Fostering Psychological Safety for Interpersonal Learning in Neurodiverse Software Teams

Darren Butler
ddbutler@andrew.cmu.edu
Carnegie Mellon University
Pittsburgh, Pennsylvania, USA

Abstract

In software engineering, psychological safety is the shared belief that team members feel safe to take interpersonal risks in the form of learning behaviors like seeking feedback or admitting mistakes in the workplace [3]. Psychological safety plays an essential role in communication, especially in tightly coupled team activities like mob programming (i.e., mobbing), in which three or more team members develop software together [35]. Mobbing requires members to play different roles while suggesting and digesting new ideas, which makes them particularly vulnerable to interpersonal risk. Autistic software engineers can struggle with mob programming, as they experience high levels of anxiety and stress when communicating with others due to their different cognitive and communication styles, and commonly co-occuring conditions like ADHD and social anxiety [13]. A collaborative space that allows autistic team members to flexibly communicate in neurodiverse teams can increase the psychological safety and accessibility of collaborative software development.

To identify tools and practices that foster psychological safety in neurodiverse collaborative mob programming, I will conduct a series of mixed-method, design-based studies. First, I conduct a survey and interview study to uncover the relationship between neurodivergent cognitive and communication traits and psychological safety in teams. Second, I generate design principles for psychological safety through the iterative design and evaluation of a neuroinclusive digital collaboration space. Third, I evaluate the impact of these design principles through an experiment with majority, minority and all neurodivergent teams.

My work makes the following contributions to accessible software engineering education and practice: 1) Novel descriptions of psychological safety relating to neurodivergent cognitive and communication attributes; 2) design principles for fostering psychological safety in collaborative software development teams; 3) a software development tool that scaffolds psychologically safe mobbing in neurodiverse software teams.

CCS Concepts

• **Human-centered computing → Empirical studies in HCI**; **Empirical studies in accessibility**; **Accessibility systems and tools**; • **Applied computing → Collaborative learning**; **Distance learning**; • **Software and its engineering → Programming teams**.

Keywords

collaborative learning, accessibility, neurodiversity, software engineering

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1 *Questions and Connections*

I am a Ph.D. student in Human-Computer Interaction at Carnegie Mellon University. I research psychologically safe collaboration in neurodiverse software teams. I aim to discover design principles for collaborative software development tools that enable equitable collaboration between software developers of different neurological profiles. This will be useful in increasing team satisfaction, well-being, and software quality [36].

I have published in top-tier venues such as ACM CHI and LAK. My previous work focuses on supporting students in rural Africa in distance STEM learning by describing the relationship between student demographics, behavior, and learning outcomes [12, 24].

As a Ph.D. student, my goal is to produce knowledge that supports novice software developers in developing skills for collaborative software development. I focus on the neurodivergent developer experience with distributed software teams to uncover design principles and develop novel systems for accessible collaboration. Equitable collaboration requires psychological safety and social and emotional skills [16, 36]. Upon graduation, my goal is to acquire an applied industry research position to introduce new tools to support the career advancement of novice software developers.

I would like assistance with the following key questions under investigation:

- **RQ1** What is the relationship between autistic traits and psychological safety in software teams?
- **RQ2** What collaborative software design principles scaffold psychological safety for autistic software team members?
- **RQ3** How do collaborative software design principles scaffold psychological safety in majority, minority, and all autistic software teams?

Key connections that would aid my dissertation research include introductions to: 1) collaborative learning researchers; 2) psychological safety researchers; 3) a potential external committee member.

2 Motivation

Software engineering requires psychologically safe collaboration and interpersonal learning, where team members feel safe to take interpersonal risks such as asking for help [2, 16]. However, neurodivergent people may process feelings of psychological safety differently than most. For example, autistic people may experience alexithymia, which means they struggle to identify or describe emotions, leading to delayed reactions [9]. To accommodate the diversity of social-emotional needs towards psychological safety, software teams need flexible communication tools during software team events.

3 Literature Review

3.1 Psychological Safety in Software Engineering

Psychological safety in software engineering is the shared belief among team members that it is safe to take interpersonal risks on the job [2]. Various constructions identify a psychologically safe environment, including comfort in communicating opinions, comfort in revealing mistakes, and the feeling of being valued by others [36].

Psychological safety has several advantages for software teams. Psychological safety fosters knowledge sharing, clarifies team norms, and complements agile values. It supports a team's ability to pursue software quality. For example, Alami et al. [3] found that admitting mistakes and taking initiative help teams learn and invest their learning in future software quality decisions. In addition, teams can couple technological tools and procedures with social strategies to promote software quality. Psychological safety also predicts self-assessed performance and job satisfaction of individual members [25].

Psychological safety in software teams requires that individuals cultivate an environment of no blame, openness, and collective decision making [2]. Human factor software engineering research has focused on mental health [41], but lacks in-depth descriptions of the relationship between common forms of neurodivergence and psychological safety in software engineering environments.

