Values, Identity, and Social Translucence: Neurodiverse Student Teams in Higher Education

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ABSTRACT
To successfully function within a team, students must develop a range of skills for communication, organization, and conflict resolution. For students on the autism spectrum, these skills mirror the social, communicative, and cognitive experiences that can often be challenging for these learners. Since instructors and students collaborate using a mix of technology, we investigated the technology needs of neurodiverse teams comprised of autistic and non-autistic students. We interviewed seven autistic students and five employees of disability services in higher education. Our analysis focused on technology stakeholder values, stages of small-group development, and Social Translucence – a model for online collaboration highlighting principles of visibility, awareness, and accountability. Despite motivation to succeed, neurodiverse students have difficulty expressing individual differences and addressing team conflict. To support future design of technology for neurodiverse teams, we propose: (1) a design space and design concepts including collaborative and affective computing tools, and (2) extending Social Translucence to account for student and group identities.

Author Keywords
Autism; neurodiversity; value-sensitive design; collaboration

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

INTRODUCTION
In higher education, instructors increasingly emphasize teamwork as a learning objective [43]. Collaborative learning fosters better outcomes than individual learning and builds skills such as communication, organization, and confliction resolution. Employers expect graduates to have teamwork experience [7], which is critical in a workforce that is shifting from individual production to team production [8].

A student team brings together diverse students, including students with and without disabilities. Our research focuses on students on the autism spectrum[1] and their teamwork with neurotypical students. Many young autistic adults desire to attend higher education, yet face academic and social challenges [3]. Individuals on the autism spectrum are impacted to varying levels in areas of verbal communication, non-verbal communication, social interactions, and cognitive styles [2]. They may benefit from adapted ways of communicating, performing executive functioning tasks, and processing sensory stimuli [41]. Autistic students who are transitioning from secondary to higher education tend to experience difficulty adjusting to new environments, navigating uncertainty in daily routines, and establishing new social connections [1,11]. Parental involvement, systemic, and mandatory support decrease as students move into adulthood and higher education. Although these changes enable autistic students to maintain privacy and autonomy, students often need to become more responsible for advocating for their needs. Some students prefer not to disclose their autism, and some students (regardless of their stance on disclosure) do not seek out services [3]. Facing social and academic challenges, often without adequate support, can be overwhelming for autistic students. These challenges are reflected in their low graduation rate: 39%, compared to 52% for the general population [47].

To support the diverse mix of students in a class, instructors employ a range of learning strategies, one of which is leveraging computer-supported collaborative learning (CSCL). CSCL incorporates technology to deliver content (e.g., computer aided instruction) and computer-mediated communication (CMC) such as video conferencing and online forums. These technologies should follow Universal Design [40] to be accessible to individuals with and without disabilities. However, technology is traditionally designed for either mainstream students *or* students with disabilities [45]. For autistic students, specialized technology includes assistive technology (e.g., augmentative communication devices) and applications that support executive functioning. Designing CSCL technology for *both* neurotypical and autistic students together can better support inclusion of neurodiverse students [45].

[1] To respect both identity-first and people-first preferences of participants [28], we use terms such as "autistic students" and "students on the autism spectrum" interchangeably.

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The HCI theory of Social Translucence [13] provides us with a useful model for exploring how technology is used in structured social interactions, such as student teamwork. This theory posits that designers can create more effective online knowledge communities by transferring in-person social norms and cues to online interactions. The main principles of Socially Translucent systems are *visibility* of socially significant information, *awareness* of relevant social cues, and *accountability* of actions among group members. These principles are highly relevant to neurodiverse teams, however, young autistic adults often describe challenges adapting to social norms and expressing themselves verbally and non-verbally in social contexts [9,59]. Thus, our novel application of Social Translucence gave rise to an additional principle for the theory, *identity.*

In this work, we investigate current strategies of supporting neurodiverse teams in higher education and what design considerations can be made in future team-supporting technology. Specifically, our research questions were:

RQ1: What are the current technology- and non-technology based strategies that support neurodiverse student teamwork in higher education?

RQ2: What are important design considerations and capabilities of team-based technology that can support neurodiverse teams? In what ways can these technologies support social translucence during collaboration?

We interviewed seven autistic students and five employees of student disability services. Our analysis focused on stakeholder values across the stages of small-group development. Within the context of higher education, our contributions are:

1. Empirical evidence on socio-technical challenges and strategies of neurodiverse teams.
2. A design space and design implications for technologies to more holistically support the values of neurodiverse teams.
3. Evolution of the Social Translucence theory to include a new principle, *identity,* and to extend beyond online settings to in-person technology-mediated settings.

RELATED WORK

Our research is motivated by Universal Design for Learning and informed by research on technology-mediated solutions for neurodiverse students and team-based technologies.

Universal Design for Learning

Many higher education institutions aim to provide personalized services to students with disabilities. They provide face-to-face counseling, peer mentoring, and support for obtaining accommodations. In partnership with instructors, these services promote the Universal Design for Learning (UDL) [40] framework for supporting all students, including those with disabilities. Under UDL, educators proactively create an environment and curriculum that accommodates different styles of learning. They should provide multiple means to represent learning materials, to express knowledge, and to engage with students [40].

