International Journal of Engineering Education Vol. 41, No. 5, pp. 1289–1307, 2025
Printed in Great Britain

0949-149X/91 $3.00+0.00

Teamwork Interactions and Cultural Orientations of Software Development Teams*

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Effectively facilitated teamwork allows students to learn from each other, regulate their learning as a team, provide feedback to each other, and challenge each other's thinking based on each student's upbringing. This multi-methods design study explores the students' perceptions of their learning in teams, work contributions, and cultural orientations in an undergraduate software development course at a large university in the Midwest. We evaluated the perceptions of 157 undergraduate students allocated in 31 teams of 4 to 5 members. Findings from the study suggest that cultural orientations do not predetermine their teamwork effectiveness. Individualistic teams can effectively deliver outcomes, but at the cost of limiting the rich potential of diverse perspectives and the collaborative benefits that effective team processes offer. Early identification of divergent cultural orientations, especially in communication styles, enables instructors to implement targeted interventions before team conflict escalates. Fostering intercultural competence is essential for effective teamwork interactions and outcomes in diverse engineering classrooms. Further research is needed on the impact of people-oriented versus activity-oriented teams, particularly regarding balanced workloads and process-outcome effectiveness.

Keywords: teamwork; STEM education; cultural orientations; intercultural competence; multi-methods

1. Introduction

Teamwork has been widely recognized as a fundamental skill in Science, Technology, Engineering, and Mathematics (STEM) education, along with the need to address the collaborative demands of professional work environments [1–4]. Furthermore, ABET, the main engineering accreditation program in America, establishes the importance of fostering the ability to work effectively in teams and to create a collaborative and inclusive environment among others [5]. One of the requirements to foster an inclusive environment in teamwork is to understand how the cultural orientations of each teammate may impact the overall team's performance, planning, monitoring, evaluating, joint goals, and individual and collective beliefs [6]. Equally important is to be aware of how individual team members' cultural backgrounds may influence overall teamwork interactions [7, 8]. Thus, developing effective teamwork and creating inclusive and collaborative environments in any educational setting requires instructional support [9].

The cultural fabric of teams plays a crucial role in the dynamics of learning and performance. Specifically, Hofstede's and Schwartz's cultural dimensions theories offer a lens to understand these dynamics, showing how cultural orientations may influence team interactions and learning outcomes [10]. For instance, individualism versus collectivism can significantly affect how students approach teamwork. Individualistic orientations lean towards independence, autonomy, and prioritization of individual objectives, and collectivist cultures emphasize group loyalty, group harmony, cooperation, and the prioritization of the group's needs [11]. Understanding these cultural dimensions is important in creating an inclusive learning and teamwork environment that respects and leverages diverse cultural perspectives. Despite the known benefits of teamwork in STEM education, there are many challenges educators face, such as ensuring equitable participation [12], managing conflicts [13], aligning individual goals with team objectives [14], and intercultural differences [15]. This study aims to bridge the latter gap by exploring how students perceive their team learning experiences and how these perceptions are related to cultural factors, specifically related to cultural orientations.

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* Accepted 24 May 2025.

Researchers have utilized frameworks to interpret how individuals interact with the increasingly multicultural academic and industry world. Such frameworks support the idea that individuals with knowledge and appreciation of diverse cultures are better equipped to work collaboratively in diverse teams, which is beneficial for individual growth and team interactions in academia and industry [16]. One such framework contextualized in educational settings is the Socially Shared Regulation of Learning (SSRL). According to Hadwin and colleagues [6], SSRL describes a collaborative process where a group strategically plans, carries out a task, reflects on their progress, and adapts as needed. This requires members of the group to take joint metacognitive control, or in other words, to think about their thinking to improve the cognitive, behavioral, motivational, and emotional aspects of their teamwork. Some researchers have used elements of self-regulated learning to encourage intercultural competence in educators [17] and university students [18], but so far, there is no evidence of work associating socially shared regulation and cultural orientations.

This research contributes to the broader understanding of teamwork in STEM education, particularly in the context of intercultural diversity and intercultural competencies. It also aims to offer valuable insights for educators and policymakers in developing effective team-based learning strategies that respect, value, and utilize cultural differences, ultimately enhancing the quality and inclusivity of STEM education. Specifically, the purpose of this study is to explore the intricate relationship between team dynamics and the role of cultural orientations in shaping these experiences at a team level. This exploration is structured around four key aspects of Socially Shared Regulation of Learning (SSRL) transactive, deeply metacognitive, collective agentic, and socio-historically and contextually situated [6]. The research questions for the study were (1) What are teams' perceived levels of teamwork contributions? (2) What are teams' perceived levels of cultural convergence? (3) What are the patterns of teams' perceptions of their teamwork contribution and cultural orientations? And (4) What elements of socially shared regulation learning can be observed from students' perceptions of their teamwork interactions and cultural orientations? In this study, we will present a background of teamwork and culture in STEM education, then the theoretical framework we used to guide this work, the course design of the data collection process, the methods used during this research, the results found in this multi-method work, and the discussion around our findings.

2. Cultural Orientations and Teamwork

There is a growing emphasis on teamwork in STEM education. This shift toward team-based learning marks a departure from the solitary nature of traditional scientific inquiry and aligns with the interdisciplinary and complex nature of modern collaborative workplaces [19]. As STEM fields become increasingly interdependent, the ability to work effectively in teams becomes vital for future professionals.

Team-based learning in STEM disciplines offers numerous educational benefits. It promotes active learning, enhances critical thinking, and enables the integration of diverse knowledge areas, which are essential in addressing complex real-world problems [20]. Furthermore, teamwork helps students develop communication skills and learn how to negotiate different perspectives, fostering a deeper understanding and retention of course material [21]. However, effectively implementing teamwork in STEM education also presents challenges. These include ensuring equal participation, managing conflicts, and aligning individual learning goals with team objectives [14]. Additional challenges to effectively implementing teamwork include assessing individual team members [22], determining the appropriate type of regulation to support students' learning [23, 24], and addressing the complexities introduced by cultural diversity [25], among others.

Cultural orientations substantially impact team dynamics, shaping how team members interact, communicate, and perform [26]. Research suggests that culturally diverse teams can either outperform homogeneous teams or struggle, depending on how cultural differences are managed [27, 28]. For example, teams with high cultural awareness are more likely to leverage diversity as an asset, leading to innovative problem-solving and creative outputs [29]. Conversely, unattended cultural differences may result in misunderstandings, reduced cohesion, and inefficiencies [30]. Effective management of cultural diversity requires fostering mutual respect and establishing clear communication norms to ensure all team members feel included and valued [31]. In educational settings, fostering cultural competence and reflective practices has shown to improve multicultural teams' processes [32].

To understand these cultural orientations, researchers use cultural dimensions which have been found to significantly correlate with cultural orientations [33]. For instance, Hofstede's framework of cultural dimensions can provide some insight for understanding teamwork dynamics in diverse educational settings [34]. Hofstede's model identifies dimensions through which cultures differ. These dimensions include *individualism vs. collecti-*

vism, which explores whether individuals prioritize personal achievements or group harmony; *power distance*, which reflects the degree to which inequality in power is accepted within society; and *uncertainty avoidance*, which examines how comfortable people are with ambiguity and risk. *Masculinity vs. femininity* refers to whether a culture emphasizes competitiveness and material success, or values care and quality of life. *Long-term orientation vs. short-term normative orientation* addresses whether a society prioritizes future rewards through perseverance or emphasizes traditions and quick results. *Indulgence vs. restraint* measures the extent to which societies allow or suppress the gratification of desires and personal enjoyment. Together, these dimensions provide a nuanced understanding of how cultural orientations shape teamwork interactions and outcomes in diverse contexts [10].

The cultural dimensions have a significant impact on teamwork in educational settings [35]. For instance, in individualistic cultures, students may prefer working independently and struggle with group dependency, while in collectivist cultures, group harmony and consensus may be prioritized [11]. Similarly, high power distance cultures may see a hierarchical structure in team roles, whereas low power distance cultures emphasize equality and participative decision-making. These differences can affect team communication, leadership, decision-making styles, and conflict-resolution strategies.