3.2 Autistic Students in Computing

Autism is a subset of neurodiversity, with many autistic people having co-occurring conditions such as ADHD or anxiety disorder [4]. Autism is a lifelong neurological condition that affects an individual's communication and social abilities, along with restricted and repetitive behavior, interests, or activities [4]. There are over five million autistic adults in the United States of America [39]. During the next decade, up to 1.1 million young autistic people are expected to turn 18 and age out of the services provided under the federal Individuals with Disabilities Act (IDEA) [11]. 50% of autistic people lack an intellectual disability (possess average or above average intelligence); 16% will choose a field related to computer science [39]. This suggests that a large group of autistic adults will enter the job market and postsecondary education.

Autistic students entering computer science without intellectual disabilities demonstrate an aptitude for technical skills in software engineering. These aptitudes include attention to detail, high level of focus, comfort with repetitive tasks, and ability to visualize problems [5–7, 30]. These aptitudes align with programming-centered attributes associated with great software engineers and products by Li et al. [26].

Despite technical aptitudes for computing, autistic people face considerable challenges in education and employment. Autistic people experience an 85% rate of unemployment and underemployment in the United States due to social stigma [33]. The unemployment rate for autistic people is significantly higher than in any other disability group, including learning disabilities, intellectual disabilities, or speech-language impairment (47% for other disability groups) [11]. Challenges in communication and social stigma challenge autistic students' advancement in education and employment. For example, Cage and McManemy found that autistic students experienced higher rates of burnout and mental health symptoms and were more likely to consider dropping out of college [13].

I consider the strengths, challenges, and promise of autistic students in software engineering education and practice. Given previous work, I focus on the need for software engineering pedagogy that better supports the cognitive styles and talents of autistic students.

3.3 Communication in Software Engineering

Communication is an essential soft skill for students in software engineering [19, 32, 37]. Soft skills are usually under-taught in software engineering and computer science courses, despite their importance. Educators and trainers in software engineering recognize the need for graduates to possess robust communication skills applicable in real-world scenarios [1, 8, 40]. Universities often attempt to equip their students with these skills by either mandating that Computer Science and/or Software Engineering (CS/SE) students enroll in communication courses conducted by another department or labeling specific SE courses as communication-intensive. However, neither of these methods has satisfied the calls for more efficient ways to prepare students for communication on SE topics within real-world professional contexts [23].

Previous work investigating software engineering pedagogy for communication and collaboration in four-year colleges and universities. For example, VanDeGrift found that students perceive benefits in pair programming, such as less frustration and less workload [38]. Furthermore, Hundhausen [21] found that participation in social network-style activity streams was positively correlated with students' grades. These studies demonstrate the growing research agenda to support software engineering communication.

Few studies investigate the implementation of software engineering communication pedagogy in 2-year institutions. Community colleges operate with significantly fewer resources for core academic and student support functions than public four-year institutions [15]. This disparity in resources can translate into less capacity to implement new pedagogy as student and industry needs evolve.

In addition, many community college students are not 18-21 years old, but instead are returning to school for upskilling or reskilling after becoming dissatisfied with their previous careers. They may have had poor experiences with discrimination and

stigma against their unique communication styles, which lead them to be apprehensive about opening up in an educational setting.

The lack of explicit instruction and scaffolding for communication and collaboration practices creates additional barriers for autistic students. Software engineering courses tend to involve projects that rely on communication and collaboration between students, such as pair programming [38, 42] and stand-up meetings [29]. This practice mirrors real-world software engineering practice. These communication practices tend to be implicitly adopted by non-autistic students (students without autism) [4].

Autistic individuals have difficulty appreciating non-autistic social rules by observation. The Double Empathy Problem is a theory that refers to mutual challenges in communication and understanding that occur when individuals from different neurotypes, such as autistic and allistic individuals, interact with each other [28]. In software development, autistic people tend to prefer events that are less dynamically flowing, less ambiguous, and slower paced [30]. Previous studies have suggested setting communication ground rules to mitigate these issues and using videoconferencing mechanisms to build trust among team members [34, 43]. This practice benefits autistic individuals as they do well when they can co-create a set of social rules agreed upon by everyone in advance [43]. Thus, I design a digital collaboration space that is aware of the needs and preferences of autistic students by incorporating elements that support parallel speaking and non-speaking communication in remote collaboration.

