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Exploring the Interplay Between Teamwork and Intercultural Competence in STEM Education

Jessica Josephine Adams, Purdue University at West Lafayette (PPI)
Camden Love, Purdue University at West Lafayette (COE)
Charis Armstrong
Devang Atul Patel, Purdue University at West Lafayette (COE)
Dr. Aparajita Jaiswal, Purdue University at West Lafayette (PPI)

Aparajita Jaiswal is an Intercultural Research Specialist with CILMAR, Purdue University. Her research endeavors revolve around exploring strategies for seamlessly integrating intercultural learning into both regular STEM curriculum and study abroad programs. Aparajita actively engages in offering guidance in developing research studies, curriculum enhancements, and assessment methods pertaining to integration and cultivation of intercultural competence. Her expertise extends to facilitating workshops and training sessions, catering to the needs of both staff and students within Purdue University.

Dr. Sakhi Aggrawal, Purdue University at West Lafayette (PPI)

Dr. Sakhi Aggrawal is a lecturer and research scientist in Purdue University's Department of Computer and Information Technology. Her work explores how project-management frameworks, teamwork dynamics, intercultural competencies and AI tools can enhance STEM and engineering education. She also serves as a technical program manager at Google—industry experience that underpins her research on data-driven project management and agile methodologies. She is currently leading efforts to incorporate AI into educational curricula and teaching methods. Additionally, Aggrawal mentors students at various levels and is actively seeking collaborative opportunities in her field.

Laura Starr, Indiana-Purdue University

Fostering Intercultural Competence Through Team-Based Learning in First-Year STEM Learning Community

Abstract

This paper is submitted to the 2024 ASEE Annual Conference in the “Complete Paper - Research” category of the First-Year Programs Division (FPD).

The paper discusses the importance of teamwork in undergraduate education. As Teamwork is a critical skill that employers seek in new graduates, especially within STEM fields where collaboration is often essential. College students, particularly in STEM programs, are required to work in teams early on, allowing them to develop these skills and become competent team players before entering the workforce. For computer science students, who often work in group-based learning environments, teamwork plays a vital role in fostering not only technical skills but also interpersonal and intercultural competencies. The main objective of this research is to explore the relationship between three key variables: teamwork regulation, effectiveness, and their impact on the development of intercultural competence goals. The study seeks to understand how effectively STEM students manage teamwork, how this behavior is reflected in their perceptions, and how these elements contribute to the development of skills that facilitate intercultural understanding.

Methods:
This study is focused on twenty-four first-year computer science students living in a learning community at a large midwestern university. These students participated in semester-long learning community focused on helping students develop professional skills such as teamwork and intercultural competence. As a part of the learning community students participated in various team-based activities and were regularly asked to reflect on two primary areas: their teamwork experiences and their intercultural goals. For this particular study students completed a final reflection at the end of the semester where they reflected on their teamwork experience of working on the capstone project and also set their intercultural goals for the upcoming year. The reflection data provided insights into how they viewed their teamwork experiences and how those experiences intersected with their development of personal intercultural competence goals.

The reflections were analyzed using two distinct rubrics. For assessing teamwork perceptions of team effectiveness (TE) we applied a rubric with categories for adaptability, communication, team cohesion. For evaluating team regulation (TR), we used rubric categories for cognitive regulation, behavioral regulation, and emotional regulation. The team effectiveness and team regulation was scored on a scale from 1 to 3 on the rubrics, reflecting the extent to which students demonstrated these attributes. For the intercultural goals setting, a rubric was used with categories for goal setting, progress and reflection, and application and future planning, scored on a 1 to 4 scale. After the reflections were scored, we calculated the descriptive statistics for team effectiveness (TE), team regulation (TR) and intercultural competence (IC). Mean standard

deviation and median for each of the three was calculated. The median score for team regulation was used to group the high and low categories. Further a matrix was created for team effectiveness and team regulation to identify trends and correlations between teamwork regulation and team effectiveness. Further the relationship between team regulation and intercultural competence goal setting was evaluated. This approach allowed us to visualize the relationship between student teamwork behaviors and their ability to develop intercultural competence.

