"Fright not and be dispersed!" Investigating the Influence of Cultural Dimensions on Communication and Collaboration in Software Development

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Abstract. The state of software practice requires developers and stakeholders worldwide to collaborate on developing and maintaining software products. In turn, managers are faced with technical challenges and those connected to global workforce dispersion, from which the practitioner's culture outstands as a protagonist. The existing body of knowledge on the role of culture in software development is substantial; however, few studies have adopted a systematic framework for their investigation and for reporting their results. This paper starts from the aformentioned objective and seeks to understand how the presence of members with different cultural attitudes influences the emergence of collaboration and communication issues in software development communities. To this aim, we investigated culture using *Hofstede's 6-D framework* as part of qualitative research. First, we conducted a focus group with six senior RedHat professionals to understand to what extent different cultural behaviors impact communication and collaboration activities and which strategies they implement to mitigate conflicts. Second, we conduct a large-scale survey to strengthen and expand the results of the focus group. Overall, our research highlights how effective management plays a crucial role in unlocking the potential of cultural diversity within software development teams. We show that, when managed strategically, cultural differences go beyond mere mitigation—they actively enrich team dynamics, promote better communication, and facilitate more efficient collaboration. This emphasizes the value of incorporating culturally aware management practices in global software development environments.

Keywords: Software Engineering · Social Aspects · Organizational Culture

1 Introduction

Software engineering (SE) is, *de facto*, a socio-technical activity [15] that often involves stakeholders from various places around the world and with different backgrounds, even more so with the onset of Artificial Intelligence (AI) driven software development where developers assume the role of supervisors and jurors of their peers' work, be it AI or human. Such heterogeneity naturally leads to the emergence of social challenges, especially in terms of collaboration and communication, like personality conflicts, language, and cultural barriers. If not properly managed, these can in turn contribute to so-called *social debt*, i.e., the additional project cost caused by suboptimal socio-technical decisions or circumstances in a development community [38].

Among the various social challenges that impact social debt, this work focuses on *culture*: this is defined as the set of common behaviors that distinguish the members of one community from another [17, 18]. As recognized in seminal work in the field [12, 31], culture has a greater influence on SE practices than originally envisioned. This is the main reason why researchers in the field of *Global Software Engineering* (GSE)—i.e., the branch of software engineering aiming at establishing a set of practices to manage globally distributed software teams—have been largely exploring the influence of cultural aspects on distributed software development and maintenance activities [12, 20, 31].

Recent literature reviews [12, 20, 31] highlight two key limitations. First, cultural dimension frameworks [13, 14, 16] are rarely or only partially adopted in SE studies [12], preventing a systematic understanding of how culture impacts development practices. Second, existing results are contrasting: cultural diversity empower decision-making [15, 35] but can also lead to collaboration and communication problems [34].

This paper addresses these gaps by investigating how cultural differences affect communication and collaboration in software development communities. Rather than treating culture as an abstract concept, we represent it using Hofstede's 6-D framework [16, 18], building on recent work on cultural dispersion in SE [23–26, 28].

The results of our study show that increasing cultural variety in development teams—having heterogeneous behaviors—impacts collaboration and communication activities, but not necessarily in a negative way. Indeed, if correctly managed, cultural variety could be beneficial, possibly improving team productivity. Moreover, as part of our study, we elicit a new behavior that seems to be related to the culture of individuals. We named this *Risk Hiding Index* (RHI), i.e., the extent to which the members of a culture feel comfortable exposing and revealing risks. Finally, we provide a list of mitigation strategies for each cultural dimension, e.g., restructuring the community. We conclude that project managers should consider culture as a key indicator during all development and maintenance activities—not only during team formation, as typically acknowledged—

to avoid the emergence of hard-to-manage socio-technical and organizational behaviors.