In STEM education, teamwork is critical, and therefore, understanding and respecting cultural differences become crucial. Intercultural competence in team settings can lead to more effective communication, enhanced collaboration, and improved conflict management, ultimately contributing to a more inclusive and productive learning environment [36]. Educators are increasingly incorporating cultural competence training into STEM curricula to prepare students for global and multicultural workplaces. It is important to note, however, that the application of Hofstede's dimensions in educational settings is not without challenges. Cultures are dynamic and cannot be entirely captured by fixed dimensions. Moreover, there is a risk of stereotyping and overgeneralization. Nevertheless, Hofstede's model provides a valuable starting point for understanding cultural differences and their implications for teamwork in education. However, a better understanding of the interplay of cultural orientations and teamwork dynamics and interactions is needed [37] to better support students' development of teamwork skills while valuing different forms of knowing and being.

A theoretical lens that can allow researchers to bring an understanding of the interplay of cultural orientations and team dynamics is the SSRL framework. SSRL can help researchers to characterize team dynamics and interactions within their sociocultural contexts [38]. SSRL argues that effective interaction processes involve team members (a) considering individual team members' perspectives to plan and execute tasks and (b) thinking and reflecting upon ways to improve the cognitive, behavioral, motivational, and emotional aspects of their teamwork.

3. Theoretical Framework

This study is guided by Socially Shared Regulation of Learning (SSRL) [39]. SSRL provides a more appropriate theoretical framework for this research than self-regulated learning, as our unit of analysis is teams, not individuals. Additionally, Socially Shared Regulated Learning offers a better conceptual fit than co-regulated learning because it incorporates socio-historical and contextually situated factors, which are intrinsically linked to the cultural orientations we are investigating in this study. Socially shared regulation is an iterative process in which a group of people regulate their actions based on a collective objective or activity [39]. Hadwin & Oshige [39] structured the cognitive, behavioral, motivational, and emotional process into four tenets:

> "(a) transactive multiple individual perspectives contribute to join metacognitive, behavioral, motivational, and emotional conditions/states as needed; (b) deeply metacognitive, monitoring and evaluation are shared amongst people to drive negotiated large and small-scale adaptation; (c) collective agentic, joint goals and standards are intentionally adopted (informed by, but not necessarily replacing, individuals goals) for monitoring and evaluating together; and (d) socio-historically and contextually situated, individual and collective beliefs and experiences create a set of shared conditions continually shaping and being shaped by joint task engagement" (p.5).

Socially shared regulation of learning adapts adequately to this study because it does not separate individual regulation or objectives for the sake of the collective. On the contrary, it encourages students to consider different perspectives from their peers to achieve a common objective. And, unlike co-regulation, it doesn't require any one person to guide group actions; collective strategies, objectives, beliefs, and awareness co-emerge from either individual or group stimuli.

The implications of the theoretical framework for the design of the study guided the selection of our constructs to characterize students' cultural orientations and elements of their teamwork interactions. Furthermore, *teamwork interactions* were characterized as perceived transactive, metacogni-

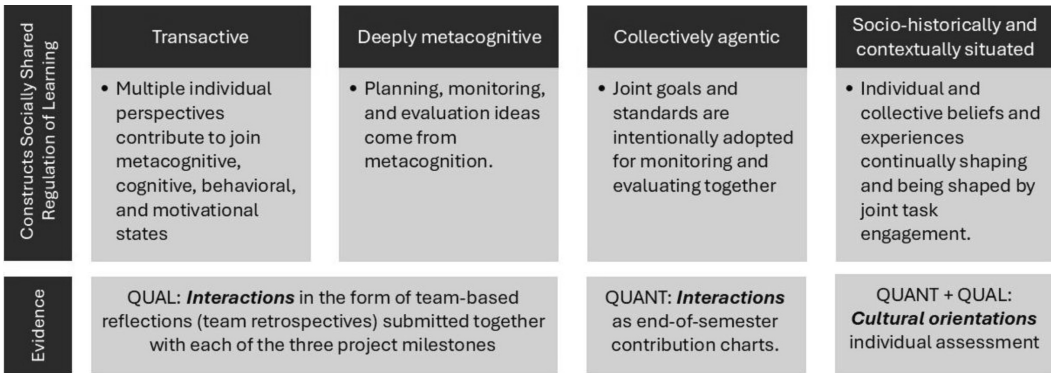

Fig. 1. Alignment between constructs and evidence associated with the SSRL framework.

tive, and collectively agentic beliefs in terms of their joint reflections on their teamwork processes and perceived team performance, and their *cultural orientations* were characterized as perceived socio-historically and contextually situated beliefs (refer to Fig. 1).

4. Methods

We implemented a multi-method design with teams as our unit of analysis. Specifically, in this qualitative-driven study, we used a supplementary quantitative analysis followed by a qualitative analysis [40]. As depicted in Fig. 1, this study implemented qualitative and quantitative methods to characterize students' perceived teamwork interactions, as well as their cultural orientations. Fig. 1 also indicates our alignment between the constructs of our theoretical framework, SSRL, and the evidence we used as data collection methods. We opted for a multi-method approach for this study as it enabled us to characterize and intertwine students' perceptions of teamwork and culture. Additionally, multi-method analyses enhance trustworthiness through triangulation by incorporating quantitative and qualitative data sources and analytical approaches [41].

Also, as shown in our visual model in Table 1, we explored four strands of data. First, we quantitatively utilized two strands of data to characterize students' cultural orientations and the perception of their work and their teammates. This exploration led us to define two categories, balanced-unbalanced and culturally convergent-divergent. Using the quantitative data of cultural orientations and self and peer evaluation, as well as the qualitative data of the students' cultural orientations, four teams were selected to represent the groups divided by cultural orientation and work balance. Finally, we deeply and cyclically analyzed the qualitative data of the chosen four teams to explore the relationship between the cultural orientations of the teams and their reflections on their planning, monitoring, and evaluation.

4.1 Context and Participants

The study's context centered on a Spring semester, second-year, three-credit hour course. The course aimed to instruct students on collaborative teamwork, emphasizing the creation of models essential for developing a comprehensive design for an information system solution. The curriculum incorporated the teaching of Unified Modeling Language (UML) alongside object-oriented tools. In addressing the non-technical aspects of their projects, students adopted a project management framework to delineate goals and objectives for project deliverables. The course comprised 157 students, each engaged in semester-long projects within teams of four or five members. Institutional data revealed that 50% of the students were sophomores, 40% were juniors, and the remaining 10% were seniors. Gender distribution showed 25% of students identifying as female and 75% as male. Among these students, 37% identified as international with various ethnic backgrounds, while the remaining students identified as domestic. The study was conducted in accordance with the Declaration of Helsinki and approved by the university's Institutional Review Board (protocol code IRB-2021-1181 and date of approval 20 August 2021). The protocol was approved as exempt because the research was conducted in a commonly accepted educational setting and involved normal educational practices. Thus, informed consent was not applicable.