Results:
Based on the matrix, student responses were grouped into four categories based on their teamwork regulation and team effectiveness scores: high/high, low/low, high/low, and low/high. These categories helped to understand the diversity in teamwork and intercultural skills development.
• High TR/High TE Group: Thirteen students (54%) fell into the high/high category, meaning they demonstrated both strong team regulation and high teamwork behaviors. Of these, ten students also showed high levels of intercultural competence, and the remaining three exhibited moderate levels.
• Low TR/Low TE Group: Four students (17%) were placed in the low/low category, indicating low team regulation and low teamwork. These students showed low levels of intercultural competence.
• High TR/Low TE Group: Seven students (29%) were categorized as low/high, meaning that although they had high team regulation, they showed low teamwork behaviors.
• Low TR/High TE Group: No students (0%) fell into this group
Further, correlation analysis between TE and TR revealed a strong relationship between teamwork regulation and team effectiveness. Also, students who were more capable of regulating their teamwork behaviors also showed higher levels of intercultural competence.

Background

The globalization of STEM fields has created an imperative for graduates who can effectively collaborate in diverse teams [1], [2]. Universities, particularly in their STEM programs, serve as crucial environments where students from various cultural backgrounds intersect and interact [3], [4]. At many institutions, international students comprise a significant portion of the STEM student population [5]. This diversity creates both opportunities and challenges for developing essential professional competencies [6].

Intercultural competence, defined as the ability to communicate effectively and appropriately with people of different cultures [7], [8], has become increasingly vital in STEM education and professional practice. Recent studies have highlighted concerning gaps in intercultural competence among STEM students despite its growing importance in the workplace [9]. While technical skills remain fundamental, employers increasingly emphasize the need for graduates who can navigate diverse team environments and collaborate across cultural boundaries [10].

The development of intercultural competence is particularly crucial during the first year of university education [9], as students often experience their first sustained exposure to diverse collaborative environments during this period. Research indicates that early experiences in diverse teams can significantly influence students' long-term development of both teamwork and intercultural skills [11]. However, these early experiences can vary dramatically in their effectiveness, depending on factors such as team dynamics, structured support, and individual engagement.

Team-based learning has emerged as a promising approach for developing both technical and professional skills in STEM education [12]. Studies have demonstrated that well-structured team experiences can improve problem-solving abilities, communication skills, and cultural awareness [13]. However, the specific mechanisms through which teamwork experiences contribute to intercultural competence development remain understudied, particularly in the context of first-year STEM education.

This gap in understanding is particularly significant given the increasing emphasis on global collaboration in STEM fields [14]. While previous research has examined either team dynamics or intercultural competence development independently, few studies have investigated the relationship between these crucial aspects of professional development. Understanding this relationship could provide valuable insights for designing more effective educational experiences that prepare students for the realities of global STEM practice.

The purpose of this study is to examine how team dynamics and intercultural competence development intersect in first-year STEM education. The central research question is: *How does the quality of team-based learning experiences influence the development of intercultural competence among first-year STEM students in a structured learning community environment?* Through investigating this question, the study aims to provide insights to inform the design of educational experiences that more effectively foster both teamwork capabilities and intercultural competence among first-year STEM students. This understanding is crucial for developing graduates who can thrive in the increasingly global and collaborative nature of STEM professions.

Conceptual Framework

This study is grounded in Social Learning Theory [15] and Bennett's Developmental Model of Intercultural Sensitivity (DMIS) [16]. Social Learning Theory posits that learning occurs through observation, imitation, and modeling within social contexts. This framework helps explain how students develop teamwork skills and intercultural competence through their collaborative experiences. The DMIS provides a framework for understanding how individuals develop intercultural sensitivity, progressing from ethnocentric to ethnorelative stages. This model is particularly relevant for examining how students' intercultural competence evolves through team interactions.

We propose an integrated theoretical model where team-based learning serves as a catalyst for intercultural competence development. The model comprises three primary components: **Team**

Regulation (TR), which encompasses how teams manage their cognitive, behavioral, and emotional processes; **Team Behavior (TB),** which includes observable actions and interactions within teams; and **Intercultural Competence (IC),** which reflects the development of cultural awareness and appropriate behavioral adaptations.