A UDL approach to teamwork would provide an adaptive learning environment, giving students multiple ways to engage with teams. This may be especially helpful for autistic students who may find group work particularly stressful [14]. In guidelines for inclusive teaching at the university level, Fabri et al. [15] recommend that instructors provide extra support for working in groups, including intervention when communication fails and giving explicit ground rules and roles to all members of the group. While designing a graduate course that adhered to the tenets of UDL, Rose et al. [45] allowed for multiple means of participation in group discussions by offering both face-to-face groups and entirely online discussion groups. We explore how existing and novel UDL approaches may better support neurodiverse teams that include autistic students.

Technology-Mediated Strategies for Autistic Students

Recent technology-based efforts in UDL for autistic students focus on supporting adaptive learning techniques and building executive functioning skills (e.g., organization and planning). Benton et al. [4] developed a participatory design approach for designing a math application with teams of autistic middle school students. This design approach scaffolded teamwork by having the children come up with a team name, rules, and roles for each of the children, and giving support and guidelines to help children brainstorm together and evaluate each other's ideas.

CMC helps autistic adults initiate social connections, especially on special-interest sites. Burke et. al [9] found that autistic adults appreciated CMC interactions in which they can communicate asynchronously with less pressure to respond to paralinguistic cues. However, over the course of using CMC, people had difficultly building online relationships due to issues such as trust and disclosure. Researchers have explored technology-mediated social supports for autistic individuals, such as specialized social network sites [24] and gaming servers [44]. Given the desire of autistic adults for social connections and inclusion, our research focuses on understanding needs of autistic higher education students and how technology can help them navigate difficulties in social interactions, avoid misunderstandings, and foster team cohesion.

Technology for Supporting Teamwork

In CHI and CSCW communities, design of technology for teamwork has primarily focused on workplace collaboration [6,33,52], software development teams [12,26,27,31], learning to collaborate through gaming [27], and facilitating global diversity in virtual teams [25,32,39,51,56]. Systems have been designed and evaluated for collaborative sharing of mood, to promote emotional well-being in workplaces [16,34,36,46,50]. From this work, we drew inspiration for design concepts that may be applied to the educational setting, noting that people's goals and motivations differ between the two settings. The workplace setting tends to be competitive, output-driven, and employees are already expected to have specialized skills to perform and compete. The higher education environment is designed to support development of specialized interests, taking risks, and learning skills by pushing students outside comfort zones.

THEORETICAL BACKGROUND

Our theoretical framing forefronts the social impacts on teamwork, technology-mediated collaboration, and identity.

Tuckman's Model for Small-Group Development

Tuckman's model for small-group development [54] describes team progression through four stages. In the first stage, *forming*, team members oriented to the task and begin to establish individual identities within the team. The *storming* stage, which may occur repeatedly, encompasses intragroup conflicts and confrontation. In the *norming* stage, the team formally or informally establishes group standards and expectations. The team finalizes the project plan and roles. During the *performing* stage, team members work together toward collective goals, and if successful, form a cohesive, stable team identity. Tuckman's model has been applied to group functioning in CSCL higher education [18], new communities [42], and even contestant communities on reality television [29]. For our research, Tuckman's model helps attune us to team friction points that can be particularly challenging for neurodiverse teams.

Social Translucence in Socio-Technical Collaboration

Erickson and Kellogg proposed Social Translucence as a model for designing technology for online collaboration among large groups of knowledge workers [13]. They argued "designers can assume the existence of a consistent and unquestioned physics that underlies social interaction" [13, p. 61]. Researchers have applied Social Translucence to domains such as social networks [19], Wikipedia [35], and wireless sensing in an urban setting [30]. Applying Social Translucence to these domains has prompted capabilities that promote social awareness and resolve communication breakdowns [5]. Some research applied Social Translucence to knowledge communities rooted in face-to-face relationships, such as collocated families who use systems [37]. We build on this work to examine knowledge workers – students – in a hybrid online and in-person setting of higher education. Student teams operate within the constraints and freedoms of higher education. The student team is self-organizing, without the formal hierarchy of a workplace or family. We examine the ways that technology can support this dynamic environment.

Identity in Human-Computer Interaction

During our research, a recurring theme emerged: identity. Within the broad psychological and sociological concepts of identity, our work surfaced issues around an individual's sense of self, disclosure to others of facets of one's identity, and group development of collective identity. Goffman [21] emphasized the social influence on identity, which develops as one negotiates social norms. Accordingly, HCI research has investigated the role of technology in an individual's sense of self and how they are perceived by others. For people with intersectional identities [48], such as veterans and transgender people, technology-mediated social connections can be especially beneficial for social inclusion and navigating life transitions [23,49]. We build upon this work to investigate the role of technology in identity formation for another intersectional group, autistic adult students. As young adults, autistic students are actively forming their identity at ego-centric, personal, and social levels [10]. Thus, they may be highly susceptible to external social influences, some of which is mediated by technology.

