Building Your Personal Toolkits to Becoming an Effective TA

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Abstract

Teaching assistants (TAs) play a critical instructional role in STEM courses; however, their preparation is often limited to brief, policy-focused orientations that do not adequately address the pedagogical, intrapersonal, interpersonal, and professional demands of the role (NAP, 2017; Barno et al., 2026). This paper examines the design, implementation, and analysis of a multi-session graduate TA training program, Building Your Toolkit for Becoming an Effective TA, developed and delivered at our institution over a two-year period. Four iterations of the workshop were conducted, with cohort sizes ranging from 25 to approximately 100 participants, using interactive and practice-oriented learning activities.

The training framework operationalizes a holistic model of TA preparation that integrates instructional strategies with intrapersonal and interpersonal competencies essential for student success, including motivation, self-efficacy, sense of belonging, communication, teamwork, and leadership. Using thematic analysis of trainee-generated artifacts and student course feedback, we examine how TAs conceptualize their instructional roles and how training principles are reflected in classroom practice. Analysis of trainee group work reveals consistent themes related to structural clarity, communication norms, shared responsibility, and collaborative accountability. Student feedback from courses taught by trained TAs indicates evidence of successful application of scaffolding and communication strategies, alongside persistent gaps in fostering belonging and clearly defining TA roles.

These findings underscore the importance of anchoring TA professional development in a learning-science framework and highlight the need for sustained reinforcement to support consistent implementation. By linking training design to trainee conceptualizations and student-reported experiences, this study contributes to ongoing efforts to strengthen TA preparation and enhance undergraduate STEM learning environments.

A. Introduction

Traditionally, teaching assistants (TAs) in our department have received minimal preparation beyond university-level orientations that emphasize institutional policies and administrative procedures. New TAs are frequently assigned instructional responsibilities without a clear understanding of pedagogical expectations, instructional roles, or the scope of their interactions with students. Consequently, many develop their teaching practices through trial and error, often without structured guidance aligned with the learning demands of complex disciplines such as computer science. Prior research suggests that such ad hoc preparation is neither an efficient use of instructional resources nor an effective professional development model, particularly in STEM contexts where TAs play a critical role in laboratories, recitations, and

discussion sections (Gardner & Jones, 2011; Wyse et al., 2014). Insufficient preparation may therefore limit both TA effectiveness and student learning outcomes.

A substantial body of literature demonstrates that structured TA training improves instructional quality and student outcomes in STEM education. Well-designed professional development programs have been shown to increase TAs' confidence and self-efficacy, promote the adoption of evidence-based teaching practices, and enhance overall teaching performance (Becker et al., 2017; Smith et al., 2023). Moreover, TA training has been associated with improved student engagement, conceptual understanding, and academic achievement (Hughes et al., 2013; Love Stowell et al., 2015). These findings position TA preparation as a critical leverage point for improving undergraduate STEM education. While prior research demonstrates that TA training improves self-efficacy and instructional practices, fewer studies examine how TA professional development explicitly integrates intrapersonal and interpersonal learning science frameworks, nor how such frameworks translate into observable instructional behaviors. This study contributes to the literature by (1) operationalizing a holistic TA competency model grounded in learning science and (2) analyzing alignment between training design, TA conceptualizations, and student-reported classroom experiences.

Building on this literature, we developed a theory-informed TA training program grounded in learning science and the development of intrapersonal and interpersonal competencies. In addition to instructional communication and active learning facilitation, the program emphasizes TAs' roles in supporting students' motivation, self-efficacy, sense of belonging, collaboration, and help-seeking behaviors—competencies increasingly recognized as central to academic persistence and success in STEM fields (National Academies of Sciences, Engineering, and Medicine, 2017). The training encourages reflective practice and peer exchange, fostering a community of practice oriented toward continuous instructional improvement.