This integrated model suggests that TR and TB create learning opportunities that facilitate IC development through direct experience with diverse perspectives and structured reflection on team interactions. The model emphasizes active engagement with cultural differences and collaborative problem-solving across cultural boundaries. Through these mechanisms, students develop both teamwork capabilities and intercultural competence simultaneously.

Methods

Context & Participants

The study was conducted at a large Midwestern university with 24 first-year undergraduate STEM majors participating in a Transformative Learning Community (TLC). The TLC program integrates shared campus housing, a one-credit course on intercultural competence, co-curricular activities, and service-learning projects. This integrated approach provides multiple opportunities for structured team interactions and intercultural learning experiences throughout the academic year.

The cohort represented significant geographic diversity, with students from seven countries (Singapore, India, Jamaica, Spain, UAE, Azerbaijan, and the US) and seven US states (California, Georgia, Illinois, Indiana, New Jersey, New York, and Ohio). The distribution was balanced among international students (33%), out-of-state students (33%), and in-state students (33%). The gender composition was approximately two-thirds female and one-third male, with representation across all major STEM departments.

Rubric Creation

Three comprehensive rubrics were developed through an iterative process involving two experts in field of teamwork and intercultural competence. The Team Regulation (TR) Rubric, given in Table 1, measures emotional regulation, behavioral regulation, and cognitive regulation within team settings. The Team Behavior (TB) Rubric, given in Table 2, assesses communication patterns, team cohesion development, and adaptability in group contexts. The Intercultural Competence (IC) Rubric, given in Table 3, evaluates goal setting, progress and reflection, and application and future planning related to intercultural development.

Table 1. Team Regulation (TR) Rubric

Category	Level 1: Basic	Level 2: Proficient	Level 3: Advanced
Emotional Regulation	Reflection shows limited awareness of managing emotions within the team. Rarely mentions supporting others emotionally.	Reflection shows some awareness of managing emotions and mentions occasional emotional support within the team.	Reflection consistently demonstrates awareness of emotional regulation and frequent emotional support among team members to maintain a positive atmosphere.
Behavioral	Reflection indicates minimal	Reflection indicates	Reflection consistently shows

Regulation	coordination of actions and behaviors. Limited examples of effective task management.	some coordination of actions and behaviors with occasional effective task management.	effective coordination of actions and behaviors, with clear examples of managing tasks efficiently.
Cognitive Regulation	Reflection shows limited collaborative problem-solving and decision-making. Few examples of sharing knowledge or feedback.	Reflection indicates some collaborative problem-solving and decision-making, with occasional sharing of knowledge or feedback.	Reflection consistently demonstrates collaborative problem-solving and decision-making, with frequent sharing of knowledge and constructive feedback.

Table 2. Team Behavior (TB) Rubric

Category	Level 1: Basic	Level 2: Proficient	Level 3: Advanced
Communication	Reflection indicates inconsistent communication, with limited efforts to clarify or listen actively.	Reflection shows generally clear communication, with some efforts to clarify views and listen actively.	Reflection consistently demonstrates clear, respectful, and constructive communication, with regular efforts to clarify views and listen actively without interruptions.
Team Cohesion	Reflection shows limited efforts to maintain team cohesion. Few examples of fostering a sense of unity or belonging.	Reflection shows some efforts to maintain team cohesion, with occasional examples of fostering a sense of unity or belonging.	Reflection consistently demonstrates strong team cohesion, with frequent examples of fostering a sense of unity, belonging, and mutual respect.
Adaptability	Reflection shows minimal adaptability to changing demands or challenges. Rarely mentions adjusting strategies or actions.	Reflection indicates some adaptability to changing demands or challenges, with occasional adjustments to strategies or actions.	Reflection consistently demonstrates high adaptability to changing demands or challenges, with frequent adjustments to strategies and actions as needed.