The course used cooperative learning [42] as an educational framework that underscores the importance of learning and collaborating within small groups. This approach provided students with a guided level of independence to explore concepts within these groups, supervised by an instructor. Studies have identified a positive correlation between cooperative learning and academic perfor-

Table 1. Visual model for our multi-methods approach for the study

Phase	Procedure	Product
QUANT data collection	• Pre-measured cultural orientations on a Likert scale (1-8). • 18 cultural orientations.	• 156 students' responses on cultural orientations. • 2808 cultural orientations.
QUANT data analysis	• Descriptive statistics. • Unsupervised hierarchical cluster.	• One cluster of 23 culturally convergent teams. • One cluster of 8 culturally divergent teams.
QUANT data collection	• Post-measured students' self and peer evaluation. • Students assigned each other a percentage of work done by each team member on two final deliverables.	• 31 teams with individual peer- and self-evaluations. • n = 620 self and peer evaluations.
QUANT data analysis	• Descriptive statistics • Unsupervised hierarchical cluster.	• One cluster of 20 balanced (agreement upon work distribution) teams. • One cluster of 11 unbalanced teams.
Integrating QUANT analysis	• Combination of quantitative clustering and descriptive statistics findings.	• n = 31 teams divided into four categories: balanced or unbalanced and culturally convergent or divergent. • 4 chosen teams to deeply explore how they represent each of the four categories.
QUAL data collection	• Post-measured students' reflections on teamwork. • Prompts based on self-regulation principles.	• n = 93 reflections, one after each of the three milestones of the team project.
QUAL data analysis	• Deductive theme analysis based on the four tenets of SSRL.	• Representing quotes on teamwork balance distribution and self and peer evaluations. • First part of the deep qualitative analysis on the four chosen teams.
QUAL data collection	• The open-ended questions on students' cultural orientations and their association with teamwork.	• n = 93 cultural orientations and their association with teamwork.
QUAL data analysis	• Deductive thematic analysis using cultural orientations and SSRL as guiding frameworks.	• Second part of the deep qualitative analysis on the four chosen teams.
Integration of the QUANT and QUAL results	• Integration and explanation of quantitative and qualitative findings	• Discussion of the findings. • Recommendations for teaching and learning. • Limitations of the study.

mance, as well as its beneficial impact on interpersonal skills like self-esteem and cooperative work abilities [43, 44]. Cooperative learning operates on five key principles: positive interdependence, internal interactions to support each other, individual commitment to project responsibilities, development of interpersonal skills, and group strategizing to achieve common goals [45]. It has been identified to be an effective pedagogy in STEM fields, particularly in settings like academic capstone projects where students work collaboratively toward a shared goal.

The course design incorporated each of the five fundamental principles of cooperative learning. Positive interdependence is the recognition that the efforts of each individual within a group significantly contribute to the overall success of the team. Promotive internal interactions involve continuous positive communication among group members, encouraging each other's success through expressions of praise, feedback, and offers of assistance. Interpersonal skills encompass the social abilities of each individual, developed and honed throughout project execution, which contribute to the team's effective project completion (e.g., skills in conflict resolution, verbal and non-verbal communication, etc.). Individual accountability refers to each group member's personal contribution to project work and their support of other group members through feedback behaviors. Group processing is the strategy devised by a group to facilitate project execution, and these procedures should be consistently assessed and refined based on feedback from group members regarding effectiveness and success.

4.2 Data Collection Method

We evaluated the responses of 157 students allocated in 31 teams of 4 or 5 members. For the quantitative data, we collected (1) the team's self and peer evaluations at the end of the semester and (2) the cultural orientations based on a scale of 1 to 8 using the instrument from The Maximizing Study Abroad Project [46]. The authors, based on Hofstede's cultural orientations, created an instrument to help students identify and use different culture-

learning strategies. Specifically, we used the MAXSA Core Cultural Values and Culture mapping [47]. For the qualitative data, we collected (3) teams' reflections after each of the three milestones of the project and (4) a written reflection of their cultural orientations. Fig. 1 illustrates the alignment between the four constructs of SSRL, our research questions, and our metrics for data collection and analysis procedures.

4.3 Scoring and Data Analysis Methods

To approach the first research question (RQ1), we quantitatively analyzed the perceived work contribution of every team. The perception of work distribution or level of effort (not quality) is crucial because it influences directly the enjoyment of teamwork and the learning outcomes of a team [48]. As shown in Fig. 1, collective beliefs, and experiences continuously shape how teams interact. Each team had two matrices of n by n, where n is the number of members; thus, n = 5 for most teams. One matrix represented the calculated percentage of work for each and all team members toward the documentation of the project, and the other matrix represented the percentage of work for each and all the team members toward the prototype of the project. Each member gave a percentage (from 0% to 100%) of what they perceived was the work of all the members, including themselves. We defined a team as unbalanced when at least two members disagreed with the work that each of the members thought they did. For example, unbalanced Team 6 had large standard deviations for three students in the distribution of work for the document and the prototype. On the other hand, teammate 6.1 thought they did more work than their peers perceived (See Tables 2 and 3 in the result section 5.1).

For the second research question (RQ2), we used quantitative data from cultural orientations. Each student ranked their three most relevant pairs of cultural orientations in a teamwork setting. It is important to clarify that pairs of cultural orientations are not polarized, a student could highly or lowly value either or both pairs of cultural orientations. To quantitatively understand the teams' most relevant cultural orientations, we gave 3 points to a cultural orientation that was chosen as the most important, 2 points as the second most important, and 1 point when it was chosen as the third most important. For example, divergent Team 6 had the cultural orientation pairs Individualism-Collectivism ranked first by two teammates, giving it a score of 6; Polychronic-Monochronic time ranked first by one teammate, second by another teammate, and third by another teammate, giving it also a score of 6; Equality-Hierarchy was ranked first by one teammate and second by another giving it a total score of 5. Teams with an affinity to the rest of the team's cultural orientations were classified as culturally convergent, and teams with a low affinity to the rest were classified as culturally divergent.

The affinity (convergence/divergence) was understood both quantitatively and qualitatively. Quantitatively we used clustering to divide convergent and divergent teams. Additionally, two of the researchers analyzed each team's qualitative responses regarding their cultural orientations based on three questions: why they chose their most relevant cultural orientations; how those cultural orientations might influence positively and negatively their team interactions; and the strategies they would use to facilitate their teamwork interactions to avoid negative influence caused by their cultural orientations. We analyzed this data using the SSRL framework.

To address the third research question (RQ3), we utilized agglomerative hierarchical clustering, which progressively merges each data point (i.e., each team) based on normalized Euclidean distance to account for variations in both cultural orientation and students' perceptions of their teamwork's contribution. This method enabled us to compare multiple dimensions of students' teamwork contribution and cultural orientation [49], providing insights into balanced-unbalanced and convergent-divergent team dynamics. The clustering process generated a heat map (see Fig. 3) that visually represents groups, facilitating our understanding of the relationship between cultural orientations and teamwork interactions [50].

To approach the fourth and final research question (RQ4) we analyzed qualitatively all the cultural orientation responses and teams' reflections. Since we had four clusters from the RQ3, we selected one team from each cluster to represent the group they were in. Two researchers read the qualitative data using the SSLR as a lens, and along with a third researcher, we analyzed each team to decide which would better represent their cluster.

4.4 Trustworthiness

To increase the trustworthiness of this study, the researchers implemented three methods including reflexivity, triangulation, and peer examination [51]. The first two authors kept a journal to reflect on our qualitative analysis, coding, and interpretations of the data. The journal was particularly helpful in finding the most appropriate quotes that would represent the cultural orientations or perceptions of work distribution within each team. The researchers used quantitative and qualitative data strands to reinforce our understanding of our research questions. Our objective was to triangulate

the quantitative and qualitative data to obtain a deeper understanding of the relationship between culture and teamwork processes. As a third method of trustworthiness, our research team had 22 one-hour meetings over 6 months. The goal of the meetings was to peer-examine our methods, meanings, and interpretations.

4.5 Team Positionality

The positionality of the researchers is highly interdisciplinary, multicultural, and diverse. The research team consisted of two males and two females, all with expertise in engineering and computing education research. One female faculty member was the course instructor, and a male graduate student was the course teaching assistant. The other two members of the team were graduate students who were not involved in teaching roles but took leading roles in the data analysis and reporting of the findings. The identities and roles, as well as the diversity in the team, have been reflected in the decisions implemented in the learning design and the research process.

Specifically, in the design process, the course instructor's experiences as an education researcher have allowed her to engage in the systematic implementation and evaluation of evidence-based practices to improve teamwork interactions. In the analysis stages, the experience of the researchers and the teaching assistant was highly complex and interdisciplinary. Thus, the analysis of the data required a high level of collaboration and learning among the team members. Finally, our multiple roles as faculty, students, and researchers allowed us to better protect students' privacy and confidentiality by establishing procedures where the course instructor would not be involved in the analysis but would inform the interpretation of the findings. Instead, the teaching assistant was able to provide contextual factors, clarifications, and insights throughout the analysis process. In the end, the course instructor also brought in the practical perspective of what is feasible in the classroom and the learnings needed to improve the learning experience for the students in future implementations.

