Understanding the Relationship of Conflict, Psychological safety, and Success in Software Development Projects

Wladimir Farias
Universidade de Pernambuco
wftf@ecomp.poli.br

Brenda Silva
Universidade de Pernambuco
bbas@ecomp.poli.br

Maria Lencastre
Universidade de Pernambuco
mlpm@ecomp.poli.br

Roberta Fagundes
Universidade de Pernambuco
roberta.fagundes@upe.br

ABSTRACT

Software development involves complex socio-technical activities with common conflicts arising from human and non-human factors. However, the impact of these conflicts, particularly non-human ones, on project success still needs to be investigated. Psychological safety is a key to mitigating these conflicts. In this paper, we aim to understand how conflicts and psychological safety impact the success of software development projects—considering the categorization of conflicts into human-rooted (HRC) and non-human-rooted (NHRC) and examining organization size, team size, and psychological safety as moderating factors. To achieve our goal, we replicated an existing study in the area and included new hypotheses; we also adapted the surveys to Portuguese, used a structured survey to collect data, and applied structural equation modeling for the analysis. The results include the reception of 155 responses and show that human-rooted conflict strongly negatively impacts software project success, regardless of organization or team size. Non-human-rooted conflict positively affects project success only in corporations (> 100 employees) but negatively impacts small and medium-sized organizations (< 100 employees). While not directly correlated with project success, psychological safety appears as a crucial moderating factor.

CCS Concepts

Social and professional topics→ Professional topics→ Management of computing and information systems→ **Project and people management**

Keywords

Conflict; Software project success; Software development; Psychological Safety

1. INTRODUCTION

Software development involves managing various conflicts arising from human and non-human rooted factors. Effective conflict management is essential for project success. Human-rooted conflict (HRC) negatively impacts project success. In contrast, non-human-rooted conflict (NHRC) impacts vary according to the organizational context [1]. This paper replicates the study presented in [1] and introduces the psychological safety factor, which fosters a team environment where individuals feel safe to take risks and express ideas. Psychological safety is crucial in this context as it allows team members to communicate openly, share concerns, and admit mistakes without fear of negative consequences. By promoting an environment where team members feel secure, psychological safety can mitigate the negative effects of conflicts and enhance overall team performance and project success [2].

By including psychological safety, we aim to understand better how HRC and NHRC, moderated by psychological safety, organization size, and team size, influence software project success. We use a survey to validate and expand upon the previous study's findings. We aim to offer new insights into theoretical perspectives and practical strategies for managing conflicts within software development projects [1].

2. BACKGROUND AND HYPOTHESES

This section first introduces the concepts of conflicts and psychological safety. As achieving success in software development projects involves understanding various influencing factors, this section also synthesizes insights from key references to explore the impact of conflicts, organizational structures, and leadership on project success. In the end, we present the relationship among these factors.

2.1 Conflicts

Understanding conflicts and their impact on project outcomes is crucial in software development, as they can lead to increasing costs, team demotivation, and a decrease in software quality [3].

HRC is defined as a conflict rooted essentially in human factors related to a person's general interests or background, such as personality or culture. In contrast, NHRC is a conflict exclusively rooted in non-human factors such as tools, processes, or artifacts. HRCs, arising from interpersonal disagreements and team dynamics, consistently threaten project success [1]. NHRCs are triggered by discrepancies in opinions about tools, methodologies, infrastructure, and challenges mainly occurring in corporate environments and small teams.

Large organizations face inefficiencies due to standardized processes, while small teams struggle with limited resources to manage tools and processes [1][2]. Conflict management is vital, especially in remote teams with prevalent communication and cultural barriers. Effective conflict management strategies include clear communication channels, cultural sensitivity training, collaborative tools, and conflict resolution protocols [4].