To sum up, this paper provides the following contributions:

1. A set of positive and negative patterns of communication and collaboration that emerge when individuals with diverse cultural background work together within the same development team.
2. A potential new cultural behaviors—i.e., *Risk Hiding Index*—representing the extent to which people feel comfortable exposing and revealing risks to ask for help instead of managing them by themselves.
3. A set of mitigation and refactoring strategies for each cultural dimension, e.g., restructuring the community.
4. A publicly available repository reporting the raw data collected in the context of the study for further research and new considerations by the community [29].

2 Background and Related Work

Several frameworks have been proposed to characterize culture through measurable *dimensions*, each capturing a contrast between two opposing *cultural behaviors* [13, 14, 16]. Among them, ***Hofstede's 6-D framework*** [16] is the most widely adopted in SE [1, 5, 6]. It comprises six dimensions, each scored from 0 to 100 per country [18]:

- Power Distance (PDI): Degree of accepted inequality in the distribution of power within a community.
- Individualism vs. Collectivism (IDV): Extent to which individuals are expected to act independently vs. as part of a cohesive group.
- Masculinity vs. Femininity (MAS): Preference for achievement and assertiveness vs. cooperation and quality of life.
- Uncertainty Avoidance (UAI): Degree of discomfort with ambiguity and unknown situations.
- Long vs. Short Term Orientation (LTO): Emphasis on persistence and long-term growth vs. quick results and tradition.
- Indulgence vs. Restraint (IVR): Tendency to allow free gratification of desires vs. regulate them through strict norms.

Despite its wide adoption, part of the research community questions the framework's validity [4, 36]. Nonetheless, Venkateswaran and Ojha [39] demonstrated that it remains the most effective instrument for characterizing cultural aspects, following a realistic approach proven effective across fields including computer science [1, 5, 6, 17].

In the SE context, various studies acknowledge culture as a relevant factor in distributed teams [15, 31, 34, 35], but they do not systematically map challenges or strategies to specific cultural dimensions. Deshpande et al. [9] elicited strategies from Indian project managers without adopting a cultural framework, and

Borchers [5] studied three of Hofstede's dimensions but focused solely on impact without addressing mitigation. Zolduoarrati et al. [41] examined how the IDV dimension affects developer behavior on StackOverflow, but considered only one dimension. In contrast, our work systematically maps both challenges and strategies to all six Hofstede dimensions.

More recently, Lambiase et al. [24–28] introduced the concept of *cultural dispersion* in SE—situations in which community members exhibit behaviors diverging from those typically associated with their cultural background—and showed that unmanaged cultural differences correlate with community smells [27] and reduced productivity [25, 26]. They proposed the *Dealing with Cultural Dispersion* framework for managing cultural diversity in software teams [24].

3 Research Design

The empirical study revolved around three research questions. First, we investigated whether developers recognize cultural behaviors described by Hofstede's dimensions in their work and associate them with culture:

> ⍰ **RQ$_1$**: *Which cultural behaviors do professionals most readily recognize in their experiences and attribute to the cultural background of individuals?*

Second, we aimed to understand how the coexistence of contrasting cultural behaviors within a team influences communication and collaboration:

> ⍰ **RQ$_2$**: *How does the presence of individuals with diverse cultural backgrounds and exhibiting contrasting behaviors (associated with specific Hofstede dimensions) influence communication and collaboration activities in software development teams?*

Third, we sought actionable strategies for mitigating challenges originating from cultural diversity in software teams:

> ⍰ **RQ$_3$**: *Which mitigation and contingency strategies are put in place to face issues originating from geo-distributed and culturally dispersed software communities?*

Our strategy follows a mixed-methods approach [8]. We first performed a *focus group* (Section 3.1) to stimulate discussion and elicit insights for all three RQs, then conducted a larger-scale confirmatory survey (Section 3.2). Rather than using Hofstede's dimension scores directly, we focused on the *behaviors* described by each dimension, using examples in focus groups and vignette-based scenarios in surveys to help participants relate to culturally influenced situations. We employed content analysis [7] for qualitative data and descriptive statistics

for closed-ended survey questions. In terms of reporting, we followed the guidelines by Wohlin et al. [40] and the *ACM/SIGSOFT Empirical Standards*.[5] A replication package is available online [29].