This study examines the design and implementation of this TA training program and analyzes how its conceptual framework is reflected in both TA-generated strategies and subsequent student feedback. Specifically, we investigate how TAs interpret and operationalize instructional, intrapersonal, and interpersonal responsibilities following participation in the program.

The study is guided by the following research questions:

RQ1: How do TAs conceptualize instructional, intrapersonal, and interpersonal responsibilities following participation in the training program?
RQ2: To what extent do trainee-generated strategies align with established learning science constructs (e.g., self-efficacy, belonging, scaffolding)?
RQ3: How are training principles reflected—or not reflected—in student feedback from courses taught by trained TAs?

B. Program Design

B.1 Organization of the TA Training Program

To date, we have conducted four TA training courses over four consecutive semesters, excluding summer terms. All TAs were from the disciplines of Electrical Engineering and Computer Science, with the vast majority (approximately 80%) assigned to computer science courses. In the first two offerings, we accepted only 25 TAs who volunteered to participate in the program. In the last two offerings, participation was required for all TAs. These two sessions each had approximately 100 participants.

We identified the following **core operational skills** essential for students to become effective TAs:

1. Understanding course content sufficiently to support use of varying instructional strategies
2. Managing student expectations
3. Effectively assessing student work
4. Addressing students' questions
5. Efficiently using office hours to help as many students as possible
6. Supporting students who face academic challenges
7. Seeking professional development and ongoing feedback

We also identified a robust conceptual framework upon which to anchor TA training that builds upon how people learn and the role of socio-psychological competences (e.g., self-efficacy, motivation) to have a lasting impact.

To prepare for the training, we created a **professional development handbook** in partnership with Northeastern University's Center for Inclusive Computing (CIC). The handbook, which guides trainees through two interactive sessions, consists of the following five sections:

1. Orientation to Being a TA
2. University TA Professional Development Handbook Components
3. Understanding the Role of Intrapersonal and Interpersonal Skills in Motivating Student Academic and Personal Success
4. Increasing Learning and Student Academic Success
5. TA Strategies for Teaching that Promote Student Academic Success

The sections are studied sequentially. During training, the trainees are divided into groups of five to six members, seated at round tables. For each handbook section, instructors introduce a sequence of key topics followed by prepared questions which guide group discussions. At the end of each section, a TA representative from each group shares their ideas or solution strategies with the entire class, followed by a Q&A session.

In the next two sections, we focus on the third section listed above, *Understanding the Role of Intrapersonal and Interpersonal Skills in Motivating Student Academic and Personal Success*, as we believe this component to be one of two key topics in the overall TA training program. While academic content support is essential (Bransford et al., 2000), students' success is often strongly influenced by their sense of belonging, confidence, and ability to communicate and seek help. TAs are frequently the most accessible point of contact for students enrolled in their section, so their capacity to foster supportive, inclusive, and respectful learning environments can significantly shape students' academic persistence and personal development, particularly in demanding STEM courses (Bransford, et al. (2000)).

B.2 Help Students Develop Intrapersonal Skills

Table 1 highlights five important intrapersonal skills TAs need to help their students master to boost their success both academically and personally: **motivation, self-regulated learning, self-efficacy, sense of belonging, and growth mindset**. Collectively, these skills influence how students engage with course material, persist through challenges, manage complex learning tasks, and complete the course with a grade of C or higher.

Motivation underpins students' willingness to invest effort, remain attentive during instruction, and persist when tasks become difficult. Self-regulated learning enables students to plan, monitor, and adapt their learning strategies, fostering greater independence and success when tackling new or complex material. Self-efficacy shapes students' beliefs in their ability to succeed, supporting perseverance, flexible problem-solving strategies, and positive expectations for future academic outcomes.

A sense of belonging plays a crucial role in students' comfort and engagement within learning environments, contributing to improved academic performance, stronger peer relationships, and higher retention, particularly in inclusive STEM settings (AAAS, 2023). Finally, a growth mindset encourages students to view intelligence as malleable, motivating them to embrace challenges, seek help when needed, and adopt new learning strategies in response to difficulty.