5. Results

5.1 Perceptions of Balanced and Unbalanced Teamwork Contributions (RQ1)

To identify the teams' perceived levels of teamwork contribution, we utilized students' ratings from the contribution charts and the Elbow Method to determine the number of clusters to study. The elbow method identifies the optimal number of clusters by plotting explained variation against cluster count and selecting the point where the curve noticeably bends. Fig. 2 shows that two is the ideal number of clusters to study, we named them: balanced and unbalanced teams.

Perceived teammate's percentage contributions revealed substantial variations in how team members assessed their peers' participation. Tables 2 and 3 represent the contribution chart of every team concerning the document and prototype, respectively. Students used a zero-sum workload distribution for the project document and prototype, some students agreed to divide the work equally for both parts of the project, while others decided to have teammates dedicated to work mainly on the document and others on the project. The perceived contribution standard deviation shows the level of agreement students had at the end of the project. The perceived contribution data showed mean values ranging from 1.25% to 43% across different

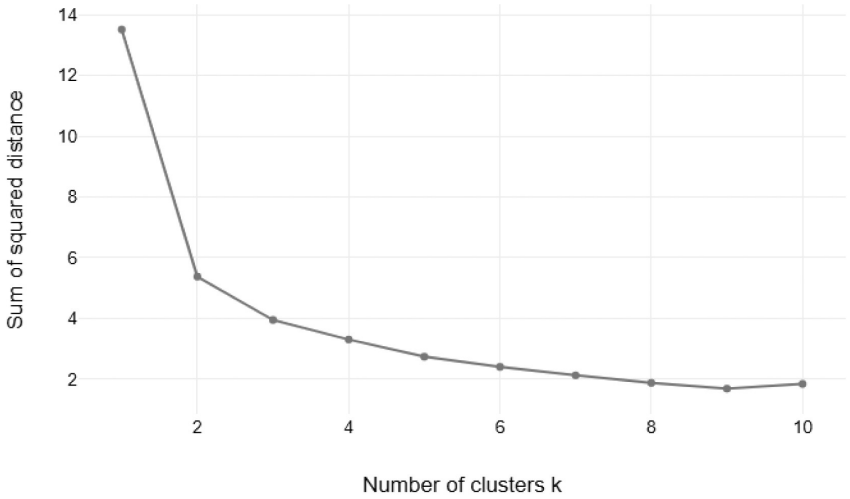

Fig. 2. Teamwork Perceptions: Number of Clusters vs Sum of Squared Distance.

teams, indicating considerable disparity in perceived workload distribution. The standard deviations were particularly pronounced in certain collaborative areas (emphasized with shades in Tables 2 & 3), reaching up to 15.77. These larger standard deviations suggest significant disagreement among team members regarding individual contributions to their document or prototype contribution. Areas with minimal standard deviation (approaching 0) indicate strong consensus among team members about participation levels. This pattern of varying consensus levels provides insights into how students perceive and evaluate their peers' involvement in collaborative work. Teams with at least two teammates' perceived discrepancy (Standard deviation larger than 4) in either of their work distributions (document or prototype) are considered unbalanced, and the rest are considered balanced.

5.2 Cultural Convergence or Divergence Among Teams (RQ2)

Using the clustering Elbow method, we determined the number of groups to study. Fig. 3 indicates the cultural orientation data naturally groups teams in two distinct patterns. We named them convergent and divergent teams.

To identify if a team is culturally convergent or divergent, we used the cultural orientation quantitative data. Students scored from 1 to 8 in each of

Table 2. Document's Contribution Chart of every team

Document	TM1		TM2		TM3		TM4		TM5	
	M	SD	M	SD	M	SD	M	SD	M	SD
Team 1	20	0	20	0	20	0	20	0	20	0
Team 2	18.33	1.25	18.67	1.25	20.33	1.25	26.67	3.3	16	1.4
Team 3	18.25	2.49	23.25	1.92	18.25	1.92	22	2.55	18.25	1.92
Team 4	19	2	19.4	1.2	22	4	19.6	0.8	20	0
Team 5	22.5	4.33	17.5	4.33	17.5	4.33	22.5	4.33	20	0
Team 6	17.25	6.58	26.38	3.96	5.63	3.7	28.88	5.25	21.88	4.1
Team 7	20	0	20	0	20	0	20	0	20	0
Team 8	16.1	4.99	23.1	3.8	21.6	3.2	15.6	5.43	23.6	4.45
Team 9	21	2	21	2	21	2	16	8	21	2
Team 10	19.75	0.43	20.5	0.87	20	0	20	0	19.75	0.43
Team 11	20	0	21	2	21	2	18	4	20	0
Team 12	20	0	18.6	1.96	21.2	1.94	20.2	0.4	20	0
Team 13	20	0	20	0	20	0	20	0	20	0
Team 14	20	0	21.67	2.36	18.33	2.36	20	0	20	0
Team 15	20	0	20	0	20	0	20	0	20	0
Team 16	27.5	2.5	26.25	2.17	20.25	3.19	3	2.12	23	2.12
Team 17	20.8	1.6	20	0	20	0	19.6	0.8	19.6	0.8
Team 18	20.8	1.6	19.6	0.8	20	0	20	0	19.6	0.8
Team 19	19	1.41	20	0	19.33	0.94	23.33	4.71	18.33	2.36
Team 20	18.8	1.94	19.2	2.14	20	0	20.8	2.14	21.2	1.94
Team 21	17.5	4.33	22.5	4.33	22.5	4.33	17.5	4.33	20	0
Team 22	20	0	20	0	20	0	20	0	20	0
Team 23	20	0	19	2	20	0	21	2	20	0
Team 24	16.67	2.36	24	2.94	22	2.83	12.33	5.56	25	4.08
Team 25	25	0	25	0	25	0	25	0		
Team 26	20	1.41	23.75	4.15	15.5	5.32	17.75	2.28	23	4.12
Team 27	23.75	2.17	26.25	2.17	23.75	2.17	26.25	2.17		
Team 28	20	0	20	0	20	0	20	0	20	0
Team 29	20	0	20	0	20	0	20	0	20	0
Team 30	27.5	7.5	12.5	7.5	27.5	7.5	12.5	7.5	20	0
Team 31	25	0	25	0			25	0	25	0

Table 3. Prototype's Contribution Chart of every team

Prototype	TM1		TM2		TM3		TM4		TM5	
	M	SD	M	SD	M	SD	M	SD	M	SD
Team 1	20	0	20	0	20	0	20	0	20	0
Team 2	16.77	4.71	16.67	4.71	34	15.77	22.67	3.77	10	4.08
Team 3	17	3.67	23	3.08	18.5	1.5	23.25	3.42	18.25	1.79
Team 4	19.4	1.2	19.6	0.8	21.6	3.2	19.6	0.8	19.5	0.4
Team 5	16.25	4.15	26.25	6.5	26.25	5.45	16.25	4.15	15	3.54
Team 6	15.63	8.36	24.38	3.7	3.75	4.15	26.88	3.25	29.38	5.7
Team 7	20	0	20	0	20	0	20	0	20	0
Team 8	29.5	11.87	14	8	12	9.8	30.5	12.88	14	7.35
Team 9	21	2	21	2	21	2	16	8	21	2
Team 10	20	0	21.25	2.17	19.58	0.72	19.58	0.72	19.58	0.72
Team 11	19	2	22	4	22	4	18	4	19	2
Team 12	20	0	22	4	20	0	19	2	19	2
Team 13	20	0	20	0	20	0	20	0	20	0
Team 14	21.67	2.36	20	0	18.33	2.36	20	0	20	0
Team 15	20	0	20	0	20	0	20	0	20	0
Team 16	26.25	2.17	24.5	0.87	21.75	3.42	1.25	2.17	26.25	2.17
Team 17	19.8	0.4	20.4	0.8	20.4	0.8	19.8	0.4	19.6	0.8
Team 18	20.8	1.6	19.6	0.8	20	0	20	0	19.6	0.8
Team 19	18.33	2.36	18.33	2.36	18.33	2.36	30	14.14	15	7.07
Team 20	19	2	19	2	20	0	21	2	21	2
Team 21	15	8.66	27.5	12.99	15	8.66	27.5	12.99	15	8.66
Team 22	20	0	20	0	20	0	18.75	2.17	21.25	2.17
Team 23	22.8	2.4	19.2	0.75	19.2	0.75	19.6	0.49	19.2	0.75
Team 24	13.33	6.24	23.33	4.71	21.67	6.24	10	8.17	31.67	8.5
Team 25	25	0	25	0	25	0	25	0		
Team 26	20.25	1.79	24.25	4.38	13.5	6.5	17.5	2.5	24.5	4.56
Team 27	43	5.2	19	1.73	19	1.73	19	1.73		
Team 28	21	2	20	0	20	0	19	2	20	0
Team 29	20	0	20	0	20	0	20	0	20	0
Team 30	27.5	7.5	12.5	7.5	27.5	7.5	10	10	22.5	2.5
Team 31	25	0	23.33	2.36			25	0	26.67	2.36

the 18 the MAXSA Core Cultural Values and Culture cultural orientations shown in Table 4 (Notice how a student can simultaneously be highly individualistic and collectivist, i.e., cultural orientations are not exclusive). Table 4 represents the standard deviation for each of the 18 cultural orientations of each of the 31 teams. Darker shades indicate greater standard deviation among team members for each cultural orientation.