3.1 Design of the Focus Group Study

To address our **RQ**s, we first conducted a *focus group* [32], a qualitative methodology that relies on dynamic interaction among participants to elicit data difficult to obtain through individual interviews. We recruited participants through a co-author working at Red Hat,[6] a large open-source company with globally distributed teams. The session was conducted virtually via Zoom, following established guidelines [21, 33].

Focus Group Participants Using *convenience sampling* through our target company, we recruited six practitioners with at least 10 years of experience in leading teams and global software development [33]. To mitigate the limited generalizability of this method, we set base criteria for participants and later conducted a confirmatory survey.

Focus Group Structure The focus group, moderated by the first two authors, consisted of an introduction, ice-breaking questions, and core questions organized in two groups: (G1) recognition and experience of cultural dimensions, including possible new dimensions; and (G2) impact of cultural behaviors on collaboration and communication. Questions were not strictly predefined to foster open discussion.

Results Analysis Methods We perform content analysis [7] on the transcript to extract cultural conditions and problems. The first two authors independently analyzed the transcript, assigning concepts to sentences and then discussing disagreements to reach consensus over two rounds. Cohen's kappa [22] measured 0.77 in the second round, indicating strong agreement [30]. All authors then verified the consistency of the results. Responses from G1 addressed RQ_1, while G2 addressed RQ_2 and RQ_3.

3.2 Design of the Survey Study

We designed a confirmatory survey [2, 21] targeting a larger population of practitioners to generalize the focus group findings. The survey covered all six Hofstede dimensions plus the *Risk Hiding Index (RHI)*, a new potential dimension that emerged from the focus group.

[5] Available at: `https://github.com/acmsigsoft/EmpiricalStandards`. We followed the *"General Standard"*, *"Questionnaire Surveys"*, and *"Mixed Methods"* guidelines.

[6] The author has recently changed company.

Table 1. Background of the focus group participants.

ID	Role	Working Activity	Years	Country
P1	Project Manager	Development	19	Germany
P2	Senior Solution Architect	Development	21	Russia
P3	Senior Quality Engineer	Researcher	10	The U.S.
P4	Project Manager	Development	15	Italy
P5	Software Engineer	Development	10	Japan
P6	Quality Engineer	Researcher	10	Italy

Survey Structure The survey consisted of seven dimension sections plus a demographics section. Each dimension section started with a vignette-based scenario [3] contextualizing the opposite behaviors in software development, followed by Likert-scale questions on frequency, cultural influence, impact on communication and collaboration, and an open-ended question on mitigation strategies. We opted for vignettes rather than abstract definitions to help respondents relate to concrete situations; all scenarios are available in our online appendix [29]. The survey was anonymous, created as a Google form, with an estimated completion time of 10–15 minutes. Ethical approval was obtained from the University of the second author.

Participants to the Survey We used Prolific[7] to recruit participants with a computer science background, experience in distributed teams, and management experience [2,21]. Studies have demonstrated that Prolific—alongside Cloud Research—offers highly reliable respondent pools when appropriate methodological safeguards are in place [10,11]. We offered a $7.50 incentive per valid respondent to mitigate self-selection bias. The survey ran from December 16 to 20, 2021, reaching 3337 experts; we received 200 valid responses (6% response rate).

Survey—Method for Results Analysis We used descriptive statistics for closed-ended questions and content analysis [7] for open-ended responses on mitigation strategies.

3.3 Participants Background Information

Table 1 reports the background of the six focus group participants, all with at least ten years of experience in open-source development at RedHat. Two are project managers and four are software engineers; we recruited two women and four men from different countries.