According to [5], we can classify intra-group conflicts into **task conflict**, which entails group members' disagreement about the tasks' content and outcomes; **process conflict**, which involves disagreements among group members about the logistics of task accomplishment, such as delegating tasks and

responsibilities; and **relationship conflict** that involves disagreements among group members about interpersonal issues, such as personality differences or differences in norms and values. These types of intragroup conflicts impact project outcomes distinctly. Task conflicts can stimulate critical thinking and innovation, provided no relationship conflicts exist. Relationship and process conflicts harm cooperation, morale, and efficiency. Strategic management of these conflicts can enhance team performance and project success by leveraging task conflicts constructively and mitigating adverse impacts [6][7].

2.2 Psychological safety

Psychological safety is a critical factor in the success of software development projects, fostering an environment where team members feel secure enough to take risks, report errors, and propose innovative solutions without fear of ridicule or blame. This involves mutual respect and trust among team members, allowing open expression of thoughts and concerns. In high-pressure environments like software development, psychological safety promotes open communication and innovation [8].

To cultivate psychological safety, organizations need to provide structural, and leadership supports, such as clearly defined roles, transparent communication, and adequate resources. These elements help reduce ambiguity and stress, enabling team members to perform their tasks effectively and confidently. Leaders play a crucial role by demonstrating empathy, inclusivity, and approachability. Encouraging diverse opinions and the admission of mistakes contributes to a culture of openness and continuous learning. Supportive policies like continuous learning, recognizing team efforts, and providing constructive feedback are essential. Practical applications of psychological safety include regular feedback sessions to address issues promptly and constructively, and inclusive decision-making processes to ensure diverse perspectives are considered, fostering a sense of ownership and commitment. Organizations that nurture psychological safety gain enhanced team performance and overall resilience, crucial for the success of software development projects [8,9].

Additionally, psychological safety serves as a moderating factor in the relationship between conflicts and project success. Teams with high psychological safety report better project outcomes despite the presence of conflicts. This is because psychological safety promotes open communication, error reporting, and innovative problem-solving, all critical for navigating project challenges. By fostering an environment where team members feel safe to express concerns and ideas, conflicts are more likely to be resolved constructively, leading to improved project performance [9].

2.3 Psychological safety and Project Success

Psychological safety facilitates learning and innovation by allowing open discussions and acknowledgment of mistakes without fear of reprisal, turning task conflicts into catalysts for innovation rather than impediments. Studies highlight its role in enhancing team performance through learning behaviors like seeking feedback and discussing mistakes openly. Practical applications include regular feedback sessions and inclusive decision-making processes. Organizations that nurture psychological safety gain enhanced team performance and overall resilience [9,10,11].

2.4 Software Project Success Factors

Critical Success Factors (CSFs) are essential for project success. They encompass managerial and technical aspects of project execution and include:

- Project Mission: Clearly defined objectives and goals communicated effectively to all stakeholders [12].
- Top Management Support: Active involvement and support from top management, providing necessary resources and removing obstacles [13].
- Client Consultation: Continuous engagement with the client, ensuring the project meets their needs and expectations [12].
- Technical Tasks: Proper planning and execution, including selecting appropriate technologies and ensuring technical competence [1].
- Client Acceptance: Measuring project success by client satisfaction and meeting expectations [12].
- Monitoring and Feedback: Regular monitoring and feedback mechanisms to track progress, identify issues early, and make necessary adjustments [13].
- Communication: Effective communication within the team and with external stakeholders to manage expectations and resolve conflicts [12].

Understanding and managing these CSFs can significantly reduce the risk of project failure. They provide a framework for project managers to focus efforts and resources on critical areas for project success. Additionally, managing both HRC and NHRC alongside focusing on CSFs is vital for enhancing software project success [1,12,13].

2.5 Relationship among Factors

The relationship among conflict, psychological safety, and critical success factors is essential for the success of software projects. If not managed effectively, **interpersonal, and role-based conflict**s can disrupt team dynamics and progress, leading to negative emotions and impaired collaboration. However, role conflicts can drive innovation if handled correctly [14,15].