Across these skill areas, TAs are positioned to intentionally support students' development by thoughtfully designing instructional materials, posing guided questions, modeling reflective thinking, and fostering supportive classroom interactions. By attending to these intrapersonal

skills, TAs can meaningfully enhance students' capacity for both academic achievement and personal growth.

For each skill, trainees are asked to provide their ideas and strategies to help students build such a skill.

Table 1: Five Intrapersonal Skills

Importance: Guide an individual's success and self-management		
TA Actions: Think critically about your lessons, the design of the materials you will use, and the guided questions you will ask.		
Skill Category	**Description/Benefits**	**TA Strategy Use to Support Students' Effectively Building these Skills. *List Key Points***
Motivation (a personal skill that leads to task completion, satisfaction, increases in learning)	*Leads to students (1) being more attentive during learning, (2) accomplishing more during lessons and beyond, and (3) putting forth greater effort when a task is difficult, and they want to display mastery	(To be completed as part of the training)
***Self-Regulated* Learning** (an internal personal ability leading to intrinsic motivation and self-determination as to what is needed and when it is needed in order to complete tasks or activities)	*Leads to students (1) carrying out successful processes when learning something new or completing a complex task, and (2) knowing what to do and when to do so with more self-reliance.	
Self-Efficacy (an individual's belief in their own capacity to achieve and preserve under most conditions)	*Leads to students (1) perseverance even under difficult tasks, (2) use of varied cognitive strategies to solve complex problems, and (3) have high expectations of future outcomes and opportunities.	
Sense of Belonging (an attribute that involves people being open-	* Leads to students (1) ease of building relationships, (2) improved academic performance, (3) improved retention	

minded, comfortable with others, more engaged, greater interest in doing well, and supportive of others' learning) (Source: AAAS, 2023)	rates, and (4) having more inclusive environments for themselves and others.	
Growth Mindset (a person's belief that their intelligence is not fixed so that they continue to learn and increase their knowledge and abilities they can continue to increase their intelligence)	*Leads to students (1) trying harder, (2) investing in new ways of learning, and (3) seeking help to address learning challenges because they believe that they can improve.	

B.3 Help Students Develop Interpersonal Skills

Table 2 identifies four key interpersonal skills that support student success through effective interaction with others: **communication, teamwork, intercultural competence, and leadership**. These competencies are broadly applicable across learning contexts and play a critical role in shaping how students collaborate in STEM environments. Additionally these competencies have been identified as key factors when students enter the workforce.

Effective communication enables students to clearly exchange ideas while achieving shared understanding. This includes active listening, accurate perception of others' perspectives, and appropriate verbal expression across multiple platforms. Strong communication skills support clearer reasoning, more productive discussions, and reduced misunderstandings during collaborative academic work (Lumina Foundation, 2015).

Teamwork emphasizes the collective ability of individuals to work toward shared goals by pooling expertise, negotiating meaning, and integrating diverse ideas. When students develop teamwork skills, they are better able to collaborate effectively, co-construct knowledge, and produce higher-quality outcomes than they could individually.

Intercultural competence encompasses the beliefs, skills, and behaviors that promote openness, respect, and engagement with diverse perspectives. This competence enables students to interact constructively across cultural, social, and disciplinary differences, contributing to more inclusive learning environments and improved collaboration in increasingly diverse STEM classrooms.

Finally, leadership involves the capacity to guide decision-making, solve problems, and support the development of others. Leadership skills encourage students to take initiative, reason through complex challenges, and contribute positively to group progress, even when they are not in formal leadership roles.

Together, these interpersonal skills enhance students' ability to collaborate effectively, engage respectfully with others, and contribute meaningfully to shared learning experiences. TAs play a critical role in modeling and reinforcing these competencies by facilitating discussion and promoting collaborative activities in classroom interactions and beyond.