Among the 200 survey participants, 47% were developers and 14% project managers; 70% male, 20% female, and 10% other. Most self-assessed their management and programming skills as high or medium (67% and 84%, respectively). Participants were geographically distributed across Africa (8.1%), Asia (3.7%),

[7] Prolific website: `https://www.prolific.co/`.

East Europe (28.1%), North America (23.1%), South America (18.8%), West Europe (21.9%), and the UK (21.2%).

3.4 Threats to Validity

We organized threats using the framework by Wohlin et al. [40].

Regarding *construct validity*, using Hofstede's framework may have omitted behaviors captured by other frameworks [13, 14]; to mitigate this, we asked participants about additional dimensions, resulting in the *Risk Hiding Index* (Section 4). We also conducted a pilot study with four developers, making minimal adjustments for clarity. A further concern is the presence of sub-cultures within a larger cultural group. Since our focus was on culturally-derived behaviors rather than geographical dispersion, sub-cultures are less significant; moreover, Hofstede considered sub-cultures when designing the survey values.

Regarding *internal validity*, the main threats involve participant recruitment and their capacity to report on culturally dispersed teams. As detailed in Section 3, we applied specific selection criteria for both the focus group and the survey, aiming for gender and nationality balance. We encourage replications to further strengthen generalizability. Additionally, culture is abstract and perceived differently by individuals; we mitigated this by using concrete behavioral examples and vignette-based scenarios.

Regarding *conclusion validity*, the focus group had six participants from the same company; while this size is appropriate for the methodology [32], further replications with different practitioners are needed. The use of Prolific involved a monetary incentive (~$1), which could affect results; however, participation was voluntary, respondents had diverse backgrounds, and questions were framed around specific situations. All study materials are available online [29].

Regarding *external validity*, focus group participants' experience at *Red Hat* could bias findings. We mitigated this through our mixed-method design [8], using the focus group as preliminary data confirmed by a large-scale survey. Our participants used a hybrid development process, common in software development, supporting transferability. Despite the sample size aligning with SE research norms, findings may still be context-specific; future research will include studies in more diverse settings.

4 Findings and Discussion

This section reports our findings, organized by research question, showing both focus group and survey results.

4.1 RQ_1—Recognition of Cultural Behaviors in Software Development Communities

RQ_1—Focus Group All participants agreed that cultural dimensions significantly represent the developers' cultural aspects in software communities, identifying cases described by the dimensions in most of their past experiences as

developers and managers and associating them with the cultural background of the stakeholders involved.

> According to our data, Hofstede's framework represents a valuable instrument for representing cultural behaviors in development teams, as already partially demonstrated by previous works [17, 39].

Further confirmation of this, derived from the confirmatory survey performed after the focus group, will be discussed later in this Section.

When we asked about new possible dimensions, an interesting thought came out regarding the difference between western and eastern cultures. For instance, P2—who worked for a few years in a geographically distributed team—reported that 💬 *"People from eastern cultures avoid risky situations; they do not like potential conflicts. Indeed, they try to 'sweep under the carpet' or do everything possible to avoid the arising of a conflict, sometimes worsening the situation."*. Initially, we intuitively mapped this with the *Uncertainty Avoidance* Hofstede's dimension, i.e., the extent to which the members of a culture feel threatened by ambiguous or unknown situations [18]. So, we kindly asked for confirmation from P2. However, P2 specified that 💬 *"Well, it is a bit different. It was that people on the western side were fine in manage risks in a proactive manner, rather than the reactive manner. What we have seen on the eastern side is that there was also a bit of productivity in taking risks, but it was much lower, and mostly, it was rather about avoiding and consuming risks on their own. So if there is something going wrong, they do not expose it internally and ask for help."*. Based on his comments, we realized that *Uncertainty Avoidance* (at least in the perception of developers) defines how people approach a risk, not how they expose it.