3.4 Universal Design for Learning

Universal Design for Learning (UDL) encompasses principles that recognize that traditional curriculum may not serve the learning preferences and needs of less traditional learners (e.g., autistic students) [10, 17]. UDL is based on the idea that rather than retroactively adjusting instruction that may be inaccessible to certain students, teachers should proactively design instruction to be engaging and accessible to a wide range of users from inception. UDL is grounded in three fundamental principles derived from cognitive science research: 1) providing various ways for students to *engage* with the material, 2) offering multiple *representations* of content, and 3) allowing a variety of methods for students to *act and express* their knowledge [22]. Each of these principles is detailed by three guidelines and supported by checkpoints that illustrate their application to instructional planning. When considered collectively, these principles, guidelines, and checkpoints assist educators in improving access and engagement in the objectives, strategies, resources, and evaluations used in teaching.

Previous work has explored the benefits of UDL in computing education [18, 31]. For example, Moster et al. found that UDL guidelines such as providing scaffolded (well-structured) instructions helped to increase self-efficacy in communication skills among autistic students [31]. UDL offers strategies to facilitate universally beneficial implementation, such as fostering collaboration, scaffolding, offering real-world experiences, and creating outcomes that address varying learning preferences. To further assess the efficacy of universal learning design implementations, it is imperative to identify the strengths and weaknesses of certain implementations in a variety of contexts. Previous works [18, 31] apply the universal design for learning for autistic students at the K-12 level. I investigate the usefulness of UDL principles in adult software engineering education.

4 Thesis

Software development is a social and emotional experience. Neurodivergent software developers have particular social and emotional experiences. Psychological safety is a social-emotional need important for collaborative software development. A collaboration tool designed with neurodiversity and a universal learning design in mind can provide neurodivergent people a flexible means to suggest and digest ideas in a way that feels psychologically safe.

5 Methods

5.1 Participants

I recruit participants from an online career development program designed to prepare autistic community college students in the United States for careers in AI-integrated software development. Participants are 18 years or older, have passed college classes in programming, and have passed mathematics courses such as statistics, calculus, and linear algebra.

5.2 RQ1: Relationship Between Neurodivergent Traits and Psychological Safety

Neurodiversity contains a diverse range and categories of cognitive, social, and emotional characteristics. Diverse mental profiles contribute to different preferences, abilities, and interpretations in social settings. Thus, understanding how neurodivergent individuals interpret the characteristics of social environments as psychologically safe is a step toward tuning collaborative tools and processes to individuals in a team.

I survey participants on their neurodivergent traits using the Deenz neurodiversity scale [14], which requires participants to rate agreement with questions such as ‘I sometimes struggle to understand when someone is joking.‘ Participants share their experience with psychological safety in collaborative work using the Edmonton Scale for Psychological Safety [16] with additional open-ended questions. For example, the requires participants to rate their agreement with statements such as ‘It is difficult to ask other members of this team for help.‘ I follow up with semistructured retrospective interviews with participants to explain their responses to surveys explaining in more depth and providing more context to their experiences. I repeat the psychological safety scale and the retrospective interview protocol before, midway, and after the program to understand how the experience of psychological safety develops with repeated collaboration.

5.3 RQ2: Identify Design Principles for Psychological Safety

Adapted from an industrial practice, Online Mob Programming (OMP) is a technique in which a group of 4-6 students collaborate online through a structured process to solve programming tasks [35]. This process involves taking an interpersonal risk, in which participants suggest and digest new ideas, and requires psychological safety to initiate. The aim is to identify design principles

to foster psychological safety in tools and processes collaborative software development using mob programming as a case study. The principles of universal learning design provide general guidelines for accessible learning environments [17]. For example, people who process speech at slower rates may feel more included when teammates visually represent their ideas. Using principles of universal design for learning, I iteratively design a collaborative visual space using a digital whiteboard to scaffold the collaborative practice of mob programming. In each iteration, I collect observations and self-reports of how participants use and talk about the design of the call to safely communicate ideas towards a shared solution to the programming problem [20]. This data is then used to refine the initial conjectures about psychological safety in collaborative software development and produce new designs that will ultimately test such hypotheses.

5.4 RQ3: Impact of Design Principles in Teams of Different Neurodiversity Compositions

Team composition may affect relationships and productivity [27]. Using the design principles and prototype resulting from RQ2, I conduct a follow-up quasi-experiment with a new cohort of majority, minority, and all neurodivergent teams to assess differences in feelings of psychological safety. The three teams will receive the tool and a mob programming ask. Their expectations of psychological safety will be measured before the tasks. After the task, participants will reflect on the psychological safety they experienced during the task through a post-survey and individual retrospective.

6 Conclusion

My work makes the following contributions to accessible software engineering education and practice: 1) Novel descriptions of psychological safety relating to neurodivergent cognitive and communication attributes; 2) design principles for fostering psychological safety in collaborative software development teams; 3) a software development tool that scaffolds psychologically safe behavior in neurodiverse software teams.

I am on track to complete my dissertation by Spring 2027. The aim is to propose the described work in Spring 2026. I appreciate guidance on methodology, feedback on proposed contributions, and connections to relevant work and people to inform my approach to research.

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