Table 2: Four Interpersonal Skills

Interpersonal Skills are developed and used when students are interacting with other students, faculty, and/or other individuals		
Definition: Interpersonal competencies – abilities and skills that result from interaction with others and are broadly applicable across groups		
Skill Category	**Description/Benefits**	**Skill Promoting Strategies for TA Use**
Communication (an ability to transmit information and ideas while also achieving shared understanding) *[**Links to CIC**: Effective communication: Barriers and Strengths]* [Active listening, perception, verbal communication]	Leads to students effectively using language to transmit information, ideas and feelings, skillfully using translations to provide information, and transmission of information across platforms. [Lumina Foundation, 2015).	(To be completed as part of the training)
Teamwork (a collective skill of a group of individuals who aim to achieve a set of goals, better performance, combine expertise for greater outcomes)	Leads student to work together effectively, pool and coalesce ideas into more coherent passages, negotiating meaning).	
Intercultural competence (a set of beliefs, skills and behaviors that lead to openness, tolerance and engaging in diverse perspectives)	Leads students to engage with open-minded perspectives when interacting with individuals across varying contexts.	

Leadership (a set of competencies and abilities that support effective decision-making and problem solving, and the capacity to generate reasoned predictions)	Leads students to reasoned decision-making and active problem-solving abilities, and fosters ability to guide the development and success of others.	

B.4 Building TA Proficiency in Applying Group Work in their TA Sessions

During the 2-hour training sessions, TAs were organized into groups of five to six and asked to design concrete strategies for implementing group activities in their STEM sections to enhance student learning and problem-solving. The resulting artifacts (Table 3) were analyzed using thematic coding to identify recurring patterns in how trainees conceptualized effective teamwork.

Analysis revealed several dominant themes. First, structural clarity emerged as a foundational principle across groups. TAs consistently emphasized the need for clearly articulated goals, explicit role definitions, and shared accountability structures. Rather than viewing teamwork as an informal activity, participants framed it as a structured instructional strategy requiring intentional design and oversight. This suggests that trainees internalized the importance of instructional scaffolding, extending it beyond content delivery to collaborative processes.

Second, communication norms and coordination mechanisms were widely foregrounded. Groups proposed structured brainstorming sessions, scheduled check-ins, brief progress presentations, and the use of collaborative tools (e.g., shared repositories, virtual meetings, discussion platforms) to sustain alignment. These strategies reflect an understanding that effective collaboration depends on ongoing interaction rather than one-time task assignment. Notably, communication was framed not only as information exchange but as a mechanism for maintaining engagement and collective progress.

Third, trainees emphasized distributed expertise and accountability, advocating for intentional task allocation based on individual strengths while preserving collective responsibility. This reflects an emerging awareness of how role differentiation can both leverage individual competencies and reduce social loafing—an issue frequently associated with poorly structured

group work. The emphasis on equitable workload distribution and role rotation further indicates attention to fairness and sustained participation.

A fourth theme involved conflict management and collective problem-solving. Several groups acknowledged that disagreement and diverse perspectives are inherent to collaboration and proposed open discussion, negotiation of meaning, and collective resolution strategies. This framing positions conflict not as a barrier but as a potential driver of deeper conceptual understanding, aligning with collaborative learning theory.

In addition to structural mechanisms, trainees identified interpersonal dispositions—including respect, reliability, adaptability, motivation, and active listening—as essential conditions for effective teamwork. The integration of these dispositions alongside procedural strategies suggests partial alignment with the program's broader emphasis on interpersonal competencies. However, explicit references to belonging and inclusive climate were less frequent, indicating that while trainees recognized the mechanics of teamwork, the socio-emotional dimensions were not uniformly foregrounded.

Finally, participants demonstrated awareness of instructional and institutional constraints, noting that successful implementation depends on course design, faculty expectations, grading policies, and TA authority. This acknowledgment reflects a developing professional understanding of the TA role within broader instructional ecosystems.