5.3 Relationships Between Cultural Orientations and Teamwork Contribution (RQ3)

Once we had a quantitative analysis of both work perceptions and cultural orientations of every team, we developed four categories to associate culture with work perceptions. Teams were classified as balance-unbalanced with the Contribution Charts and as culturally convergent-divergent based on their Cultural Orientation quantitative responses (Table 5). After classifying the teams, we selected one team to represent each of the now-formed four categories: balanced-convergent Team 29; unbalanced-convergent Team 5; balanced-divergent Team 16; and unbalanced-divergent Team 6. To identify these representative teams, two researchers conducted a deductive analysis using the Socially Shared Regulation of Learning framework, which is based on four tenets: transactive, metacognitive, agentic, and socio-historically and contextually situated. The analysis involved examining two

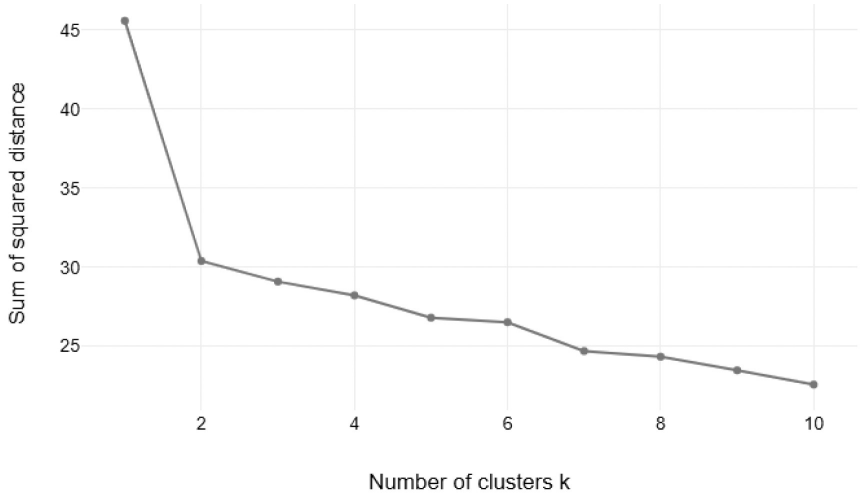

Fig. 3. Cultural orientations: Number of Clusters vs Sum of Squared Distance.

Table 4. Cultural orientations' standard deviations by team

Team	Individualism	Collectivism	Equality	Hierarchy	Polychronic T	Monochronic T	Meritocracy	Ascription	Activity	People	Change	Stability	Formality	Informality	Fate	Personal Efficacy	Directness	Indirectness
Team 1	0.75	1.72	0.98	1.74	1.36	1.02	0.49	0.63	1.20	1.85	1.36	1.74	0.80	2.06	1.55	0.80	1.17	1.94
Team 2	1.02	1.36	1.72	1.36	1.36	2.04	0.80	0.98	2.20	0.63	1.60	1.47	1.26	1.17	0.75	0.75	1.26	1.72
Team 3	1.55	2.06	1.20	1.74	1.85	1.50	1.17	1.72	1.02	2.14	1.67	1.41	1.94	1.17	0.75	1.17	2.45	1.94
Team 4	0.75	2.06	1.94	2.32	2.28	0.80	1.17	1.85	0.75	1.94	1.83	1.33	1.36	0.89	2.48	1.85	1.96	1.94
Team 5	0.49	1.67	0.75	0.98	1.17	1.02	1.17	1.85	1.36	0.98	0.75	1.62	1.50	0.75	1.33	0.98	1.02	1.41
Team 6	1.50	0.98	1.85	2.04	1.85	2.15	0.63	0.75	0.75	1.72	1.47	1.26	2.24	2.33	1.33	1.96	1.47	1.36
Team 7	0.49	1.50	2.10	2.06	1.36	1.20	1.02	1.50	1.41	1.36	1.62	1.74	2.14	2.06	1.60	1.50	1.72	1.36
Team 8	1.36	1.20	1.72	1.94	1.94	0.40	0.98	1.41	1.02	0.49	1.85	1.85	2.14	1.67	1.26	1.72	0.63	0.80
Team 9	0.80	0.98	2.32	0.63	1.10	1.17	1.55	1.72	1.17	1.02	1.17	1.62	1.02	1.47	1.62	1.26	0.89	0.80
Team 10	0.75	2.24	0.98	1.62	0.98	0.80	0.80	1.94	1.36	1.20	1.36	1.50	1.41	1.02	1.26	1.36	1.47	1.85
Team 11	0.75	1.50	1.67	1.33	1.02	1.17	1.50	2.23	0.98	1.36	1.67	1.74	1.72	2.15	0.80	0.98	0.75	1.90
Team 12	1.50	1.36	1.90	2.61	2.48	0.80	1.79	1.10	1.47	1.85	1.62	1.02	1.33	1.85	1.74	1.62	0.89	1.02
Team 13	1.17	1.17	1.26	1.17	1.96	0.98	0.75	0.75	1.36	1.90	1.36	1.36	1.94	1.50	1.60	1.36	0.75	1.41
Team 14	0.49	0.80	1.74	1.85	1.74	1.36	1.50	0.63	1.02	1.85	1.20	1.27	1.33	0.98	1.47	1.26	1.41	1.72
Team 15	0.80	1.36	1.10	2.37	1.94	1.17	1.94	2.24	1.01	1.02	2.31	1.79	2.25	1.36	2.25	1.47	1.02	0.98
Team 16	1.60	1.32	1.74	2.32	2.42	2.91	2.42	2.00	1.47	0.75	2.65	1.74	0.98	1.17	1.47	1.36	1.17	1.36
Team 17	0.75	1.79	1.41	1.62	2.33	2.53	1.85	1.60	1.02	1.02	1.10	2.73	1.20	0.75	2.32	1.74	1.90	1.74
Team 18	0.75	1.02	1.50	2.06	2.04	1.17	0.80	2.42	1.36	1.72	1.20	0.98	2.28	1.72	2.04	1.85	2.24	2.06
Team 19	2.00	1.64	1.50	1.87	1.00	0.83	1.30	1.79	0.87	1.73	1.50	2.49	0.43	0.87	1.22	0.83	1.58	1.00
Team 20	1.48	0.83	1.50	1.09	1.41	0.83	0.50	1.22	1.73	1.50	1.87	1.50	1.66	1.12	1.41	1.30	0.87	0.43
Team 21	1.74	1.72	1.50	1.17	2.10	0.80	2.58	1.47	1.33	1.20	1.67	1.41	1.10	0.80	1.83	1.20	1.60	2.48
Team 22	1.10	0.49	0.89	1.36	1.26	1.20	0.80	1.50	1.02	1.26	1.20	1.47	1.02	0.89	1.85	0.75	0.98	1.67
Team 23	0.89	0.98	1.17	0.98	1.83	0.80	1.55	0.63	2.28	1.96	1.36	1.17	0.98	0.98	1.83	1.17	1.72	2.53
Team 24	1.41	1.74	0.80	1.83	1.20	0.63	0.49	1.47	1.67	1.72	1.02	1.67	1.60	0.63	1.17	0.75	1.94	1.67
Team 25	1.12	1.12	1.50	2.69	2.59	0.43	0.83	1.92	1.22	0.83	1.12	1.66	1.50	1.30	2.49	2.35	0.50	0.71
Team 26	1.17	1.17	1.10	1.67	1.41	1.10	0.49	1.94	0.75	1.10	0.89	1.17	2.58	1.20	1.26	1.47	1.33	0.75
Team 27	0.83	1.09	0.43	0.83	1.22	1.64	2.05	1.48	1.79	0.83	1.48	0.83	1.58	1.12	2.77	1.50	1.79	0.83
Team 28	0.98	1.26	1.41	1.10	1.85	1.33	0.75	0.63	1.26	1.10	2.06	1.72	0.98	1.17	1.47	2.40	0.75	0.80
Team 29	0.98	1.62	1.36	1.74	2.04	1.02	1.26	2.04	1.85	1.41	1.02	0.80	0.80	1.33	1.85	1.20	1.17	1.17
Team 30	0.75	1.73	0.75	1.50	1.71	1.34	1.00	1.34	1.83	1.80	1.25	0.90	1.89	1.21	1.34	1.34	0.69	1.46
Team 31	0.83	0.83	1.66	1.58	0.83	0.50	0.83	0.00	2.18	1.50	1.79	1.22	1.22	1.66	1.50	0.43	0.83	0.71