For the above-mentioned reason, we decided to map the described behaviors, i.e., (i) exposing risky situations or (ii) hiding them, to a potential new cultural dimension that we named ***Risk Hiding Index*** *(RHI)*, namely, the extent to which people feel comfortable exposing and revealing risks to ask for help instead of managing them by themselves. Nevertheless, further research is needed to explore and validate such dimension as actually differing from *Uncertainty Avoidance*, to which it can be somehow related.[8]

RQ_1—Survey As shown in Figure 1, most participants recognized the different culturally originated behaviors inside their team, confirming the finding of the focus group. In particular, *Individualism vs. Collectivism Index* and *Indulgence vs. Restraint Index* were the most frequent, while *Power Distance Index* was less frequent (74% vs 48%). Additionally, 60% of the participants experienced

[8] Following the same pattern of Hofstede's dimensions, RHI maps two opposite behaviors: (i) a low level indicates people who prefer to share risk and uncertainty and seek help; (ii) a high level represents situations in which people tend to hide risks and problems, trying to manage them alone.

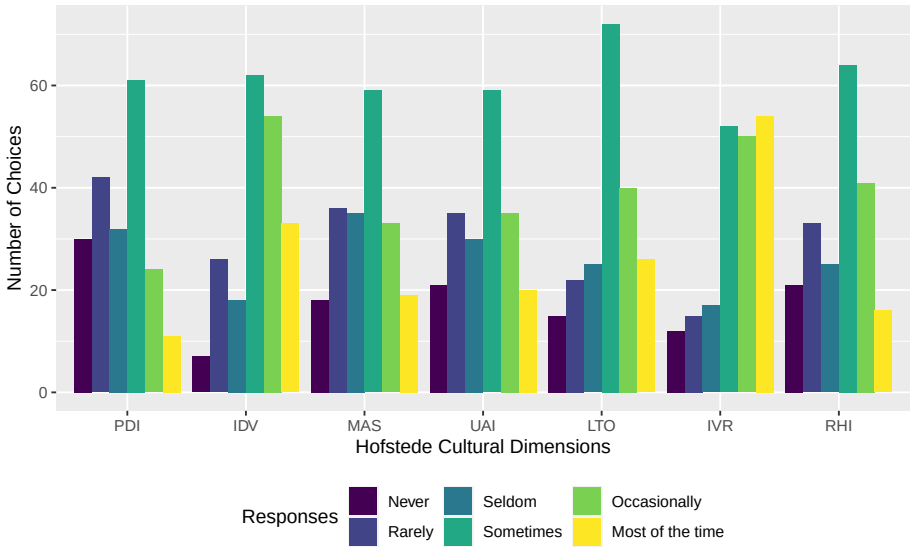

Fig. 1. Frequency of experienced behaviors in the Survey.

behaviors related to *Risk Hiding Index*, thus highlighting the importance of this new aspect.

When asked to what extent culture influences these behaviors, most participants confirmed the connection (Figure 2): the lowest agreement was 46%, while the highest reached 83%. **These results reinforce the focus group findings and the relationship between belonging to different cultures and exhibiting certain behaviors.**

👉 RQ_1: Summary.

Developers recognized Hofstede's cultural behaviors in their experience. A new dimension, *Risk Hiding Index*, emerged as relevant from both the focus group and survey.

4.2 RQ_2—Impact of Cultural Dimensions on Software Communication and Collaboration

RQ_2—Focus Group The focus group participants highlighted that they mainly experienced issues with developers showing opposite behaviors in the context of *Individualism vs. Collectivism*, *Uncertainty Avoidance*, and *Risk Hiding Index*.