This pattern indicates strong alignment with instructional scaffolding principles but partial alignment with the program's intrapersonal framework, particularly regarding belonging and affective climate (Table 4). At the same time, uneven attention to socio-emotional dimensions highlights areas where deeper integration of the intrapersonal and interpersonal framework may be necessary in future iterations of the training.

Table 3: Strategies for the Topic Teamwork Suggested by Trainees (as Groups)

Group #	Suggest Group Strategies	TA Notes - Comments
1	TA ideas for engaging students in their section: • Encourage teamwork as teamwork is "dreamwork" • Promote open communication • Support and model how students understand each other's strengths and weaknesses • Celebrate individual achievements as a "team achievement" • Provide clear communication about final objectives of the team	(To be used during training)

	• Know proper roles and responsibilities among team members • Trust each other's abilities • Make sure to spend time in recreational activities • Offer brain-storming sessions	
2	TA ideas for engaging students in their section: Have students learn how to • Share responsibilities • Know how to handle conflicts • Work with each other to solves problems • Engages effectively in discussing goals, strengths and weaknesses, diverse ideas, different perspectives on achieving goals, roles.	
3	TA ideas for engaging students in their section: • Gets each team member to know about each other • Encourages open communication • Engages in problem-solving as a group • Uses multitasking platforms like Git-hub, Zoom meetings, discussion posts on Canvas • Gets feedback from the group to achieve their goal	
4	TA ideas for promoting teamwork: • Check to see if the professor want teamwork. • Check to see if students are interested in engaging in teamwork. • Check to see if the professor allows the TA to have leverage in implementing and grading individual work as part of a team.	
5	TA ideas identified as important when engaging students in their TA section in teamwork: • motivation, adaptability, communication, collaboration, reliability, respect, active listening, and problem-solving	
6	TA ideas for promoting teamwork: • Assign group projects with each member having respective roles and responsibilities • Create tasks similar to this one we are working on now • Distribute the workload based on team strengths! • Then share their insights/learning	
7	• Characteristics identified as important when engaging students in their TA section: understanding topics, having everyone participate, making sure there is an equal distribution of tasks, and ensure all are making adequate progress (synchronization)	

8	Characteristics/skills identified as important for students to be developing while they are participating in our TA section: • problem solving skills, leadership skills, sharing knowledge, team-based challenges, inclusion and accessibility, sharing new ideas, varying and rotating roles, and equal participation and task distribution	
9	Activities to consider when being a TA: • Have students get to know each other—identify student's strengths and interests in relation to the project • Plan, organize, and distribute the workload evenly • Encourage conversation and understanding of the project (good research) • Encourage ethical collaboration and good synchronization	
10	Activities for students for promoting teamwork that the TA should consider: • Collaborate on common goals • Acknowledge efforts • Practice and encourage time management • Be sure to have clear roles and responsibilities • Use ice breakers • Encourage debates where helpful in discussing ideas	
11	Activities for students for promoting teamwork that the TA should consider: • Coordinate group activities • Share ideas together • Model collaboration techniques • Incentives and rewards • Competitions • Encourage pursuit of new opportunities • Motivate growth mindset • Bonus: determine roles, strengths and weaknesses	
12	TA ideas for promoting teamwork: • Schedule communication (weekly) • Have them to have a brief explanation about what they did on a project (5-10 minute presentation) • Encourage professor to design a new group project • Divide the total points to the group of students	
13	TA identified issues that may arise when students work in groups: • Effective communication • Conflict of ideas • Perspective • Understanding of roles and responsibilities	

	• Clear communication • Accountability • Shared mutual trust	

Table 4: Emergent Themes in Trainee Teamwork Strategies

Theme	Description	# Groups Mentioning
Role Clarity	Defined responsibilities	10/13
Communication Norms	Scheduled check-ins	9/13
Inclusion	Equal participation	6/13
Conflict Resolution	Managing disagreements	7/13

C. Student Feedback

We collected student feedback in Fall 2025 from core computing courses taught by TAs who had participated in the training program. Course enrollments ranged from 50 to 150 students. Based on a close review of the training materials and the student feedback, there is evidence that some TAs effectively applied the strategies outlined in the *Building Your Toolkit* handbook, particularly those related to communication, step-by-step scaffolding, and interpersonal skills. However, significant gaps remain, as some TAs did not consistently implement core training concepts, especially those related to fostering a sense of belonging and clearly defining roles.