different qualitative strands of data: for the work distribution analysis, the retrospectives or reflections after each project milestone; and for the cultural orientation analysis, the open-ended responses on their reasoning for choosing their most significant cultural orientations, the influence of those cultural orientations to their teamwork interactions, and based on their cultural orienta-

tions, strategies to facilitate teamwork interactions. Through an iterative process of triangulation, we evaluated each team's responses using the SSRL framework to identify four teams that represented the four associations of balanced, unbalanced, culturally convergent, and culturally divergent teams.

5.4 SSRL Across Representative Teams: Team Reflections and Cultural Orientations

To address the fourth research question, we explored each team's qualitative responses to their cultural orientations and the teams' reflections after the milestones of their class project. Using the SSRL framework, two of the researchers analyzed and triangulated all teams in each of the four groups and, after some iterations, agreed upon the teams shown in the following subsections. We analyzed the data through the lens of Socially Shared Regulated Learning (SSRL), examining how transactive perspectives contributed to joint conditions, shared metacognitive processes drove adaptations, collective goals guided monitoring and evaluation, and socio-historical contexts shaped shared conditions. Two of the researchers used a journal for 6 months to register and triangulate their findings.

5.4.1 Team 29: Balanced and Culturally Convergent

Team 29 was selected to represent balanced and culturally convergent teams because of their high alignment on prioritizing people over activities, and despite having higher individualism, teammates valued collectivism, recognizing its benefits. With most of the team inclined towards people and a similar orientation between individualism and collectivism, Team 29 performed well as a culturally convergent team with a balanced perception of the work of each team member.

The team registered People as their most important cultural dimension with a score of 9 *(M = 6.0, SD = 1.41)*. Teammate 29.2 reflected their people orientation "*I will do my best to respect others and their likely different orientations, while also factoring in what I believe to be right for the good of everybody in the group*.". Teammate 29.3 added to the people orientation "*[N]oticing that everyone in our group is equal and that we are all students trying to accomplish our goals will help group work move forward effectively*." Team 29's second most important cultural dimension was individualism *(M = 6.2, SD = 0.98)*. Members of Team 29 were individualistic and, at the same time, valued people and recognized collectivism as beneficial, Teammate 29.4 "*Even though I am individualistic I believe that working with more than yourself provides a unique atmosphere that creates innovation*".

Team 29 prioritized effective task allocation and equal contribution by all members as a way for productive teamwork: "*We have worked hard to evenly divide up the tasks/deliverables for each sprint and milestone, and the results reflect that effort*". Team 29 distributed the work in a well-coordinated effort where roles were defined to allow collective involvement. Furthermore, reflective practices were integral to their process. The team continuously evaluated their performance, as highlighted by "*our teamwork has continued to go very well . . . all members are showing up for each meeting and are contributing equally*." They also displayed proactive problem-solving and forward-thinking "*For our second milestone, we plan to narrow the scope of our proposed solution and discern what aspects will require the most time and attention. This will ensure that all team members are working as efficiently as possible on necessary milestone tasks*.".

The team displayed high collective agency and inclusive decision-making, enabling them to integrate diverse perspectives effectively, "*We are making sure to always take the opinions of all members into account before making important decisions, and our work is the product of strong collaborative efforts between the five of us*." This approach helped create an inclusive and supportive environment where every team member felt valued, respected, and heard.

5.4.2 Team 5: Unbalanced and Culturally Convergent

Team 5 was selected as the representative of unbalanced and culturally convergent teams because of their high standard deviation in the work perception of the document (See Table 2) and prototype

Table 5. Clustered teams: cultural orientations & contribution charts

Cultural orientations \ Contribution charts	Balanced	Unbalanced
Culturally convergent	1, 3, 10, 11, 13, 14, 20, 22, 23, 25, 27, 28, **29,** 31	2, **5**, 9, 19, 24, 26
Culturally divergent	4, 7, 12, 15, **16,** 17, 18	**6,** 8, 21, 30

Table 6. Balanced-Convergent Team 29's preferred cultural orientations

Cultural dimension	Score	Average	Standard deviation
People	9	6.0	1.41
Individualism	6	6.2	0.98
Personal efficacy	5	6.6	1.20
Monochronic time	5	6.4	1.02

(See Table 3) and high convergence in their understanding of time, directness, and collectivism. Team 5 valued time as a finite resource that needs to be purposefully distributed to complete the most important tasks. Teammate 5.5 "*Time is the ruler of everything. As I started growing older, I realized that time is fleeting, and so we need to make the most of what little time we can grasp on to. Spending time with friends and family is good, but sometimes it feels wasted when we just lounge around and do nothing. As time moves forward, things change, and if we keep looking behind to the past, then time will unrelentingly leave us in the dust*." Teammate 5.3 said, "*I will value my time and use it to my ability*.". Most of Team 5 valued collectivism *(M = 6.0, SD = 1.67)* except for one teammate who did not, thus explaining the high standard deviation. Teammate 5.1"*A lot of my top ideas often relate to the individual rather than the collective and the effect we have on ourselves, and the aspect we teach others is often a reflection of how we treat ourselves.*" Four out of five teammates in Team 5 valued time as a finite resource, directness, and collectivism. In the words of Teammate 5.2 "*These [top three cultural orientations] will influence very positively if everyone works together well, but if one person does not take time seriously, does not speak up, or may not have the motivation to work as a team, there will be problems that may slow down the project process*.". Unsurprisingly, the teammate who valued individualism in this collectivist team was the main cause for the unbalanced perception of the work distribution in Team 5.

Team 5 displayed some coordination in the initial planning stages, but there were significant challenges in role clarity and task distribution. They noted, "*For future milestones, we could improve our team collaboration by openly communicating what each member will be tasked to do and to double-check everyone's work before submitting the final draft*." This issue persisted, as they expressed a similar sentiment in Milestone 3, "*we could improve . . . by openly communicating what each member will be tasked to do since there were many project assignments that were due these past 2 weeks*." indicating ongoing attempts to address these coordination issues.

Team 5 showed a reflective awareness of their scheduling and task management challenges. Members acknowledged the need for improved planning: "*we should definitely start earlier . . . This way, we can find a time that we are available since no one has the exact same schedule*". They recognized the inefficiencies in their work process but found it difficult to implement more effective strategies consistently.

Despite the contribution imbalance, there was a shared effort to improve communication and collaboration. One member remarked, "*with the increase in communication, we were able to identify what needed to get done and to track each team member's progress*." This shows a collective push towards better managing their teamwork, even as the lack of balanced contribution hindered a fully agentic stance. To collaborate, the team relied heavily on digital tools for communication, reflecting a sociohistorical shift towards remote collaboration methods due to individual schedule constraints: "*It was really hard to find a time where everyone was free outside of class to meet in-person. As an alternative, we discussed online through our Teams chat as well as worked together on a document, so we can all add on whenever we get a chance*."