Psychological safety is crucial for managing conflicts. It allows team members to report errors and propose innovative solutions without fear, fostering trust and open communication. Effective leadership promoting empathy and inclusivity helps maintain this environment, turning conflicts into opportunities for improvement [16]. CSFs such as effective communication, client consultation, and top management support are deeply influenced by psychological safety. When team members feel safe, they communicate openly and engage effectively with clients, while top management ensures resources and addresses concerns [12].

The interplay between conflict management, psychological safety, and CSFs enhances team performance, drives innovation, and leads to sustained project success. Organizations integrating these factors can better navigate

software development complexities, ensuring higher success rates [15,16].

3. RESEARCH DESIGN

We aim to understand how conflicts impact software development projects and what factors and variables can influence this relationship.

First, in previous work [22], we conducted a systematic mapping study about conflict measurement in the software engineering life cycle, which returned 34 studies. Most of them proposed more replications as future works. Two studies caught our attention [1,11]. The first one, *understanding the relationship of conflict and success in software development projects* [1], applies a model that relates conflicts to project success. After contacting the first authors of [1] about our intention to replicate the paper study, we got access to the data used in their study. So, we decided to replicate it. We complement this model with two new hypotheses from [11] related to Psychological Safety. Then, we replicated the survey, combining and testing it with the new factor.

To replicate the study, we modified the model to fit our context and objectives by adding the factor "Psychological Safety" as a moderator, which was not present in the original model [1]. The hypotheses in our model (H1 to H6) are designed to explore not only the direct impact of HRC and NHRC on software project success but also how these impacts are moderated by organizational size, team size, and psychological safety. We formulated and tested the hypotheses in Table 1 and demonstrated them in Figure 1.

Table 1: Our paper hypothesis (new to [1])

Hypothesis	Source
H1: Human Root Conflicts (HRC) negatively correlate with software project success.	[1]
H2: Non-Human Root Conflicts (NHRC) negatively correlate with software project success.	[1]
H3: Psychological safety positively correlates with software project success.	[9]
H4: Organization size moderates the relationship between conflicts and software project success.	[1]
H5: Team size moderates the relationship between conflict and software project success.	[1]
H6: Psychological safety moderates the relationship between conflicts and software project success.	[9]

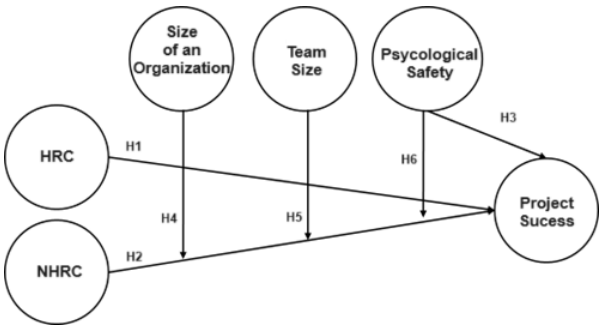

Fig. 1 Our Research Model

Our research model, in Figure 1, explores the relationships between HRC, NHRC, and psychological safety and their impact on project success, with hypotheses H1 and H2 [1] and H3 [11] being new to this model. Hypotheses H4 and H5 [1] were used as moderating factors for the size of the organization and the size of the team. Finally, we checked hypothesis H6 to see whether the psychological safety factor could also be used as a moderator or not, based on [11].

Facts were related, and hypotheses were tested using Structural Equation Modeling, which is widely used in Software Engineering to analyze and understand factors that influence software development, product quality, user satisfaction, and team productivity [1,11]

3.1 Survey and Data Collection

We gathered data through an *on-line* questionnaire targeting professionals involved in software development projects, encompassing managerial and technical roles.

Like the replicated study, we did not employ a probabilistic sampling method as we aimed for a broad respondent base. The questionnaire distribution started on 26 February 2024 and concluded on 15 April 2024. This data collection approach mirrors the methodology outlined in the replication of the study [1]. We also distributed the questionnaire through various channels, including our existing professional contacts, industrial partners involved in research projects, and LinkedIn.

