nudged Daniela, pointing to something. Daniela laughed.* Attending to the context, especially the quietness of the room and the exercise being a "warm-up," helps us see why there was only one course-related side: The hushed room would have made it more difficult for students to side unnoticed and the easier task meant students might need less peer support to finish it.

4.4.2 Influences of Sanctioned Collaboration Time. After the instructor explained the exercise, she directed students to work on a more complex, 30-minute activity. Claire, Daniela, and Ethan collaborated in ways that laid the groundwork for their later siding. This could be seen 10 minutes into the structured group work time, as they fixed an error on Daniela's laptop.

> Ethan said that the problem was a certain line, which he pointed to with his finger before highlighting it using Daniela's trackpad. Claire agreed, "Yeah, it's that line!" Daniela changed something, then Ethan exclaimed, "It runs!" pointing to the output and laughing. He suggested, "We should—" and Daniela made another edit, and hit run. As text was output, they giggled. Daniela took out her notes, and Ethan put his hands on the keyboard.

Ethan and Daniela's relationship of co-authorship with input from Claire was perhaps most visible when Ethan couched a suggestion in the phrase "we should," but it was also clear in how Ethan and Daniela exchanged ownership of the computer. During this time, the students also entered a sociotechnical system as they attended to feedback from Daniela's IDE to adjust their code. This feedback even became a site of joy, as seen in their laughter when the code ran. As we show in the following section, these patterns fed forward into siding once the class transitioned back to lecture.

4.4.3 Influences of the Instructor's Verbal Instructions. As the instructor started her explanation, she said: *"if anyone is cruising on the problem, feel free to tune me out and keep working."* This explicitly created an opening for students to side, which our focal group did much more than before. As the instructor continued, the group's siding was a point of interpersonal connection as they reacted to the unfurling solution. This could be seen when: *the instructor said that she was moving on to the "hard part," and Claire whispered to Daniela, "This is what I did—if I actually… that's crazy!"*

Meanwhile, Daniela and Ethan continued siding to debug: *Ethan said, "This syntax is—" and Daniela responded, "Well, actually this is… " She highlighted lines on her screen and typed. As the instructor continued explaining, Ethan exclaimed, "You put down 'cat,' that's what the teacher is doing!" he smiled. "She's goated bro, she's goated!"* Here, Daniela and Ethan collaborated like they did in structured group work time, with Ethan pointing out potential issues that Daniela fixed. The laptop remained an important resource, but now that their interaction occurred in parallel to lecture, this interaction became sociotechnical siding, echoing previous examples where students received feedback from the IDE, highlighted code, and compared the instructor's work to their own. Then, like Claire, Ethan shared his excitement when their code aligned with the instructor's explanation, giving Daniela credit.

4.4.4 A Best-Case of Siding's Influence on Students' Learning Experiences. Sustained, supportive connection through siding has potential to improve students' CS self-efficacy. After finishing her explanation, the instructor polled the class on how the exercise went: *"Eyes closed, who got it on your own?" Claire raised her hand. After a moment, Ethan reached over to grab Daniela's wrist and raised her hand for her, smiling.* The instructor often asked students to share how they did, since she said it helped her adjust her teaching. Though the instructor experimented with other phrasings over the quarter, this question privileged students who got it "on [their] own," potentially contributing to Daniela's reluctance to raise her hand. Yet, as Ethan raised Daniela's hand for her, he communicated his view that the code they wrote together, both in group work and siding, merited her claiming that she "got it." This final side, and the joy and connection that suffused it, ultimately may be important for Daniela's confidence on this assignment and in CS1.

5 Discussion

Through ethnographic observations of CS1, we have sought to contribute to a relatively small body of ethnographic research understanding students' classroom activities in university-level CS. We found that students in CS1 sided frequently in a variety of ways and presented a taxonomy of the siding interactions we observed, which helped us differentiate among sides by their collaborative features. Our taxonomy aligns with functions of siding found across existing research, including trialing ideas, recontextualizing lecture content, and building community [2, 4, 27, 31, 45]. These roughly align with our co-construction, soliciting clarification/tutoring, and connecting types of siding, respectively. Building from this, we elaborate on how siding manifested specifically in CS1. In particular, our data showed that certain digital interactions could accomplish similar goals as peer siding. We argued that, especially in CS1, we can see interactions with technology through the lens of siding, since students get *interactive* feedback from these tools in a *context* that parallels the main activity of the class, which is analogous to peer siding. This allows us to attend to *how* students use both digital and peer siding to meet different learning needs as they arise.

However, we found important differences between digital and peer siding. For one, peer siding benefited from shared context, while its absence in digital siding often introduced friction. Peer siding also enabled the co-construction of knowledge and afforded community-building in ways that digital siding did not. Researchers have also seen teachers cue in to side talk to adjust their teaching [4, 31], an affordance absent in digital siding, which is often less visible to teachers [52] but which may also disrupt other students less. Digital siding also enabled students to access systematic, rapid, and consistent feedback, especially when they had no peer to turn to. Students also sometimes blended side interactions with peers and digital tools in what we called sociotechnical siding, which often uniquely allowed students to build understandings through shared coded artifacts. We point to these distinctions not to say that any of peer, digital, or sociotechnical siding is better than the others, but to highlight the complex tradeoffs students may tacitly attend to when choosing to side in one of these modalities.