Individualism vs. Collectivism Participants agreed that both individualistic and collectivistic people in a team could lead to the emergence of communication

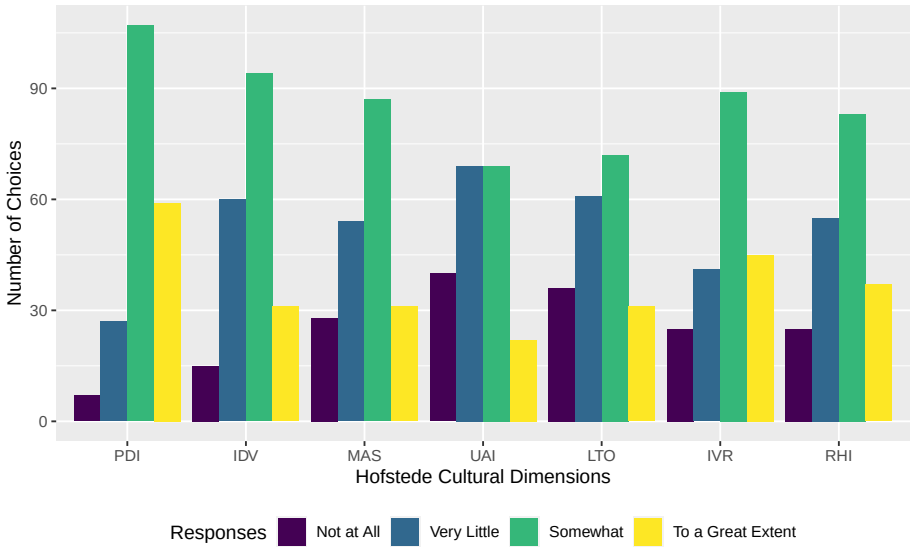

Fig. 2. Perception of the connection between culture and behaviors in the Survey.

and collaboration issues. P1 reported 🗪 *"There was definitely an issue because individualistic individuals constantly had friction (hard feelings), working with other individuals."*. We can draw two conclusions: having opposite behaviors can lead to friction in communication; however, integrating people who tend to isolate themselves could not always be a good idea since collaboration problems can emerge.

Uncertainty Avoidance Index Participants contextualized *Uncertainty Avoidance* behaviors in two contexts:

Risk Tolerance. From a *risk tolerance* perspective, i.e., the sensitivity of an organization or people to risks, people with a high value of uncertainty avoidance take risks that they know to have success rates. P5 reported that 🗪 *"In my experience, it is a pretty big advantage by having people with the high-risk tolerance and the low-risk tolerance on the same machine or the same team."*. This suggests that culturally-driven diversity in risk tolerance can be beneficial, helping teams balance innovation with caution and preventing collaboration issues. The confirmatory survey further supported this result.

Gender Disparity. Participants also discussed *gender disparity* rooted in cultural influences, which we categorized under both *UAI* and *MAS*. P2 reported 🗪 *"We had a problem with part of the teams that did not accept that women had a high role in the team, i.e., head. So, obviously, that has been a huge problem for us because we have had a few talented females in our team, and this team has been completely unreceptive, not comprehending how those people could*

be in the same room with them.". This suggests that cultural backgrounds can affect gender dynamics, leading to communication and collaboration problems.

Risk Hiding Index On the consequences of *Risk Hiding* on communication and collaboration activities, P2, talking about people preferring to manage the risk by themselves, reported, 💬 *"... basically, if there is a deadline that is not possible to be met at all, they might wait until the last moment, until the last day, for communicating the fact, because they tend to try to think that - it is okay, it will somehow rule itself out - and that is, that occurred in my practice more than once."*. Based on the reported example, we can notice that how different cultures treat risk can lead to communication and collaboration problems.

RQ_2—Survey Figure 3 reports the extent to which participants agreed that the coexistence of both opposite behaviors negatively affects communication and collaboration. Most participants agreed with our conjecture. For instance, for *Power Distance Index*, 57.5% of participants, i.e., 114, at least agreed that the presence of opposite behaviors in the same team could impact collaboration and communication negatively, while for *Masculinity vs. Femininity* index, 42% of participants,i.e., 84, at least agreed and 34%,i.e., 68, neither agree nor disagree.