3.2 Questionnaire and Measurements

To design the questionnaire, we investigated factors that were related to each other but were in different studies. We thus created a new questionnaire form and adapted it for Brazilian participants (translating it to Portuguese) [1,17]. We also carried out a pilot study ensuring an iterative process for refining the questions and the response scales, guaranteeing clarity and comprehensiveness.

The final questionnaire, structured in two main sections, asked the participants to reflect on their experiences in a specific project. The first section collected general information, including the size of the organization (corporate or SME), the respondent's position, years of experience, team size, and country of residence. The second section focused on their perceptions of project success and the presence of HRC and NHRC [1,17]. Table 2 presents only the second section of the questionnaire (due to space restrictions). Questions 13 to 17 represent the new questions related to Psychological Safety that we added based on [11].

To measure project success, we included five questions addressing changes, deadlines, budget limits, project goals, and stakeholder satisfaction using a five-point Likert scale. For HRC and NHRC, we included direct and indirect questions to identify conflicts related to domain knowledge, team interactions, work processes, tools, and development artifacts. This approach aimed to distinguish between specific conflict instances and their underlying causes. This method of designing the questionnaire, like the development of instruments for measuring IT innovation adoption, emphasized verifying the validity and reliability of the constructs through rigorous sorting and field tests. The objective was to ensure that the items effectively measured the intended constructs, thereby providing a robust tool for studying the impact of conflicts on software project success [1,18].

4. RESULTS

This section presents the Demographic profile of the respondents, the Evaluation of the model and the Results of the hypothesis evaluation. We used the Laavan library [19] to calculate the model evaluation indicators.

Table 2: Questionnaire

ID	Question
	Software Project Success
Q1	How quickly does your team adjust to changing priorities?
Q2	How often does your team meet its deadlines?
Q3	How often do your projects go over their allocated budget/headcount?
Q4	How much of the projects' goals does your team meet?
Q5	How often are stakeholders (users, customers, management board, etc.) satisfied with the projects' results?
	Human-rooted Conflict
Q6	Members of this team admit mistakes, apologize, and share learnings with one another.
Q7	There are often tensions and conflicts in the room that do NOT get surfaced or resolved.
Q8	How often do you experience conflicting situations due to people from different domains and functions in projects?
Q9	How often do your general interests and priorities conflict with the others during projects?
	Non-human-rooted Conflict
Q10	How efficiently do the methodologies (agile, waterfall, etc.) and processes match with goals or people skills?
Q11	How appropriate do you find the tools (e.g., domain-specific tools, communication tools, etc.) used in workflows?
Q12	Are the major documents and product parts generally well-constructed, up-to-date, and free of inconsistencies?
	Psychological Safety
Q13	If you make a mistake in a work unit, it is often held against you.
Q14	Members of the work unit can bring up problems and tough issues.
Q15	People in the work unit sometimes reject others for being different.
Q16	It is safe to take a risk in this group/organization.
Q17	It is difficult to ask other group/work unit members for help.
Q18	No one in this work unit/group would deliberately act in a way that undermines my efforts.
Q19	Working with members of this group/work unit, my unique skills and talents are valued and used.

4.1 Demographic Profile of Respondents

The demographic profile of the respondents is summarized in Table 3. A total of 155 responses were received, 71.6% from corporate firms and 28.4% from SMEs. Most respondents were experienced professionals (52.9%), followed by senior managers (16.1%), and executive managers (7.1%). Regarding experience, 29.0% had 11-20 years of experience, 24.5% had 6-10 years, and 22.6% had 3-5 years. Team sizes were primarily in the 6-10 range (51.6%), and most responses came from South America (96.8%).

Considering the participant's organization type, 71.6% work in corporate organizations (> 100 employees). Most of them, 96,8%, are from South America and have 11-20 years of experience (29%). Most of them are Senior Managers (25%). Finally, 51.6% work on teams with 6-10 members.