C.1 Application of Communication and Scaffolding Strategies

The training emphasizes the TA's role to "facilitate meaningful... communication" and "guide and promote high-quality student learning outcomes". Student feedback indicates that successful TAs applied these concepts through "step-by-step" guidance and resource creation.

- **Step-by-Step Guidance:** The training suggests TAs should provide "more thorough explanations" because they "know where the roadblocks were".
    - *Evidence of Use:* In **Foundations of Computing (COT2000C)**, students reported the TA "walking through the steps with us coding" and "explaining everything... helping out everyone one-by-one". Similarly, in **Structured System Programming (COP3275C)**, a student noted the TA "showed a step-by-step understanding".
- **Providing Timely Information:** The training lists "Provide updated information in a timely fashion" as a key role.

- *Evidence of Use:* Students in **COP3275C** praised the TA for posting PowerPoints and videos. In **COT2000C**, students highlighted "easy to understand videos by the TA".

C.2 Application of Interpersonal and Intrapersonal Skills (Successes & Failures)

The training dedicates a section to Interpersonal and Intrapersonal Skills, defining them as "abilities and skills that result from interaction with others," specifically highlighting "Communication" (achieving shared understanding) and "Sense of Belonging" (making students feel comfortable and supported).

- **Successes (Alignment with Training):**
  - **Supportive Environment:** In **Computer Logic Design (CDA3203)**, one TA (Laura) was described as "phenomenal... extremely helpful and kind," directly reflecting the training goal of building a "positive attitude toward the course content".
  - **Empathy:** Feedback for **Foundations of Cybersecurity (CNT4403)** noted the TA was "extremely empathetic" and showed "genuine support".
- **Failures (Gaps in Training Application):**
  - **Violation of "Sense of Belonging":** The training explicitly links "Sense of Belonging" to students being "comfortable with others" and "more engaged". Conversely, feedback for **CDA3203** describes a TA as "hostile" and "rude," making a student feel "like an idiot," which directly contradicts the training's instruction to create an inclusive environment.
  - **Lack of "Motivation" Support:** The training states TAs should help students "persevere even under difficult tasks". However, in **Principles of Software Engineering (CEN4010)**, TAs reportedly told students they "don't help with anything involving the project," which fails the training's directive to "Serve as a meaningful link... between the students and the instructor".

C.3 Role Definition and Professionalism

The training defines the TA's job as creating "the best environment for guiding student learning" and "managing student expectations".

- **Mixed Application:**
  - In **Intro Programming in Python (COP3035C)**, students noted a lack of consistency, stating "Some TAs may not currently possess the professionalism... needed," suggesting the training on "Professional Development" was not fully absorbed or implemented by all staff.

- In **Computer Architecture (CDA4102)**, students felt the TA "basically ran the whole class". While this shows high engagement, it may indicate a deviation from the training's defined role of *assisting* and *linking* rather than replacing the instructor.