By probing into the social construction of identity, we seek to add social needs of autistic users to technological representations of identity. Primary examples are technology systems that deliver personalized user experiences based on user profiles. Researchers and practitioners have developed architecture platforms and applications that present customized user interfaces (e.g., a high contrast color scheme) and provide assistive technology (e.g., a screen reader) based on a user's profile and selected preferences [55,57]. Some systems enable a user to explicitly state one's specific type of disability, and thus, access a set of pre-selected interface settings and assistive technology. Although some initiatives, notably the World Wide Web Consortium, include autistic users as target users, their technical guidelines are limited primarily to limiting sensory overload and providing simplified content [57]. We seek to inform the design of richer, more socially-aware personalization options for autistic users.

METHODS

We approached our research using the Value Sensitive Design (VSD) [17] framework, which forefronts the values of stakeholders of technology. During our empirical investigations, described in this section (and early in our research [58]), we strove to elicit the values and value tensions between the stakeholders of technology designed for neurodiverse student teams.

Interviews with Staff of Student Disability Services

To gain an understanding of the support provided by universities, we conducted semi-structured interviews with five employees of student disability services at two local higher education institutions (henceforth labelled as E#). All interviews (4 female; 1 male) were conducted in person, lasting no more than one hour. We inquired about the types of services they provide, common challenges of autistic students, and the strategies they teach the students.

Attribute	Demographics
Age	19-39 years of age
Gender	4 female, 2 male, 1 transgender male
Autism	All identified as "being on the autism spectrum" and/or "autistic." 1 specified Asperger diagnosis noting it is no longer an official diagnosis
Period of diagnosis	3 were diagnosed in childhood, 1 as a teenager, and 3 as adults within the past 4 years
Level of education	All currently enrolled or graduated within past 2 years. University undergraduate (2); University Masters (2). Attended 2-year community college and then transferred to university (1)
Department	Technology design, applied theater, sociology, woman's studies, film studies, biology

Table 1: Summary demographics of student participants.

Interviews with Autistic Students in Higher Education

We interviewed seven autistic students (henceforth labelled as S#). We recruited students via email through higher education disability student services and autism therapy clinics. To protect participant anonymity, we report summarized demographics (Table 1) and not the specific characteristics of each participant. Students were interviewed in-person (4) or online (3). Sessions lasted from 50-85 minutes (average=67 minutes). The sessions had three components: (1) a semi-structured interview, (2) a Q-methodology exercise [38] to rank value statements, and (3) a collage activity. The interview questions covered their autism diagnosis and resulting experiences related to education, plus their attitudes and experiences regarding higher education teamwork.

Developing and Probing Stakeholder Values

As we developed our conceptual understanding neurodiverse student teams, we identified the key stakeholders as autistic students, neurotypical teammates, instructors, disability services staff and support peers. We generated value statements (Appendix A) to capture the important attitudes and tensions of autistic students. These statements were based on literature and a preliminary analysis of our interviews with disability service employees [58]. Four key values emerged: (1) individual comfort, (2) social comfort, (3) social connection, and (4) team cohesion (Table 2). We used the Q-methodology exercise to probe autistic students about these values and to get insights on value tensions. The Q-methodology exercise requires the participant to place value statements in a pyramid shaped grid, from least important to most important (Appendix A, Figure 1). This exercise provided an opportunity for participants to raise issues and experiences that were important to them.

Developing Teamwork Design Space and Concepts

We developed a design space to contain concepts of team-based technology that currently exist, or may, in the future. This teamwork design space has two dimensions: *team stages* and *stakeholder combinations*. On the *team stages* dimension, we examined the tasks and challenges of Tuckman's team model. On the *stakeholder combinations* dimension (solo, peer pair, teams, and student-instructor pairs), we explore how values of the students can influence with whom they want to share personal and project information.

Design Method: Collage Activity

We used a collage activity to elicit participant needs and impressions of the design concepts. We explained the collage activity as a joint-brainstorming activity in which we used images and text phrases to highlight main points. We presented abstract and photorealistic images representing key design concepts (Table 2), common technology (e.g., a calendar), and common team activities (e.g., presenting on a whiteboard). We briefly explained unfamiliar concepts, such as group mood boards [34,46]. To seed the brainstorming, we pinpointed a challenging team scenario that had emerged during the semi-structured interview. The participant and researchers co-created the collage with images, written notes, and hand drawings.

	Forming	Storming	Norming	Performing
Student	Self-reflection app on academic and team strengths and goals	Affective computing to convey mood (wearable; mood light) *; Stress relieving tool*	App to communicate teamwork needs and preferences; App to support autism disclosure (reduce emotional burden and misconceptions) *	Executive Functioning supports (e.g., checklists; schedules) *
Team	Team matching tool*; App to facilitate matching roles to strengths *	Group mood board *; Team negotiator app *	Collaboration tools that help distribute tasks	Collaboration tools to coordinate activities
Student + Instructor	App to facilitate disclosure and negotiate accommodations; Facilitate team contract on roles and rules *	App to request assistance from instructor	Class-based Q&A and note-taking to clarify project and roles*	Online forum for tracking team progress towards goals
Support Peer	Video modeling of discussing team selection with classmates	App to communicate during times of intense stress *	App to learn and share best practices for defining roles	Structured, online or text-based check-ins

Table 2. Teamwork design space, with rows of stakeholder combinations and columns of Tuckman's team stages. The design space is populated with design concepts that were seeded by researchers and employee interviewers, with a subset (*) substantiated by students during interviews.