Table 3: Demographic Profile of Respondents

Variable	Category	N	% of Resp.
Organization Type	Corporate (> 100 employees)	111	71.6
	Small&Medium Ent.	44	28.4
Position	Executive Manager	11	7.1
	Senior Manager	25	16.1
	Middle Manager	9	5.8
	Experienced professional	82	52.9
	Entry Level	28	18.1
Years of Experience	20 +	16	10.3
	11 - 20	45	29.0
	6 - 10	38	24.5
	3 - 5	35	22.6
	0 - 2	21	13.5
Team Size	20+	23	14.8
	11 - 20	36	23.2
	6 - 10	80	51.6
	0 - 5	16	10.3
Region	South America	150	96.8
	North America	2	1.3
	Europe	2	1.3
	Africa	1	0.6

More details, and the link for the surveys data, can be found in the master's work that originated this paper [22].

4.2 Measurement Model Assessment

To evaluate a structural equation modeling model, we applied the same indicators used in [1]. See next our results.

- The Root Mean Square Error of Approximation (RMSEA) takes values between 0 and 1. The lower the value, the smaller the error, i.e., the smaller the discrepancy between the data and the hypothesized model. The value of our error was 0.068 and is in the range of a reasonable error [17] [18].
- The Comparative Fit Index (CFI) ranges from 0 to 1, the higher the better, i.e., there is a good fit between the data and the hypothesized model. The CFI for our study is 0.960, which is above what the literature suggests of 0.95, indicating a good test fit [17] [18]. This approves the fit of our model.
- The Tucker-Lewis Index (TLI) captures the difference between the chi-square (R^2) of the hypothesized model and the chi-square (R^2) of the null model. The TLI also varies between 0 and 1, the higher the better, values above 0.95 are desirable [17] [18]. In our model, the TLI is 0.953, which shows the adequate fit of our model.

When evaluating the RMSEA and CFI, if one is not within the standards, the model should not be considered "bad", but should only be understood and reported, understanding that both indices evaluate the model's fit, but from different perspectives [20]. The CFI compares the theoretical model with a null model, while the RMSEA assesses the closeness of the observed model to a perfectly adjusted model.

4.3 Hypothesis Assessment

The Laavan library [3], complemented by plspm, both in the R programming language, was used to carry out the analysis. Below we describe the hypotheses' results based on the indicators: regression coefficient, average error, and p-value.

The new hypotheses added in the current study, based on the need to explore the role of psychological safety more deeply, are H3 and H6. By integrating these hypotheses, the study aims to provide a more nuanced understanding of the dynamics between different types of conflicts, psychological safety, and software project success, offering valuable insights for both theory and practice in software project management.

H1: Human Root Conflicts (HRC) negatively correlate with software project success.

The first hypothesis is confirmed. Its regression coefficient is negative with a value of -0.409. This negative value indicates an inverse relationship between HRC and project success. As conflicts increase, project success tends to decrease. The average error was 0.156, indicating the variance of the residuals in the model. Finally, the p-value obtained was 0.025, which, being less than 0.05, confirms the statistical significance of the negative impact of HRC on the success of software projects.

H2: Non-Human Root Conflicts (NHRC) negatively correlate with software project success.

The second hypothesis is not confirmed. The regression coefficient of 0.490 suggests a positive impact on the success of software projects. Its average error of 0.063 is relatively low, suggesting that the model has a good fit in relation to this variable. The p-value of less than 0.001 confirms the high statistical significance of this effect.

H3: Psychological safety positively correlates with software project success.

The third hypothesis is not confirmed. According to the data, the regression coefficient was -0.038, revealing a negative but very low connection with software project success. This value suggests that psychological safety has a minimal influence. Its average error was 0.165, indicating a high degree of variability and susceptibility of the result to the sample. The p-value of 0.439 reinforces that the relationship between psychological safety and project success does not reach statistical significance.