Table 7. Unbalanced-Convergent Team 5's preferred cultural dimensions

Cultural dimension	Score	Average	Standard deviation
Monochronic time	8	6.6	1.02
Directness	7	6.4	1.02
Collectivism	6	6.0	1.67

5.4.3 Team 16: Balanced and Culturally Divergent

Team 16 was selected to represent teams that were balanced and culturally divergent. This team had different cultural orientations. Out of the nine pairs of cultural dimensions, they picked six different top three favorites. For Team 16, Monochronic time was really important *(M = 6.4, SD = 2.73)*. Teammate 16.1 "*I won't be wasting anyone's time*.", Teammate 16.2 "*I have a very busy schedule and keep myself occupied all the time*", and Teammate 16.4 "*I believe it is important to have a schedule for group work and setting a side a time where we have a set work time and everyone can collectively work together to attack the time we have to get work done is important*". Although for four teammates shared similar orientations, the fifth thought differently "*I am laid back with time and more creative.*" This accounts for the high standard deviation in the time orientation, which did not affect the team's effectiveness.

As important as time team 16 valued People *(M = 7.2, SD = 0.75)* showing the positive influence of this cultural orientation over the team's perception of work. As one teammate argued, they could work together even with different cultural orientations "*I think the more that others are aligned with my value orientations the smoother the project will go. However, even if there are contrasting values with other teammates it does not mean that I cannot change and adapt to further improve the team.*" They also followed up by saying, "*I will use to facilitate my teamwork interactions to avoid negative*

influence caused by my value orientation is to become adaptive."

Team 16 exhibited a flexible and adaptable approach to task allocation and collaboration to ensure timely completion of tasks, as evidenced by "*Everyone was considerate of time management and was willing to work at any point in order to get assignments completed. . .We were able to get all assignments done in a swift manner and in very good quality of work, which was split up equally. Even when someone noticed something was missing, there was no hesitation to jump on the problem at hand and get the work completed.*"

Team 16 actively reflected on their performance and adjusted strategies accordingly. They noted the benefits of their approach: "*As a group, we all worked well together to get the requirements done on time . . . everyone was very understanding about getting the assignment done and putting in the work to do so prior to the due date in order to reduce any stress on the day off.*" Their commitment to starting tasks earlier to avoid last-minute pressures was a recurring theme in their reflections, reflecting ongoing metacognitive engagement.

The team was collectively agentic and demonstrated a strong sense of solidarity and support, consistently stepping in to assist each other whenever a member was in need. They mentioned: "*When it came to working in a group (in teams), each member was willing to offer a helping hand with whatever was needed. If somebody was confused, or wanted extra feedback, a member was ready to help them with whatever was needed.*"

5.4.4 Team 6: Unbalanced and Culturally Divergent

Team 6 was selected as the representative team for unbalanced and culturally divergent because of its high standard deviations in work perception (See Tables 2 & 3), conflict around communication, and the differences in their cultural orientations. The tension between directness and indirectness particularly exemplifies these opposing cultural orientations, which is why we included it in Table 9 despite its lower quantitative significance.

Table 8. Balanced-Divergent Team 16's preferred cultural orientations

Cultural dimension	Score	Average	Standard deviation
Monochronic time	6	6.4	2.73
People	6	7.2	0.75
Directness	5	6.8	1.17

Table 9. Unbalanced-Divergent Team 6's preferred cultural orientations

Cultural dimension	Score	Average	Standard deviation
Collectivism	6	6.2	0.98
Monochronic time	6	5.4	2.15
Hierarchy	5	5.8	2.04
Directness	3	5.2	1.47

The difference between these cultural orientations led to tensions that disrupted the team's effectiveness. For example, Teammate 6.3 valued directness "*Being direct is also important as it can help resolve conflict.*". On the other hand, Teammate 6.4 valued indirectness "*I think being too direct is never a good thing since people can lose motivation one they get too much critique without positives*". This team shows how low orientation in the directness indirectness cultural dimension can result in poor team effectiveness due to the misunderstanding of people's preferred orientations for communication.

The team acknowledged struggling with project planning and task allocation, as they mentioned: "*There were some struggles when finalizing our plan for the system but with the delegation of work and good communication, milestone 2 was completed relatively stress free.*" These concerns regarding accountability became worse over time, "*Team members were not submitting work and contributing to the team effectively, which caused other team members to pick up the slack and do extra work.*"

Communication within Team 6 was a recurrent theme, with efforts to improve it evident across milestones. The team realized in Milestone 1, "*As a team, there were times where we did not communicate properly, but from now on, we hope to let others speak and not talk over each other.*" Similar sentiment was echoed in Milestone 3, "*we hope to let others speak and not talk over each other*" which shows their inability to rectify communication issues over the course of the semester.

Despite recurring struggles, the team was able to recognize the need to improve communication, time management, and preemptive problem-solving strategies. They noted, "*In the future, we plan to do a better job of updating our documents throughout instead of at the end so our changes are more seamless and we don't forget any detail*" as well as "*In the future, we strive for clearer communication with all members putting in equal amount of effort and quality.*" This shows that while the team was unable to resolve their issues, they remained hopeful and committed to implementing better strategies in their future collaborations.

6. Discussion, Implications, Limitations, and Future Work

This study investigated the relationship between teamwork dynamics and cultural orientations, spe-

cifically, the impact of cultural orientations on the team's perception of team efficacy. Through the quantitative and qualitative analysis of 31 teams in a large STEM classroom, we researched students' perceptions of teamwork interactions and cultural orientations in diverse teams, examining balanced and unbalanced team dynamics, convergent and divergent cultural orientations, patterns in perceived teamwork contributions and cultural orientations, and how these elements relate to socially shared regulation of learning.

Research has identified instances where cultural diversity can facilitate team performance [52], however, our findings reveal a more nuanced relationship between cultural orientations and teamwork effectiveness. Our research shows that cultural orientations in teams, whether balanced or unbalanced, do not definitively predict teamwork effectiveness. This complexity is demonstrated through the contrasting yet successful experiences of Teams 16 and 29. Despite their different cultural orientations, both teams shared a strong emphasis on prioritizing people over activity, with Team 16 *(M = 7.2, SD = 0.75)* and Team 29 *(M = 6.0, SD = 1.4)* in this people's dimension. In line with Cheng and colleagues' [53] findings about relationship-oriented teams performing better in later stages of team building, Team 16 achieved balanced teamwork through their flexible approach to task allocation and a strong emphasis on mutual support, as evidenced by their commitment to helping teammates and proactive task completion. Their success aligns with Jones et al.'s [52] argument that diverse backgrounds can foster novel approaches to problem-solving. Conversely, Team 29, with more convergent cultural orientations centered on individualism, demonstrated effective teamwork through structured task distribution and inclusive decision-making. Both teams succeeded through different approaches: Team 16 excelled through adaptability and collective support, while Team 29 thrived through well-defined role allocation and balanced collaboration. Their success, despite different cultural orientations, demonstrates that effective teamwork can emerge from both culturally convergent and divergent teams when they develop appropriate collaborative strategies and prioritize people in the team over the activity they are undertaking.

However, our findings also support Jones and colleagues' [52] caution about cultural differences potentially creating challenges in teamwork. The case of Team 5 demonstrates that cultural convergence alone does not guarantee balanced teamwork interactions. Despite the team's strong alignment in their cultural orientations, they experienced unbalanced workload distribution. This imbalance manifested in ongoing coordination challenges, evidenced by their recurring need to "improve team collaboration by openly communicating what each member will be tasked to do." Team 5's experience illustrates that while cultural diversity can drive innovation and improve team performance, as Jones and colleagues [52] suggest, other factors beyond cultural alignment play crucial roles in team effectiveness. This highlights the importance of not only considering cultural orientations but also actively cultivating a safe environment, managing team dynamics and communication strategies to scaffold the benefits of both culturally convergent and divergent teams.