Table 3. Intercultural Competence (IC) Rubric

Criteria	Exemplary (4)	Proficient (3)	Developing (2)	Beginning (1)
Goal Setting	Sets clear, specific, and meaningful intercultural development goals that demonstrate a deep understanding of personal growth areas.	Sets clear and specific intercultural development goals that show an understanding of personal growth areas.	Sets general intercultural development goals with some understanding of personal growth areas.	Sets vague or unclear intercultural development goals with minimal understanding of personal growth areas.
Progress and Reflection	Provides detailed and insightful reflections on progress towards goals, including specific examples of actions taken and challenges faced. Demonstrates significant growth and self-awareness.	Reflects on progress towards goals with some detail, providing examples of actions taken and challenges faced. Shows growth and self-awareness.	Provides basic reflections on progress towards goals with limited detail and examples. Shows some growth and self-awareness.	Provides minimal or no reflection on progress towards goals with few or no examples. Shows little growth or self-awareness.
Application and Future Planning	Applies insights from progress and reflection to set new, specific, and actionable goals.	Applies some insights from progress and reflection to set new	Sets basic new goals based on limited insights from progress and	Sets vague or unclear new goals with minimal insights from

	Demonstrates a clear plan for continued intercultural development and a commitment to ongoing learning.	goals. Provides a plan for continued intercultural development and shows commitment to learning.	reflection. Shows some plan for continued intercultural development.	progress and reflection. Shows little to no plan for continued intercultural development.

Data Collection and Analysis

The data collection process involved gathering student reflections on team project experiences, written responses about intercultural goals, and documentation of team interactions during service-learning activities. The use of multiple data sources allowed us to triangulate the findings and develop a comprehensive understanding of the relationships between team dynamics and intercultural competence development.

A mixed-methods approach was used to analyze the data. The quantitative analysis involved scoring student reflections using the three developed rubrics (given in Table 1-3) and averaging the scores across different components to develop 3 final scores for each student - Team Regulation (TR), Team Behavior (TB), and Intercultural Competence (IC). This was followed by statistical analysis to examine relationships between TR and TB, a correlation analysis was conducted. Further the median values of TR and TB were compared with the median of ICL scores to identify any patterns and relationships. The qualitative analysis included thematic analysis of student reflections, coding of emergent patterns in team dynamics, and identification of key factors in intercultural development. This dual approach allowed us to develop both broad understanding of patterns and deep insight into individual experiences.

Several key measures were implemented to ensure research quality and ethical conduct throughout the study. Three coders analyzed the data independently to establish inter-rater reliability achieving an IRR of 93%, and member checking was conducted to verify interpretations. Regular peer debriefing sessions helped maintain objectivity in the analysis. Data collected was anonymized, any personally identifiable information was removed, and saved securely in encrypted files on Box. These measures helped ensure both the ethical integrity of the research and the trustworthiness of our findings.

Results

Quantitative Results

The quantitative analysis began by examining the distribution of scores across the three measured components: Team Regulation (TR), Team Behavior (TB), and Intercultural Competence (IC). The statistical analysis revealed distinct patterns, as shown in Table 4.

Table 4. Statistical Summary of Individual Measures

Measure	Mean	Median	Standard Deviation
Team Regulation	1.89	1.67	0.49
Team Behavior	1.88	2.00	0.52
Intercultural Competence	2.20	2.33	0.56

Using these median values as thresholds, students were categorized as high or low in each component. For example, if a student's average TR score was less than 1.67, they were categorized as *low TR* while a student's average TB score of more than 2.00 would categorize them as *high TB*. Then, to analyze the relationship between TR and TB a 2x2 matrix of possible combinations was created, as shown in Table 5.

Table 5. Team Regulation vs Team Behavior

	High TB	**Low TB**
High TR	13 students (54%)	7 students (29%)
Low TR	0 students (0%)	4 students (17%)

However, the analysis revealed 0 students in the Low TR/High TB category, suggesting a potential dependency between these skills where high team behavior typically requires at least moderate team regulation abilities. This resulted in three distinct groups for further analysis: High TR/High TB, High TR/Low TB, and Low TR/Low TB. A strong positive correlation, R=0.687, between TR and TB measures was found (refer to Figure 1), supporting the observed pattern that students who effectively regulated team processes also tended to demonstrate positive team behaviors. The next step was to examine how these three observed groups (High TR/High TB, High TR/Low TB, and Low TR/Low TB) related to students' IC scores. Table 6 presents this analysis.