The survey confirmed focus group insights. Indeed *UAI* and *IDV* are perceived as negatively impactful. However, we obtained new hints, i.e., *PDI* appears to be the most impactful cultural dimension, although focus group participants did not focus their attention.

👉 RQ_2: Summary.

The coexistence of contrasting cultural behaviors can lead to collaboration and communication issues. Key challenges include managing individualism vs. collectivism tensions, balancing risk tolerance, and preventing gender-based discrimination rooted in cultural norms.

4.3 RQ_3—Mitigation and Contingency Strategies

We elicited mitigation strategies from both analyses: in the focus group, we asked how participants dealt with reported issues; in the survey, we included an open question on strategies. The outcomes were highly similar, so we report them together. Specifically, Table 2 summarizes the strategies with their frequency. The first five were common to both the focus group and the survey; the last three emerged only from the survey. A comprehensive list of quotations is available in the online appendix [29]. We describe each strategy below:

Support the individualistic nature. Supporting individualistic developers with a correct division of responsibilities can lead to practical benefits. P1 reported 💬 *"I reorganized the duties of this person, for supporting his decision to work alone."*.

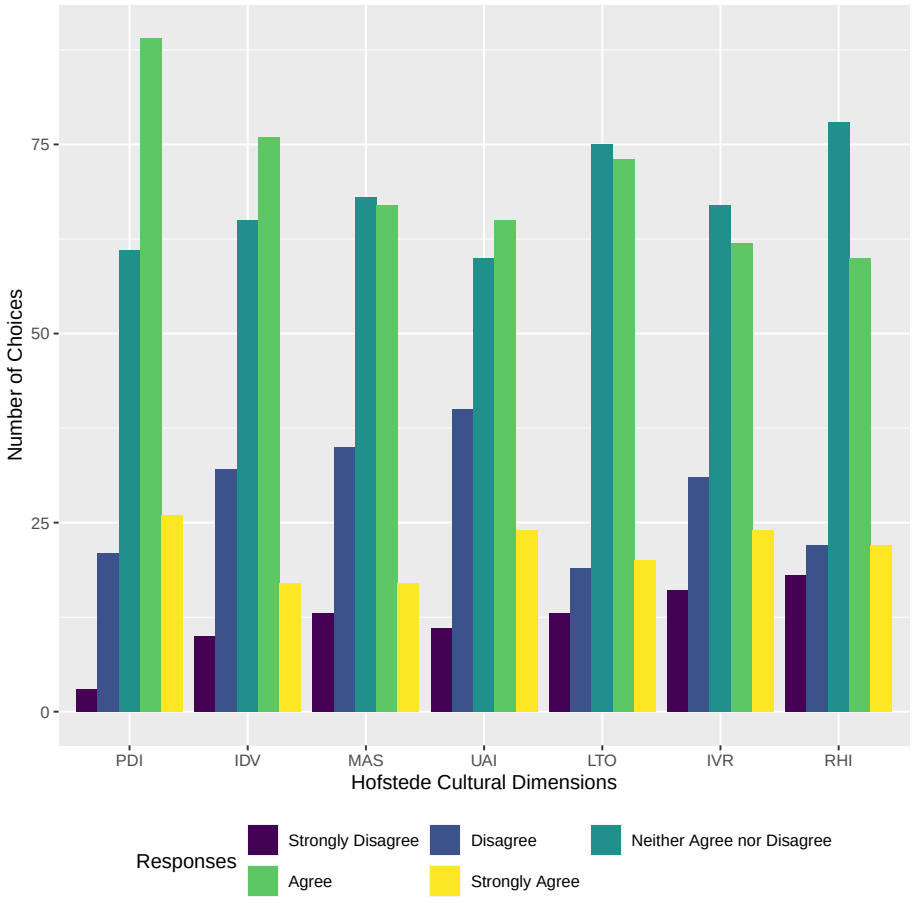

Fig. 3. Survey—Impact of the coexistence of different cultural behaviors, in the same team, on collaboration and communication activities.