We present implications from our research, though we note that the aims of ethnography are not to draw conclusions that generalize widely. Rather we have aimed to provide a rich and grounded description of our particular context so that other researchers and practitioners may apply our insights where they see meaningful analogies to their own.

5.1 Beyond Binaries: Siding as a Lens for Understanding CS Classroom Learning

We illustrated that the activities students engage in "to the side" of a CS class have a distinctly varied character. Because of this, siding resists easy, blanket categorization into binaries of "good" or "bad," "productive" or "unproductive." In writing this paper, we found that paying careful attention to our language has been a useful analytic tool for helping us see where those binaries were beginning to creep into our own thinking and to push beyond them [58]. For example, we deliberately chose to call a large amount of peer siding "connecting" rather than "off-task" to orient around what the siding was doing for students, rather than implicitly classifying sides as good or bad based on their relationship to course material. The choice of "siding" as a term itself is also just different enough from the more commonplace "side-talk," that we hope using it offers other researchers and educators the same moment of hesitation it did for us—a hesitation that allows us to consider how we want to understand and respond to students. "Side-talk" is often the default language we use to describe many student activities that do not outwardly look like paying attention, and it carries with it connotations of students' distraction and even disrespect. But in the gap between side-talk and siding, we encourage researchers and educators to take "a small leap of faith, one that acknowledges the new possibilities" [41]. Among these possibilities is that, entangled with and inseparable from the myriad of "off-task" or "unproductive" activities it is easy to imagine students doing during class, students are *also* doing things that help them learn course material in new ways or meaningfully connect to peers. In short, we advocate for allowing some amount of siding, and for challenging our instinct to always immediately redirect or dismiss students who are siding.

Perhaps even bigger than the linguistic gap between "side-talk" and "siding" is the gap that exists between the language of "digital distractions" and "siding." Students' classroom activity is often understood through what Gourlay terms a "tyranny of participation," where publicly communicative and collaborative classroom activities are more likely to be seen as evidence of active meaning-making, while practices that are quiet, private, and non-verbal are often seen as "in need of remediation" [17]. Prevalent among these "quiet, private, and non-verbal" activities today are students' uses of technology. Applying siding more expansively to understand students' interactions with digital tools is especially timely, as technologies like GenAI are increasingly integrated into classrooms, amplifying questions about their role in learning (e.g., [33]). Adopting the lens of siding helps us see how digital tools participate in students' learning in ways that are not uniformly good or bad, and can help us recognize that even students who are silently on their computers during lecture may be actively learning [52].

Finally, siding may also help us see beyond the binaries of active and passive, collaborative and non-collaborative learning. Learning sciences researchers have shown that humans are inherently social beings who actively make meaning of our social and cultural worlds through interaction with each other [60, 64]. In CS classrooms, however, collaboration is often studied and designed for as something that is bounded to structured collaboration times that are explicitly organized by an instructor [53]. Yet by analyzing side interactions in our data along three dimensions of collaborative learning [11], we showed that collaborative learning happened apart from formal collaborative structures through siding. Side activities like *Co-Constructing* embodied a high degree of symmetry between collaborators with conversational exchanges that built toward mutual understanding, showing the value of siding as a site of rich collaborative learning in its own right. While we acknowledge that many sides, like those for *Soliciting Clarification*, could seem less collaborative when taken as stand-alone interactions, we also showed in Section 4.3 that sides that appeared at first glance to be isolated could actually be extending group work beyond the bounds of a formally structured activity. This demonstrates that siding can be considered a collaborative learning activity, as truly generative collaborative learning can and does happen across many different types of sides. Treating siding as a legitimate way students collaboratively make meaning can ultimately help us see students as more complex than "passive" listeners during direct instruction or lectures, conceptualizing learners as agentic people who are able to seek out interactions that can support their learning [15].

5.2 An Argument for Designing Learning Environments to Support Siding

Because ethnographic observation allowed us to pay attention to both micro- and macro-level activities, we began to understand how siding is entwined with broader course practices, pointing to design opportunities. These insights may be useful for CS instructors who see analogies between their course context and the one described in this paper [5]. Integrating collaboration into large-enrollment CS courses that use lectures to teach can be difficult. Given that our work has provided evidence that students' siding can be an important site of collaborative learning and should be understood expansively as active engagement within these contexts, we see siding as an already-existing classroom activity that instructors may wish to encourage to increase student participation and interaction.