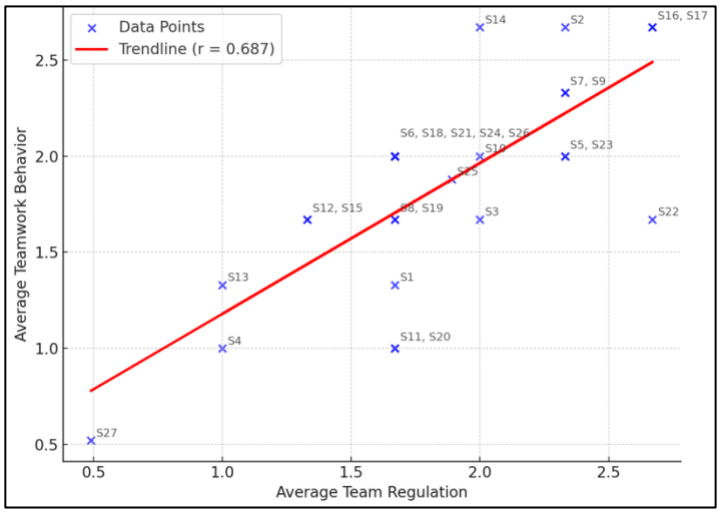

Fig 1. Correlation between Team Behavior and Team Regulation

Table 6. TR/TB categories vs Intercultural Competence

	High IC	**Low IC**	Total
High TR/High TB	10 students (77%)	3 students (23%)	13
High TR/Low TB	1 students (14%)	6 students (86%)	7
Low TR/Low TB	2 students (50%)	2 students (50%)	4

These results reveal a notable pattern: students who demonstrated high performance in both team regulation and team behavior (High TR/High TB) were substantially more likely to show high

intercultural competence, with 77% of this group achieving high IC scores. In contrast, students with high team regulation but low team behavior (High TR/Low TB) predominantly showed lower IC scores (86%). The Low TR/Low TB group showed an even distribution between high and low IC scores, though the small sample size (n=4) limits the conclusions that can be drawn from this particular subgroup.

Qualitative Results

To better understand these quantitative patterns, a thematic analysis of student reflections was conducted, organizing the analysis around the three TR/TB categories identified during the quantitative analysis. This approach allowed examination of how different combinations of team skills related to students' experiences and intercultural development.

Students demonstrating high team regulation and high team behavior (High TR/High TB) consistently showed evidence of organized planning, balanced effort distribution, and clear communication. As one student described their systematic approach: "*Our team's process to complete this project had two stages: a stage for planning and administration, and a stage for action. In the first stage, we discussed group norms and wrote a plan of action.*" These students also exhibited strong cultural awareness and actively worked to integrate diverse perspectives into their team processes as evidenced from a student response, "*While completing this project, our top notch communication was definitely the best aspect of our group. We made it clear from the beginning that everyone is free to share not just their opinions, but also that they can ask for any accommodation from the group.*"

Students with high team regulation but low team behavior (High TR/Low TB) often experienced significant time management challenges while still achieving satisfactory outcomes. One student reflected this tension: "*Because of these communication issues and failure to contribute to the project in a timely manner, there were great disparities in the amount of work done throughout the group.*" Another student noted their compromised approach: "*We worked separately, but everyone did what was needed of them and communicated their needs with the group efficiently…Everything went smoothly…However, I do wish that we could have met up in person more, but none of us had room in our schedules that worked for all of us.* " These reflections indicate difficulties with communication, ability to completely adequately but limited cultural integration, despite having strong individual regulatory skills.

The group showing low scores in both team regulation and team behavior (Low TR/Low TB) faced substantial challenges with workload distribution and team dynamics. One student's frustration was evident: "*I took on a lot of responsibility, and the weight was not distributed evenly.*" Another student captured the deeper issues in their team: "*We had issues with two of our members not doing anything for the entirety of the project... What I learned was that, in the end, people are people. Communicate how you work, explain your personal stance if you can, especially if spats arise, but don't make excuses for people who refuse to participate.*" These reflections indicate minimal awareness of cultural differences and limited understanding of how to navigate diverse team environments effectively.