Moderate communication to avoid conflict. Being present as a manager to moderate communications during critical phases can mitigate issues. P1 stated 🗨 *"During critical communication, I am there as a manager to moderate the conversation and act if some conflicts arise."*.

Support Team Exchange. Temporarily exchanging members between conflicting sub-teams can help bridge cultural gaps. P2 pointed out that 🗨 *"This experience helped us to understand the difference between team cultures, figuring out solutions and turn this into the kind of internal handbook, or book of best practices."*.

Converging in one behavior. This strategy consists of enforcing the adoption of only one of the two behavioral extremes by all community members. One survey participant stated that 🗨 *"In some situations, it is important to*

Table 2. Mitigation and contingency strategies originated by cultural issue.

Strategy	PDI	IDV	MAS	UAI	LTO	IVR	RHI
Support the individualistic nature		24					
Moderate communication to avoid conflict	17	20	25				
Support Team Exchange	14	3	7	12			10
Converging in one behavior	25	22	8	23	13		7
Reach a compromise between two behaviors	25	5	8	25		31	34
Increase communication	17	15	8		8		14
Restructure the community	15		8		23		
Seek meeting with problematic members	10	5	7			22	

take a one-time decision and enforce the adoption of one behavior (for example, select a particular technology and discuss it in a team meeting). Undoubtedly, it helps a lot if more people in the team are aligned to similar ideas to adopt new technology or not.".

Reach a compromise between two behaviors. Rather than converging, teams can seek a middle ground between opposite behaviors. One survey participant pointed out that 💬 *"I've seen the solution to having both kinds of people, which was to reach compromises between the two, introducing newer technologies no one knew how to use at 100% while keeping a little over half with older but more traditional techniques/technologies, which allowed to create a working software with innovative features.".*

Increase communication. Increasing communication through meetings and targeted channels can help spread team culture. P4 said that 💬 *"The second best thing that we did was establish a consistent, continuous training program for everyone arriving on-site or who was starting to interact with the partners and with customers in the other country ... and that really helped in mitigating many problems in our collaboration.".*

Restructure the community. Mixing team members between sub-teams to increase heterogeneity, particularly effective in geographically dispersed settings. P2 pointed out that 💬 *"The only way we managed to tackle that was to literally move around a few people on both sides, mostly on the other side, so that we manage it to find the right interaction. So basically, we found more flexible and less rigid people who managed to work with our female workforce.".*

Seek meeting with problematic team members. Having the manager speak directly with conflicted members to address behaviors that lead to conflict. One survey participant said that 💬 *"Usually, this has been another task for the project manager to talk to the person who was overly competitive about how it's not a contest to be the best developer. There is often no reward for it anyway, so some people learn on their own that the only way to win is a team win.".*

Most strategies were elicited from the focus group and independently confirmed by the survey.

☞ RQ_3: Summary.

Participants reported mitigation strategies such as moderating communication, seeking compromises between contrasting behaviors, and supporting team exchange.

5 Conclusions

This paper presents the first large-scale empirical exploration of Hofstede's cultural dimensions [16] in software development communities, combining a focus group with experienced practitioners and a confirmatory survey with 200 developers. Our results show that cultural behaviors impact collaboration and communication, yet not necessarily negatively. We also identified a new potential cultural behavior, the *Risk Hiding Index*, which appears to affect social activities in geographically distributed teams.

As future work, we plan to deepen the analysis of RHI through dedicated studies, operationalize our findings through the lens of *community smells* [37,38], investigate the interplay between gender and culture using frameworks such as GLOBE [19], and develop tool support—e.g., chatbots suggesting mitigation strategies based on cultural dispersion data—to help managers lead distributed teams more effectively.

Acknowledgments. The authors would like to thank the participants of our study for the time and feedback provided.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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