Table 5: Summary of Training Usage

Training Concept	Evidence of Use in Feedback	Evidence of Missed Training
Scaffolding/Guidance	"Walking through steps," "step-by-step understanding" (COT2000C, COP3275C)	"TA did not do the best job at informing the class" (COP3035C)
Intrapersonal Skills	"Empathetic," "Kind," "Genuine support" (CNT4403, CDA3203)	"Rude," "Hostile," "Didn't seem to WANT to help" (CDA3203)
Timely Info/Feedback	"Posted PowerPoints/Videos," "Responds fast" (COP3275C, CNT4403)	"Wait 4-6 wks for grades" (CAP6315)
Linking Student/Faculty	N/A	TAs "said they don't help... email the professor" (CEN4010)

D. Concluding Remarks

D.1 Lessons Learned

In this paper, we presented the design, implementation, and outcomes of a multi-session TA training program aimed at better preparing TAs to support student success in STEM courses. Through the *Building Your Toolkit for Becoming an Effective TA* workshops, we sought to move beyond traditional, policy-centered orientations by emphasizing a comprehensive set of instructional, intrapersonal, and interpersonal skills essential for effective TA practice. Our approach positions TAs not only as academic support providers but also as key contributors to students' sense of belonging, motivation, and persistence in challenging STEM learning environments.

The structure of the training enabled trainees to actively engage with core concepts and collaboratively develop strategies for supporting students' learning in complex domains (Pashler, et. al. 2007). Analysis of trainee-generated strategies, particularly those related to teamwork, revealed consistent themes around communication, role clarity, shared responsibility, and inclusive collaboration. These findings highlight TAs' growing awareness of the intrapersonal and interpersonal dimensions of learning and their potential to intentionally shape positive classroom and group-work experiences.

Student feedback from courses taught by trained TAs provides further insight into the impact of the program. Evidence suggests that some TAs successfully applied training concepts related to communication, scaffolding, and interpersonal support, resulting in clearer instruction, increased accessibility, and more supportive learning environments. At the same time, gaps in implementation underscore the challenges of translating training into consistent practice. These results suggest that while short-term training is impactful, sustained reinforcement, mentoring, and accountability mechanisms are necessary to ensure broader and more uniform adoption of core principles.

Overall, this work reinforces the growing consensus that TA training represents a critical leverage point for improving undergraduate STEM education. By intentionally centering intrapersonal and interpersonal skill development alongside instructional strategies, TA professional development programs can better prepare TAs to meet the complex academic and social needs of students. Future iterations of this work will focus on strengthening follow-up support, refining assessment mechanisms, and examining longer-term impacts on both TA development and student outcomes. We hope that the practices, reflections, and lessons shared in this paper will inform and inspire similar TA training efforts across institutions.

D.2 Limitations

This study has several limitations that should be considered when interpreting the findings. First, the analysis relied primarily on trainee-generated artifacts and student course feedback rather than validated assessment instruments or direct classroom observations. Although these sources provide meaningful insight into TA conceptualizations and perceived instructional impact, they do not allow for causal claims regarding the effectiveness of the training program on student learning outcomes.

Second, student feedback was used as an indirect indicator of training transfer. Course evaluations are influenced by multiple contextual variables—including instructor practices, course difficulty, grading policies, and individual student expectations—which limits the ability to attribute positive or negative comments solely to TA preparation. Additionally, feedback comments were not originally collected for research purposes, which may introduce selection and response biases.

Third, the study was conducted within a single department, with the majority of TAs serving computer science courses. As such, findings may not generalize to other STEM disciplines, institutional contexts, or TA preparation models. The training intervention itself was relatively short in duration, and the analysis captures early-stage implementation rather than long-term instructional development.

Fourth, while thematic analysis was conducted to identify patterns in trainee strategies and student feedback, the study did not incorporate inter-rater reliability metrics or external validation procedures, which may limit the robustness of the qualitative claims.

Future work will address these limitations by incorporating formal assessment instruments for both TAs and students, including validated measures of TA self-efficacy, instructional practice, and student belonging. Subsequent iterations of the study will also include pre–post designs, structured classroom observations, and longitudinal tracking to examine sustained implementation and impact. A more rigorous evaluation framework will enable stronger inferences regarding how theory-informed TA training influences instructional practice and student outcomes in STEM education.

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