H4: Organization size moderates the relationship between conflicts and software project success.

For large companies (n=111), analyzing the relationship between HRC and project success shows no significant impact (p-value = 0.657), and NHRC has a strong and positive impact on project success (p-value < 0.001) with high statistical significance. For SMEs (n=44), the relationship between HRC indicates a very strong negative impact on project success but is not statistically significant (p-value = 0.375). NHRC and project success show an extremely strong negative impact (R^2=-0.856) but also without statistical significance (p-value = 0.298). With the current data, we can say that for NHRCs, company size is a moderating factor, but not for HRCs.

H5: Team size moderates the relationship between conflict and software project success.

For teams with more than 10 members, using HRC in relation to project success has a regression coefficient of -0.473, indicating a negative impact on project success, but it is not statistically significant (p-value = 0.140). In contrast, for teams with 10 or fewer members, the regression coefficient for HRC is -0.326, indicating a negative impact on project success, but this relationship also lacks statistical significance (p-value = 0.092).

H6: Psychological safety moderates the relationship between conflicts and software project success.

The moderation analysis was carried out by transforming the dichotomous moderator variable into a dichotomous variable, performing structural equation modeling calculations again, and comparing the results to verify their variation. Psychological safety was found to moderate the relationship between NHRC and project success significantly, with a regression coefficient of 0.582 and a statistically significant p-value of less than 0.01. This suggests that psychological safety can enhance the positive impacts of NHRC on project success.

5. DISCUSSION

Our results confirmed that human-rooted conflicts (HRC) negatively impact software project success, aligning with

previous research [1]. The regression coefficient of -0.409 indicates a strong inverse relationship, emphasizing the critical need for effective management of interpersonal dynamics within teams. This finding reinforces the importance of addressing interpersonal disagreements and fostering a cooperative team environment to ensure project success.

Conversely, non-human-rooted conflicts (NHRC) presented a more nuanced picture. In our study, NHRC positively correlated with project success in corporate environments, diverging from findings in [1], which identified a negative impact. This suggests that well-structured processes and standardized tools in larger organizations might mitigate some adverse effects typically associated with NHRC. These findings highlight the ability of larger organizations to leverage their structured environments to transform potential NHRC into beneficial outcomes. However, smaller teams showed significant vulnerability to NHRC, underscoring the importance of tool and process suitability in resource-constrained settings. Smaller teams might lack the necessary resources or expertise to effectively manage and adapt tools and processes, leading to conflicts that negatively impact project success.

Our study highlights that psychological safety significantly moderates the relationship between conflicts and project success [21]. Teams with high psychological safety reported better outcomes despite conflicts, aligning with previous research that shows psychological safety fosters open communication, error reporting, and innovative problem-solving. Psychological safety mitigates the negative effects of human-rooted conflicts by creating an environment where team members feel secure to express concerns and admit mistakes, thus resolving conflicts constructively. It also enhances the positive impacts of non-human-rooted conflicts by promoting proactive problem-solving and continuous improvement. This focus can help transform conflicts into opportunities for improvement, leading to better project performance and success.

6. CONCLUSION AND FUTURE WORKS

This study replicated and expanded upon the research [1], examining the impact of HRC and NHRC on software project success, and introducing psychological safety as a moderating factor.

Our findings confirm that HRC consistently negatively impacts project success, underscoring the need for effective interpersonal conflict management. NHRC showed a positive correlation with project success in corporate environments, suggesting that well-structured processes can mitigate negative effects. Smaller teams were more vulnerable to NHRC, highlighting the importance of suitable tools and processes.

While not directly correlated with project success, **psychological safety** plays a crucial moderating role, enhancing conflict management effectiveness.

Future research should involve more extensive, diverse samples and longitudinal studies to improve generalizability and understanding of these dynamics over time. Further exploration of the mechanisms through which psychological safety moderates conflict impacts and examining different cultural contexts and industry sectors will provide more comprehensive insights.

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