Category	Code	Definition
Team stages	**Forming**	Processes for creating a team. Orientation; acclimatization. Desire for acceptance. Reliance on polite, safe, patterned behavior. Unsaid social norms. Determining roles; looking to a leader for direction.
	Storming	Conflict; emotions run high; chaos stage. Roles confusion. Team may experience cycles of storming.
	Norming	Agreeing on standards of group norms. Getting organized; creating a plan.
	Performing	Team functioning smoothly towards goals. Executing routines (e.g., attending meetings)
Values	**Individual comfort**	Being able to interact and work in ways that feel physically, emotionally, and intellectually natural to oneself. comfort with differences manifested with autism.
	Social comfort	Understanding and following social norms. Interpersonal interactions in a team setting. Supporting each other's needs. Includes people in and outside of team.
	Social connection	Connecting on a personal level in addition to a professional level. Disclosure of autism that deepens a relationship. Can be in a team context or college-wide context (e.g., peer mentoring; disability services)
	Team cohesion	Degree to which members of a team: (1) contribute to the task at hand and (2) foster productivity by setting and attaining project goals. Emphasis is on team deliverables.
Experiences	**Challenges**	Challenges with self or school environment. May or may not be connected to autism traits.
	Strategies	Personal and organizational strategies. Self-efficacy; cognitive shift and growth. Accommodations.
	Technology	Behaviors, attitudes, and perceptions related to current or future technology use.

Table 3. Final codebook with team stages, values, and experiences.

Data Analysis
The first author prepared a codebook based on team stages and emergent student values regarding teamwork, which are described above in "Developing and Probing Stakeholder Values." Using NVivo, the first and second authors then independently coded all interview transcripts. The research team iterated on code definitions and resolved discrepancies with coding. The final codebook (Table 3) consisted of Tuckman's team stages, the four student values, and codes based on challenges, strategies, and technology use.

FINDINGS
Similar themes emerged from the interviews with disability employees and students. We found that challenges and strategies were distinct in the stages of forming and storming, and overlapped during norming and performing.

Uncertainty During Forming
Challenges for autistic students in the forming stage include selecting team members or being excluded, judging compatibility, deciding whether to disclose their diagnosis, distributing roles, and identifying team leaders. Even before teamwork begins, three students discussed experienced anxiety as they anticipated team projects. The higher education staff relayed that the apprehension of teamwork can be such a high barrier that some students have chosen to avoid working in teams, as stated by E01, *"Some of these [autistic] students try to just do the project on their own. And it's not very successful."* Student participants discussed a range of team formation experiences: (1) teams assigned by the instructor, (2) class activity for students to form teams, and (3) students formed team without any mediation. Five participants expressed stress around team-formation, preferring when teams were assigned by the instructor. When forming teams on their own, two students noted that students often grouped based on existing relationships. If they did not know anyone, which was most often the case, then the remaining students chose each other by happenstance. As S01 described, *"One guy didn't know what he wanted to be in and one other person [was left out]. I just grabbed them."* Three participants mentioned concerns about team size. As stated by S05, *"The smaller the group, the better it works, when you're autistic. There's less people to have to deal with. There's less social cues to learn to recognize. It just kind of decreases the overall stress load."* A major unknown during the forming stage is teammate compatibility. Two participants expressed difficulties with teammates' work ethics. When asked what attributes he would like in a teammate, S02 explained, *"someone who has the same kind of work ethic schedule type thing…that tends to help me feel more comfortable."*

Potential stigma and experiences with disclosure began in the forming stage. One student never wanted their instructors or teammates to know they have autism, three students often disclosed, and three students were open to situationally disclosing. S05 was very comfortable disclosing, *"It would not surprise me if I reached the point where we're asked to pick groups, and I just stand up and say, 'Hey, I'm autistic. If you're ADHD, if you have a learning disorder, or you have any psych stuff going on and you don't mind being outed, come over here."* S05 articulated how professors could help in the formation process, *"One of the biggest helps would be if professors were willing to say, I can't discuss who in the class has neurodiversities. If you want to work with people who understand those things, send me an email."*

Three students said they distributed roles among their team members based on skillsets or interests as students volunteered themselves. Most students and employees discussed the importance of fair distribution of work and matching tasks to individual strengths. Explicit coordination by students or instructors helps distribute work, as noted by E04, *"I suggest to teachers that they provide more structure for groups; maybe assign roles themselves, or maybe assign roles for the project and let students choose roles."*

A key step during the forming stage is identifying a team leader. Students said team leaders were either assigned by the instructor, identified based on the roles (e.g., a theater director), or emerged as certain students took on leadership tasks. The team viewed the leader as the person who had experience, knowledge about what they are doing, and confidence in assigning tasks. Only two participants said they had been team leaders, one due to her expertise and the other due to her stated desired to take on new challenges. Contrastingly, S06 expressed discomfort with the role of leader, *"I knew what I was doing, but I wouldn't have been confident enough to instruct others on what to do."*