Our second finding presents an interesting contrast to established management literature regarding individualism in team settings. While Gundlach et al. [54] demonstrated that individualistic team members typically negatively influence team performance and face challenges in team-based structures, our findings in STEM education reveal a more complex picture. Measuring teamwork effectiveness solely by the outcome allows individualistic teams to divide the work, avoid team interactions with its challenges and benefits, and possibly be very efficient at delivering the task required. For example, Balanced and Convergent representative Team 29, despite their high individualism, achieved effective teamwork outcomes through structured task division and high value on people. Their success challenges the traditional understanding that individualistic members inherently impede team performance, suggesting that STEM contexts, particularly in computer science, might accommodate individualistic tendencies differently than management settings. This divergence from Gundlach et al.'s [54] findings might be attributed to the nature of computer science work, where modular task division aligns naturally with software development practices. The team successfully managed their work through clear task allocation, leading to balanced workload perceptions, as evidenced by their reflection that "all members are showing up for each meeting and are contributing equally." While Gundlach's social identity theory suggests that individuals need to self-categorize as group members for effective team performance, our findings indicate that STEM teams might achieve cohesion through structured independence rather than traditional group identification.

However, the limitations of this individualistic approach emerge in the team's reflections. As noted by Teammate 29.4, "Even though I am individualistic I believe that working with more than yourself provides a unique atmosphere that creates innovation." This insight aligns with Gundlach et al.'s [54] broader concerns about organizations potentially missing the benefits offered by

team structures. While individualistic teams in STEM can effectively deliver outcomes through task division, this approach tends to prioritize product completion over the richness of the collaborative process itself. The focus on individual task completion might overlook valuable opportunities for knowledge exchange, iterative feedback, and the synthesis of diverse problem-solving approaches that emerge when team members actively engage with each other's perspectives. This is particularly crucial in STEM fields, where complex technical challenges often benefit from the intersection of different technical backgrounds, problem-solving strategies, and ways of thinking about solutions. This tension between individualistic efficiency and collaborative innovation presents a unique challenge for STEM education. While the current industry practices, for example in computer science, might encourage individualistic tendencies through modular work structures, the evolving nature of STEM challenges, particularly in addressing complex societal needs, may require meaningful collaborative processes over individualistic task efficiency.

Different communication styles are often an obstacle to effective teamwork, so early identification of communication divergence can help instructors scaffold strategies to provide support for their teams. Research by Butchibabu et al. [55] suggested that teams perform better when members anticipate each other's information needs rather than relying on explicit communication. Expanding on this understanding of implicit coordination, our findings reveal how cultural orientations shape these communication dynamics, particularly when team members must navigate different preferences for directness in their interactions. Our findings extend this understanding by demonstrating how divergent cultural orientations of communication can impede implicit coordination, highlighting the importance of early cultural orientation assessment to help instructors proactively address potential communication challenges. Team 6 exemplifies this challenge through their contrasting cultural orientations, directness-indirectness, where team members held opposing views about communication approaches. This divergence was evident from their conflicting perspectives: while Teammate 6.3 strongly valued directness (7/8), believing "Being direct is also important as it can help resolve conflict," Teammate 6.4 preferred indirectness (6/8), arguing that "being too direct is never a good thing since people can lose motivation once they get too much critique without positives." These contradictory communication preferences led to persistent team challenges and unbalanced work distribution, as reflected in their recurring struggles: "As a team, there were times where we did not communicate properly". As Khadpe and colleagues [56] emphasize, once team norms are established, it becomes difficult to reset mid-interaction, making early intervention crucial. Moreover, as presented by Khadpe et al. [56], these interventions should focus on creating an environment where team members feel safe to voice their opinions and confident that their perspectives are valued. This case demonstrates that early identification of cultural divergences enables instructors to implement targeted interventions that foster inclusive team norms.

This research supports that intercultural competence is a cornerstone for teamwork in a globalized environment such as engineering classrooms in the US. Engineering instructors and students should foster intercultural competence to help improve teamwork interactions and outcomes. Intercultural competence promotes the inclusion and balanced participation of team members. Instructors of diverse teams should develop strategies to encourage inclusion or to reduce the dominance of language [57] and assimilation of ways of doing and being. Intentionally creating intercultural learning is necessary for students to cultivate intercultural competence. Research has shown that being exposed to intercultural interactions, either in the classroom or studying abroad, is not enough to increase intercultural competencies [58].

Additionally, the implications of this study relate to ways to promote cultural self-awareness in the context of teamwork. Specifically, findings from this study suggest that by promoting cultural self-awareness, students may be more conscious of how such backgrounds and views can have a potential impact, positively or negatively, on their teamwork experiences and outcomes. According to transformative learning, students can learn or acquire new practices and skills by adapting their frame of reference by engaging in experiences mentally and behaviorally [59]. Reflective practices can help in this regard, as students may become more aware of how their backgrounds influence their interactions. They may then critically evaluate their interactions and adapt them accordingly [60]. Thus, it is important for instructors to guide students through reflection prompts and use those reflections in ways that enhance their understanding of themselves as individuals and in the relationships, they form with their team members [61] and teach them how to reflect by themselves, so they become reflective practitioners [62].

This study also offers important theoretical and practical implications for higher education. Theoretically, it provides documented evidence of the relationship between teamwork perceptions and cultural orientations in large STEM classrooms,

contributing to our understanding of intercultural dynamics in educational settings. From a teaching and learning perspective, our findings demonstrate how structured reflection on cultural orientations can enhance students' intercultural competence. By encouraging students to examine their own cultural orientations and those of their teammates, educators can foster awareness and appreciation of diverse ways of being and knowing, moving beyond mere tolerance toward genuine valuation of cultural differences in collaborative settings.

Future research should explore several key areas. First, investigation is needed into how specific cultural orientations, such as prioritizing people over activity, influence team dynamics and potentially help teams overcome cultural divergences. Second, research should examine which cultural orientations and at what levels contribute to more effective team processes, particularly focusing on interaction patterns, communication effectiveness, and the integration versus assimilation of diverse perspectives. Finally, further research is needed to help identify which divergent cultural orientations can serve as early indicators of potential team challenges, enabling instructors to implement proactive interventions that enhance teamwork effectiveness.

7. Conclusion

This study investigated the patterns that emerge in teams' perceptions of their teamwork and how these perceptions are related to their cultural orientations; we found four outstanding findings. First, the literature supports how cultural diversity can foster innovation and different angles for problem-solving. However, the success of teamwork depends more on how teams develop their collaborative strategies than on their cultural composition alone, with neither convergent nor divergent cultural orientations inherently determining teamwork effectiveness. Second, individualistic members are often viewed as challenging in team settings, in STEM contexts, particularly computer science, individualistic teams can achieve effective outcomes through structured task division, yet this approach limits the rich potential of diverse perspectives and collaborative benefits that characterize effective team processes. Third, early identification of cultural divergences, especially in communication styles, is crucial for implementing targeted interventions that create psychologically safe environments where team members feel confident expressing their views and engaging with different perspectives. Fourth, fostering intercultural competence is essential for effective teamwork interactions and outcomes in diverse engineering classrooms, requiring intentional and explicit strategies to promote inclusion and meaningful interactions between multicultural team members.

Declarations

Ethics statement – The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Purdue University (protocol code IRB-2021-1181 and date of approval 20 August 2021). The protocol was approved as exempt because the research was conducted in a commonly accepted educational setting and involved normal educational practices. Thus, informed consent was not applicable.

Availability of data and materials – The datasets generated and/or analyzed during the current study are not publicly available due to participants' privacy and confidentiality but are available from the corresponding author upon reasonable request.

Competing interests – The authors declare no competing interests.

Funding – This work was supported in part by the U.S. National Science Foundation (NSF) under awards #2113991 and #2219271 and the Center for Intercultural Learning, Mentorship, Assessment, and Research (CILMAR) at Purdue University. The views and conclusions contained herein are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of NSF, the U.S. Government, or Purdue University.

Authors' contributions – JCR: conception and design of the work, interpretation of data, drafted and substantively revised the work; SA: analysis of data, interpretation of data, drafted the work; DP: analysis of quantitative data, interpretation of data; AM: conception and design of the work, drafted and substantively revised the work.

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