We argue that we can and should account for the types of side interactions that exist outside the formal bounds of collaboration time when we design for collaborative learning. Some lightweight activities like think-pair-share have been introduced in CS classes to encourage students to communicate and work with others during lectures [28], and applications like Backstage have created shared platforms for students to communicate with one another during class [48]. Yet, while it might seem that these designs redirect students' siding through sanctioned channels, what is lost in this process of inscribing siding into official activities? We find a kernel of wisdom in adapting Mueller's words: since siding often manifests "beyond an observer's gaze," once we apprehend siding and design channels to enable it, it cedes some of its "side"-ness [41]. At the same time, the sociological concept of the "underlife"—or practices which, like siding, arise in contradistinction to the institutional order—holds that since these practices offer people ways to express their agency and identity beyond what is offered by the institution, we cannot expect them to ever disappear fully [16], even if students are offered "official" channels through which to work toward similar ends. We therefore suggest shifting our focus away from designing channels through which siding can happen with the aim of eliminating siding. Instead, we invite researchers and educators to lay out the soil in which siding, as a student-initiated practice, might grow. While we discuss entry points to doing this more concretely in the following paragraphs, we call back to our first implication as containing an important overarching strategy: we encourage instructors to find some amount of siding they can be comfortable with letting happen without redirecting students.

To cultivate an environment where students can peer side in ways that are consequential for learning, instructors might adopt the following practices, which we observed to be effective in this class: (1) group students with friends or others with similar interests, so they can form relationships in a community of learners; (2) incorporate structured group work, so students can practice discussing ideas; (3) have students sit by their assigned collaborative groups so they can continue to collaborate outside of formal group time; (4) signal when direct instruction is interruptable, so students can sensemake as an explanation unfolds; (5) use a microphone or strong vocal presence to be audible over side-talk. A shortcoming in CS1 was that some students sat alone, so instructors might implement structures to keep students grouped so a student never has to digitally side simply because they have no peer to turn to.

Designers should also explore how to support digital siding. We saw value in students having tools that could (1) supply "official" definitions, helping students gain familiarity with professional tools and information; (2) provide on-demand tutoring, potentially helping avert patterns of disengagement; (3) give immediate feedback, allowing students to rapidly iterate on their work; and (4) invite in the world beyond the classroom, enabling students to form connections that extend beyond the class. We acknowledge risks of these tools, including that GenAI tutors may foreclose the human connection that is so integral to learning [23], and that digital tools may make it easier for students to disengage with classroom learning [22, 38]. Yet, we agree with Sahlström et al. that disengagement is not a new behavior created by technology [52]. As digitized classrooms are here to stay in CS, research should explore how to make the most of these potentially beneficial uses of technology and design tools that fit with how students actually interact and learn with them to the side of classroom activities.

In sum, our work points toward the value of applying the lens of siding to better appreciate the complexity of students' classroom learning experiences. Echoing others (e.g. [31, 41]), we recommend allowing siding for its ability to support learning and community, though how and to what extent siding should be facilitated via course design is a rich and active area for future research.

6 Limitations and Future Work

While we hope this work starts conversations about siding among CS education researchers, we acknowledge that there are limitations to this work. First, although our method of sitting in a variety of seats in a CS1 classroom allowed for theoretical sampling [56] which surfaced a variety of interactions, this choice also limits the conclusions we can draw about broader patterns of siding. Because of this, a compelling area for future work is to more systematically document siding across a large-enrollment classroom. More systematic study would reveal how frequently siding has effects on self-efficacy and belonging, like those we observed in what we termed a "best-case scenario" of siding. More systematic sampling could also allow us to understand, from an equity perspective, who is included in or excluded from siding and what impacts this might have on their learning and participation in CS. Further, following a smaller group of students consistently over a long period of time could, in future studies, help us understand how siding changes over time within a group. This more extended observation could also allow for more detailed interviewing to better account for students' own perspectives on siding's impacts on their learning.

Further, though our decision to capture written, observational field notes lessened researcher influences on students' activity, this method limited our ability to capture precise details of students' interactions. Future work should extend ours by capturing audio/visual recordings, including screen recordings, to produce more detailed descriptions of siding, including digital siding. Developing approaches to capture these recordings while minimizing disruptions to students can benefit research on siding broadly.

Finally, we observed siding in a flipped CS1 classroom that incorporated some lectures, and that integrated technology and encouraged collaboration in very particular ways. This means siding may look different in both other university-level CS classrooms and in non-CS contexts. While our work opens the conversation on siding in CS, we encourage researchers to explore siding in their own contexts to better understand the interplays between classroom structures and students' interactive meaning-making. Online CS courses are an area of particular interest for exploring digital siding, given that digital tools also serve as the medium of instruction and students are not co-located with their peers.

7 Conclusion

In this paper, we conducted an ethnography of siding in a CS1 classroom, showing that siding interactions can be sites of rich, collaborative learning. We also introduce *digital siding*, our term for students' interactions with digital tools that occurred to the side of the main activity of the class. Our categories of peer, digital, and sociotechnical siding, along with our typology of sides that we observed across those categories, provide a detailed understanding of how siding occurred in our focal classroom. Future work should more deeply investigate siding through more longitudinal and systematic study that employ ethnographic and other research methods, and determine how our findings translate to other contexts.

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