Design Concept for Automated Matching of Team

In general, participants responded positively to the concept of an application that would intelligently match classmates into teams. Participants said that such an app would enable them to avoid the social discomfort felt during happenstance practices. S02 described that automating the matching process would, *"make everything a lot easier. I don't know how you would implement it, so that way people wouldn't feel shame around certain work styles, and that would influence the way that they would respond. But if there was a way to eliminate that completely that would be absolutely ideal."*

Students preferred team matching to be based on compatibility of classmates, as determined by self-reported factors such as: (1) work ethic; (2) work timing (e.g.; deadline driven or finish work early); (2) collaboration preferences (e.g.; online or offline); and (3) personal criteria, such as increased comfort with other neurodiverse students. Personal criteria would need to respect preferences regarding disclosure and privacy.

Individual Comfort and Accountability During Storming

Within a *storming* stage, the main challenges that participants described were articulating their individual comforts and addressing accountability. Freedom from stigma, individual comfort, social comfort, and team cohesion were values that played into balancing tensions between personal and group preferences. Four participants described challenges from their inability to articulate their individual comforts to others. Six participants mentioned factors of individual comfort — physical limits, sensory limits, feeling emotionally overwhelmed, desire for structure — that caused tensions. How and what individual comforts a participant wanted to articulate was impacted by the identity they wished to establish. For example, one student was overwhelmed by her recent transition to college and was unable to articulate that stress to her teammates. In another case, the student had limited ability to travel comfortably so she missed team meetings and events without explanation. As a result, her team members rated her poorly in peer-evaluations and she felt that they interpreted her challenges as laziness or incompetence. Other students experienced challenges with auditory overload, especially in unstructured group discussions with many people talking and the unclear discussion direction. Participants also mentioned that lack of planning and structure came in tension with their personal desire for routine and straight-forward interaction. Another student spoke of a when a team member was completing tasks too close to the deadline for the participant's work and rest styles and forced him to wait and work at odd hours.

Students and employees described some approaches to resolving conflicts in the storming stage: personal reflection and self-advocacy and communication. Some resolving measures were discussed and acted upon within the same group project, while others used the storming phase from prior projects as a learning opportunity for how to approach future group projects. Three participants felt that self-reflection and adaptation was the best way to address challenges. They did not want their teammates to have to change behaviors or accommodate them. In these cases, the participants were more willing to forgo, or work to change, their individual comforts and identity to match social conforms and the team identity.

On the contrary, six participants discussed self-acceptance, power in their identity, and self-advocating for their needs as tools for conflict resolution. One student informed their team about their communication preferences (e.g.; text based chat) and challenges up-front to prevent later conflicts or to have a point of reference if a conflict did arise. In this way, she established her identity entering the team. Another student said she may disclose her autism, and thereby explain her challenges, if a conflict arose. In times of stress, S04 wanted to convey, *"I'm online, but having a bad day. So, I'm doing the bare minimum today"* or *"I'm having a horrible day and cannot do my tasks. Someone else needs to do it."* Participants described the emotional burden of facing social stigma and educating others. Participants discussed potential supports for disclosure, such as a script to follow to lessen the stress.

In addition to articulating individual comforts, three participants discussed tensions in trusting teammates to be accountable and committed. For example, two participants expressed anxiety from not knowing if a teammate was completing their share of the work in time. In a few instances, participants lost contact completely with teammates who were neither attending class nor responding to communications. Three participants also expressed concerns about their own accountability. This was especially true for participants who experienced periods of not working at their optimal level due to stress or illness. These concerns raised issues of identity for participants as they worried about whether, and how, to convey this sensitive information to their teammates.

Social support outside the team helped some students work through the storming stage. One student spoke of a professor who intervened and helped the team contact a member who had been non-responsive and therefore unaccountable. Another participant, S02, said she articulated her individual comforts with her friend outside of the team to get support and direction. *"I felt like I was being demanding, asking that [my partner finished by a certain time]. But I ran it by a few of my friends and they're like, Nah, you're fine."*

Design Concepts for Negotiating Conflict

An important first step toward resolving conflict is bringing focus to the conflict in a diplomatic manner. Affective computing technology is one way to make conflict more visible. For example, some affective design concepts have explored the use of lights that changed colors based on an individual's or team's mood. A socio-technical design concept that emerged during our research was a team negotiation application. Such an application could be an objective actor to mediate small and large conflicts around articulating individual comfort, such as requesting a break during a long meeting or recommending actions for when a team member misses a deadline. Participants had mixed responses to such technologies. Preference for techniques were driven by a desire to not feel "othered," to not feel pressured, and to facilitate two-way communication. Three participants thought this technology could equalize vulnerability of all team members rather than singling out the autistic student. To them, this concept had potential to support expressing their individual comfort while maintaining social comfort and freedom from stigma. Suggesting a break anonymously without having to actively intervene was appealing to them. S03 described a potential situation: *"If it suddenly went red because somebody's stressed out, then you could open it up to the floor. If nobody wants to talk about it, then the next response is, OK, let's all take 30 seconds, close our eyes, take a few breaths."*

Two participants found the affective computing design concepts invasive or overwhelming. They stated that having a direct, automatic reflection of their emotions or state would violate their privacy. They would rather regulate what emotions were conveyed as emotions influence their projected identity. One participant, S01, thought seeing their team member's emotions reflected in technology would be stressful and overwhelming, saying, *"If somebody looks red, oh, freaking out — oh my god, like they're angry at me or something, like, that would just be way too stressful."* The key take-away is that technology designed for the storming stage would need to promote team trust and an inclusive team identity.