Discussion and Implications

Discussion of Findings

Our findings reveal a complex relationship between team dynamics and intercultural competence development among first-year STEM students. The strong correlation between team regulation and team behavior (R=0.687) aligns with Social Learning Theory's premise that cognitive processes and behavioral manifestations are closely interlinked in social learning contexts [15]. The absence of students in the Low TR/High TB category suggests that effective team behavior requires foundational regulatory skills, supporting previous research on the hierarchical nature of team skill development [17].

The relationship between team skills and intercultural competence provides interesting insights into Bennett's Developmental Model of Intercultural Sensitivity [16]. Students who demonstrated high performance in both team regulation and team behavior (77% showing high IC) appear to have progressed further along Bennett's continuum toward ethnorelative stages. This suggests that successful team experiences may accelerate intercultural development by providing structured opportunities for engaging with different perspectives and navigating cultural differences [18].

However, the distinct pattern observed in the High TR/Low TB group, where 86% showed lower IC scores, presents an intriguing contradiction to previous findings by Zhu et al. [19], who suggested that individual regulatory skills strongly correlated with intercultural development . Our results indicate that the ability to implement team behaviors effectively may be crucial for translating individual capabilities into intercultural competence. This finding adds nuance to current understanding of how intercultural skills develop in educational settings.

The qualitative findings further illuminate these relationships. The sophisticated planning and communication strategies exhibited by the High TR/High TB group reflect what Rodriguez-Mejia et al. [20] described as "integrated cultural learning," where students actively incorporate diverse perspectives into their work processes. In contrast, the experiences of students in the High TR/Low TB group suggest that knowledge of effective team practices alone is insufficient for developing intercultural competence without practical implementation.

Implications for Teaching and Learning

These findings have several important implications for STEM education practitioners. First, instructors should design team-based learning experiences that explicitly develop both regulatory and behavioral skills. This could involve structured team formation processes that consider cultural diversity, clear guidelines for team interaction, and regular opportunities for guided reflection on team dynamics.

Course design should incorporate scaffolded team experiences that progress from simple to complex collaborative tasks. Early assignments might focus on developing basic team regulation skills, such as time management and task distribution, before advancing to more complex projects that require deeper cultural engagement [21]. Regular checkpoints and

feedback mechanisms should be implemented to help students identify and address team dynamics issues before they become problematic.

Faculty can support intercultural competence development by creating opportunities for meaningful cross-cultural interactions within teams. This might include assigning roles that require all team members to engage in substantive communication, providing frameworks for discussing and resolving cultural differences, and incorporating cultural perspectives into technical problem-solving tasks [22], [23].

Assessment strategies should evolve to consider both individual and team development [24]. Instructors should implement regular team process evaluations that examine not just final outputs but also the quality of team interactions and cultural engagement. These assessments should provide specific feedback on both regulatory and behavioral aspects of team performance, helping students identify areas for improvement in both domains [25].

Professional development programs for STEM faculty should include training on facilitating intercultural learning through team-based activities [26]. This training should emphasize strategies for creating inclusive team environments, managing cultural conflicts, and helping students translate team experiences into intercultural competence development. Additionally, departments should consider implementing mentoring programs where experienced students can guide newer students in navigating diverse team environments.

Conclusion, Limitations, and Future Work

This study demonstrates the interconnected nature of team skills and intercultural competence development in STEM education. The strong correlation between team regulation, team behavior, and intercultural competence suggests that well-structured team experiences can serve as effective vehicles for developing these crucial professional skills.

Some limitations should be considered when interpreting these results. The small sample size and single institution focus limit the generalizability of the findings. Future research directions should include longitudinal studies tracking development over multiple years and multi-institution comparisons to validate these findings across different contexts. Investigation of specific intervention strategies could help identify the most effective approaches for developing both team skills and intercultural competence. Development of standardized assessment tools and examination of industry outcomes would also provide valuable insights for improving STEM education practices.

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