Striving for Dependability in Norming and Performing

The stages of norming and performing are highly connected. Well established and followed norms was one of the biggest contributors to the team transitioning to and maintaining performance. Six participants especially appreciated the organization steps of the norming stage. Due to their preference for straight-forward instructions and interactions, they benefited from the team establishing clear plans. In turn, they had an increased sense of team identity, which helped participants feel like they were on the same page as their teammates. Six participants mentioned that keeping to the plan or clearly articulating updated plans allowed them to perform effectively within the group.

In addition to a clear project plan, setting expectations also helped structure the interactions among team members. These tactics included establishing technology for collaboration, a fixed agenda for a meeting, and a timeline to complete components of the project. S03 discussed norming the conversation structure of the weekly meeting that she had with her teammate, *"It was always, this is what I read this week, and this is what I think about it…So that it was a really structured, formatted thing*." She then described how helpful such structure was during the performing stage, so they could focus on work content. Support from instructors could also contribute to successful group performance as S04 explained, *"The professor has been sending the class emails throughout the semester sort of guiding the project along. She'll send out an update saying, 'Hey, you should all be at this stage of the project right now.'"*

Design Concepts for Assisting Workflow

Communication was key in many participant's descriptions of positive and negative experiences during their team's norming or performing stages. Technology played a major role in communication and collaboration in successful teams. Four participants discussed using Google Docs and Google Slides. Three students particularly appreciated the feature that supported the ability to comment on other's work in the same document. This allowed for asynchronous communication and provided structure to feedback. As S03 said, *"You share [Google Docs] and everyone gets their own color. And any time you are working on the doc, you work in that color, so that then you can leave notes for each other."* It also supported accountability, as they could watch the progress made by their teammates on the document.

Five students utilized messaging applications on their phones and computers to help plan and share progress. However, technology could also be a stressor for some participants. One student discussed challenges with a forum-style discussion board for collaboration, stating that the dis-organized style of posting made it difficult to follow ideas. S01 described how her individual comforts had switched from text-based communication to in-person, highlighting some strengths and weaknesses of both; *"[In-person,] it's more interactive. You can get up and just draw things and discuss ideas. Whereas [for] text, there's always a barrier…It's not spontaneous. I think at one point, when I was less social, this was a real help, because I was able to plan out what I was going to say. I wasn't put on the spot. I could think and edit things carefully."*

Three participants needed to reduce external stimuli while still attending in-person work sessions. To do so, one participant used noise-canceling headphones to reduce auditory stimulation in his work setting. Another participant used headphones to listen to nature soundtracks to help focus and calm her when she was not able to step outside.

DISCUSSION

Our interviews illuminated ways that neurodiverse teams benefit from clearly established team norms and conflict-resolution strategies. Typical team friction points can be particularly problematic for neurodiverse teams. In exploring design concepts for technology supports for friction points, participants had diverse responses to our design concepts. Thus, technologies need to address individuality, even when striving for universal design.

Social Translucence in the Teamwork Design Space

To further our understanding of team breakdowns and strategies, we integrated our findings into our design space. Our original design space had two dimensions: team stages and active users. However, these dimensions did not adequately capture issues around identity, disclosure, and social barriers. Students approached their project work according to their individual comfort, which impacts one's executive functioning, social interactions, and cognitive style. To address this gap, in the final version of our teamwork design space (Table 4), we added a third dimension to our design space, Social Translucence. Social Translucence posits that the social connections of a team

	Forming	Storming	Norming	Performing
Student (Neuro-typical or -atypical)	1. Self-assess individual working style, strengths, weaknesses (I) 2. Create intersectional profile including privacy and disclosure rules (I) 3. Neurotypical peers learn about neurodiversity; support disclosure conversations (I, V)	4. Add-in module to support changes in routines (I; Ac) 5. Support student to express confusion and needs *("Repeat, please")* (I, Aw)	6. Tech support to make needs and styles known to others (I, V) 7. Adjust profile (and sharing of attributes) as team bonds and negotiates roles (I)	8. Personal work space that can be incorporated into team deliverables (I; Ac) 9. Individual views of team calendars and work schedules (I; Ac)
Team	10. Shared note taking in class to discuss and clarify team assignments (V; I) 11. Tech-mediated group forming based on individual preferences, work ethic and work styles (I, V, Ac) 12. Definition and allocation of team roles (I) 13. Begin developing team identity (name, goals, common interests) (I)	14. Neutral conflict resolver when tasks past due, etc. (Ac) 15. Explicit communication of work tasks and social information, e.g., emotional state; confusion about instructions (V; Aw; I) 16. Chat history to help keep everyone on same page and for future reference, especially during times of change (V, Aw, Ac, I) 17. Convey engagement, when engaged in activities that could be misunderstood (headphones; laptop use) (I, V, Ac) 18. Team escalation to instructor (I, Ac)	19. Plan for variety of forms of CMC and collaboration (e.g., synchronous; asynchronous; video; text; images) (I) 20. Put in place team best practices (note taking, status reports) in the format that works best for team and individual needs (Ac, I) 21. Explicit knowledge of who owns a work task and explicit handoffs (V, Ac) 22. Supportive prompts for those who are not as comfortable speaking up (I; V) 23. Support different paces of communication (e.g., *"Message read and being considered"*) (I, Aw)	24. Tech actor as the project manager (Ac) 25. Support anonymous requests to take breaks, clarify information (I, Aw) 26. Manage transitions between online/offline work modes (V; Aw) 27. Nuanced engagement cues, e.g., members are collocated/remote; available/ limited availability; restrictions (V; Aw) 28. Team workspace allowing for different work styles (I, V) 29. Visualizations of collective team progress and group well-being (I; Ac)
Student + Instructor	30. Facilitate introduction to instructor, including individual needs and learning style (I, V)	31. Facilitate raising questions and escalating issues (I, Ac)	32. Upon request from student, instructor advises on role fit (I)	33. Performance reviews include self-reflection and teammate feedback (I, Ac)
Support Peer	34. Express apprehension about team projects and prepare (I)	35. Access support from peers, providing context about project and current issue (Ac)	36. Learning and practicing team norms (I)	37. Support building skills (e.g., presentations) (I, Ac)

Table 4. The final iteration of our teamwork design space incorporating Social Translucence. Each cell in this framework is an evolution of our design concepts, which are mapped to driving principle(s) of Social Translucence: Visibility (V), Accountability (Ac), Awareness (Aw), and/or Identity (I).

improve collaboration. We propose this theory should be extended to (1) advocate for social information to be made *more explicit* online and *in-person*, and (2) include a fourth principle, *identity*, to account for personal and group identity work that occurs during collaboration. Below, we expand on our arguments and describe a subset of our design concepts (cross-referenced with Table 4 design concept numbers).

Extending Social Translucence to Make Social Information Explicit Online and In-Person

A core premise of Social Translucence is that social information is apparent and appropriately acted upon when in-person. However, for autistic individuals, social information is *not* readily apparent and can cause misunderstandings and frustrations. For neurotypical team members who may not be aware of this challenge and/or diagnosis, knowing how to communicate effectively may be difficult. Neurodiverse teams could benefit from explicit visibility and awareness of social information when they are online and even in-person. For instance, in-person and online tools could help express emotional states or ownership over a work task (#15). Helpful features of online collaboration, such as asynchronous communication and explicit hand-offs of tasks, could be implemented for in-person interactions (#19, 21, 24).

Proposed Principle: Identity

Social Translucence encourages designers to make salient social information visible. We argue that a model for designing collaboration systems should have a rich description of *who* is visible. The identities of collaborators are not merely their name, organizational affiliation, and photo commonly found in CSCL profiles. Richer profiles would include salient attributes related to cognitive, social, and work styles (#1, 2, 29). The profiles would also be connected to a unifying team profile that would be used for team representation in CSCL, such as the submission team deliverables and showing team progress (#13, 28).

Designing for Identity

We focus on ways that technology can support values (e.g., individual comfort) and allow users to express those values in user profiles. For example, designing for individual comfort means accounting for (1) different modalities of communication that are accessible to the individual (e.g., text, images, voice, video, in-person); (2) options to choose between asynchronous and synchronous communication for meetings and work; (3) supporting UDL needs, such as role preferences (presenter, planner) (#11); and (4) work ethic for team matching and task delegation (#12). We propose these as profile attributes and personalized user experiences in CSCL and personalization initiatives. Due to the contextual, intersectional, and transitional nature of identity, technology should support self-assessments of personal needs (#1), faceted expressions of identity, changes to identity and disclosure (#7).

We call for a Universal Design approach that accounts for diversity across groups and individual differences within groups. In a neurodiverse group, disclosure of one's autism is a personal decision. The need for explicit identity (e.g., "autistic") should not be a prerequisite for accessing customized support in any environment. Regardless of disclosure status, students may seek visibility and awareness of their preferences and needs so they can be supported. Alternative ways to initiate support may help the individual access support despite the fear of stigma (#24, 25, 27). For example, a person can add an anonymous request of "*I need to take a break*" and the technology suggests this new or adapted task to the team workflow. Alternatively, students could pin a *"strengths and weaknesses"* column in their profile on a team page, which they may tailor to requirements of the project at hand. In that way, autistic students and others can explain their specific preferences, without disclosing a diagnostic label.

Another key design consideration is to balance individual and team identities. When presenting their work and deliverables outside the team, teams usually present themselves as a collective identity and their work as a collective effort. Recent studies suggest that in workplaces, individuals are motivated more to contribute in programs for physical and emotional wellbeing when they are enrolled as a part of a larger team rather than participating individually [20,22]. Features in the system can support group identity and actions taken as a group that develop in the norming stage (#13). During the critical stage of team norming, tools provide access to best practices for workflow process and foster team cohesion with fun, team bonding activities. During performing stage, tools can prompt the team to reflect on progress and fine-tune project plans. Future research could explore design concepts for collecting and visualizing collective team progress (#28).

Designing to Support Visibility

Socially translucent systems make *visible* the socially significant information with control over how much information is shared. During neurodiverse team interactions, the students are learning and adjusting to team norms and different communication styles. For example, some participants said they preferred asynchronous communication at times as it allows them time to process the information and respond. Current chat features allow awareness for when a person *"is typing"* or has read the conversation. However, most do not provide cues to the sender on processing or wait time, which may be misinterpreted as being ignored. To support different paces of communication, tools should include cues to convey that the individual is still active and allow for pauses and repeats during communication (#5, 23). In face-to-face settings, such wait times may lead to moments of awkward silence and misunderstandings. Using a communication aid to indicate that a person is thinking or wants the information repeated might facilitate mutual understanding.

Misunderstandings and hidden work occurred due to different working styles, especially when an individual's communication and work ethic differed from the team norm. Participants were unsure if their teammates were making progress, when their teammates would be done, and what would be expected of them when the document cycled back to their ownership. The often ad-hoc workflow process often involved manual collaboration steps, such as an email thread with notices like, *"I'm working on it offline until 3 pm."* Without clear team norms and proactive communication skills, these manual collaboration steps can easily be forgotten or misunderstood. Additionally, team norms improve with practice, repeated cycles of successful collaborations, and detailed advice from experienced collaborators, which are all factors often lacking in neurodiverse student teams. Collaborative systems could add more structured connections between documents and workflow processes (e.g., schedule, next steps). Also, systems could give instructors insight into the team's workflow practices to offer advice and share best practices.

Designing to Support Awareness

The second principle encourages creating *awareness* of what information is shared among collaborators and their constraints. Our research surfaced scenarios in which teams faltered when collaborators' engagement levels and constraints were uncertain. For participants, awareness of each other is not a binary status to only indicate: *"online/available"* or *"busy/away."* Related work has investigated workplace use of socially translucent status messages to indicate levels of concentration, time-pressure and disturbance [53]. Unlike a work setting, at school, norms are less established regarding time away or even dropping a class. Students expressed a need for reassurance about overall enrollment in a project and ongoing status. Student participants wanted to know, and share, more explicit knowledge about their teammate's location, mood, challenges, and intent of engagement. For example, a student may use technology to indicate a status of "*I can't get to my tasks today because I got called into work.*" Similarly, these types of technology-mediated expressions of status can also be helpful when meeting in-person. For example, someone can be physically present in a meeting but appear to be disengaged due to their behavior or body language. Technology-mediated in-person support could include explanatory status such as *"I'm on my laptop to take meeting notes."* or *"Stressed cuz I need to leave ten minutes early."* (#5). To normalize such expressions of limitations and needs, tools should elicit all teammates for their level of availability and personal well-being (e.g.; *"Would you like your team to know how you are doing?")* (#22, 27). The system can encourage all students to ask for help from others if they need it, such as with a prompt *"Need help? Ask your team members for what you need this week."* Such requests can then be relayed to other members who are available. Participants were most comfortable when team routines were predictable. To support adapting to changes in routine, such as meeting off-campus, technology could enact add-in module functionality (#4). A student could use the add-in to pinpoint the new location on a map, plan necessary commute changes, and request that the first teammate to arrive post a location flag.

Designing to Support Accountability

Socially translucent systems support *accountability* of actions among team members. When conflict arose about accountability of completing tasks, student participants described anxiety about speaking up, and if they did, they could not tell if they were being too pushy or anxious. Technology can be envisioned as a neutral tool for project management and conflict resolution (#14, 24). Scheduling tools could track if tasks are overdue and then probe the student who has not finished to either extend or report back on status and issues. Tools could also prompt other students to discuss and escalate issues of accountability with support systems (e.g., teaching assistants, trusted peers). These systems helped participants maintain their own accountability. However, these systems were not fully activated because students were unsure who was approachable and when. Technology could make supportive relationships more explicit, and availability status more transparent (#29, 30, 34). By coordinating task management and helping initiate support, technology can minimize the emotional stress of conflicts.

CONCLUSION

Our research motivates the need for HCI researchers and designers to support development of more inclusive socio-technical environments for teamwork. Throughout the team stages, successful team projects leverage team member strengths to form a cohesive team. Autistic students described ways that technology can act as a mediator to provide them support and structure in navigating the challenging environment of higher education. There is a need to protect privacy of these individuals, while supporting equity within the team. By incorporating the notion of identity into the design of socially translucent systems, technologies can give people control over disclosure and mechanisms to advocate for their needs in accessible, respectful, and discrete ways. Our tailored design space for teamwork can be used to explore more socially translucent ideas by considering stakeholder values as they are negotiated across team stages. Future research should prototype and evaluate team-based technologies for neurodiverse teams to refine our design space and design concepts. This advancement can help mediate interactions among teammates, peers, and instructors, and ultimately, support neurodiverse adults as they pursue their goals in higher education.

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