The Impact of Human Aspects on the Interactions Between Software Developers and End-Users in Software Engineering: A Systematic Literature Review

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Abstract

This online appendix contains supplementary information of our systematic literature review.

Contents

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Online Appendix A: Search Strings

We refined the primary search string multiple times to identify the most effective string for each database. The following are the final search strings used for each database.

Table 1: Search strings of each database

DB	Final Search String
IEEE Xplore	(End-User OR End-Users OR End-Customer OR End-Customers OR Software-User OR Software-Users OR User* OR Customer* OR Client*) AND (Developer* OR Software-Developer OR Software-Developers OR Software-Engineer OR Software-Engineers OR Coder* OR Programmer* OR Programer*) AND (Human-Factor OR Human-Factors OR Human-Aspect OR Human-Aspects OR Human-Influence OR Human-Influences OR Human-Issue OR Human-Issues) AND (Interaction OR Relationship OR Involvement OR Association OR Participation)
ACM DL	("End User" OR "End Users" OR End-User OR End-Users OR "End Customer" OR "End Customers" OR End-Customer OR End-Customers OR "Software User" OR "Software Users" OR Customer OR Customers OR User OR Users OR Client OR Clients) AND (Developer OR Developers OR "Software Developer" OR "Software Developers" OR "Software Engineer" OR "Software Engineers" OR Coder OR Coders OR Programmer OR Programmers OR Programer OR Programers) AND ("Human Factor" OR "Human Factors" OR "Human Aspect" OR "Human Aspects" OR "Human Influence" OR "Human Influences" OR "Human Issue" OR "Human Issues") AND (Interaction OR Relationship OR Involvement OR Association OR Participation)
Wiley	("End User" OR "End Users" OR End-User OR End-Users OR "End Customer" OR "End Customers" OR End-Customer OR End-Customers OR "Software User" OR "Software Users" OR Customer OR Customers OR User OR Users OR Client OR Clients) AND (Developer OR Developers OR "Software Developer" OR "Software Developers" OR "Software Engineer" OR "Software Engineers" OR Coder OR Coders OR Programmer OR Programmers OR Programer OR Programers) AND ("Human Factor" OR "Human Factors" OR "Human Aspect" OR "Human Aspects" OR "Human Influence" OR "Human Influences" OR "Human Issue" OR "Human Issues") AND (Interaction OR Relationship OR Involvement OR Association OR Participation)
TFO	("End User" OR "End Users" OR End-User OR End-Users OR "End Customer" OR "End Customers" OR End-Customer OR End-Customers OR "Software User" OR "Software Users" OR Customer OR Customers OR User OR Users OR Client OR Clients) AND (Developer OR Developers OR "Software Developer" OR "Software Developers" OR "Software Engineer" OR "Software Engineers" OR Coder OR Coders OR Programmer OR Programmers OR Programer OR Programers) AND ("Human Factor" OR "Human Factors" OR "Human Aspect" OR "Human Aspects" OR "Human Influence" OR "Human Influences" OR "Human Issue" OR "Human Issues") AND (Interaction OR Relationship OR Involvement OR Association OR Participation)
Springer Link	("End User" OR "End-User" OR "End Customer" OR "End-Customer" OR "Software User" OR Customer OR User OR Client) AND ("Developer" OR "Software Engineer" OR "Programmer" OR "Programer" OR "Coder") AND ("Human Factor" OR "Human Aspect" OR "Human Influence" OR "Human Issue") AND (Interaction OR Relationship OR Involvement OR Association OR Participation)
Science Direct	("User" OR "Customer" OR "Client") AND ("Developer" OR "Software Engineer" OR "Programmer" OR "Coder") AND ("Human Factor") AND ("Interaction") ("User" OR "Customer" OR "Client") AND ("Developer" OR "Software Engineer" OR "Programmer" OR "Coder") AND ("Human Factor") AND ("Relationship")

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Table 1 – *Continued from previous page*

DB	Final Search String
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Factor”) AND (“Involvement”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Factor”) AND (“Association”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Factor”) AND (“Participation”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Aspect”) AND (“Interaction”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Aspect”) AND (“Relationship”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Aspect”) AND (“Involvement”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Aspect”) AND (“Association”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Aspect”) AND (“Participation”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Influence”) AND (“Interaction”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Influence”) AND (“Relationship”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Influence”) AND (“Involvement”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Influence”) AND (“Association”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Influence”) AND (“Participation”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Issue”) AND (“Interaction”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Issue”) AND (“Relationship”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Issue”) AND (“Involvement”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Issue”) AND (“Association”)
	(“User” OR “Customer” OR “Client”) AND (“Developer” OR “Software Engineer” OR “Programmer” OR “Coder”) AND (“Human Issue”) AND (“Participation”)

Online Appendix B: Data Extraction Form Fields

The following are the criteria used in our data extraction form. The data extraction form comprised 47 questions, divided into five sections including publication details, key areas of the study, research methodology, research gaps, limitations & future work, and research findings.

General Information:

1. Paper ID
2. Paper title
3. Authors of the paper
4. Published year
5. Venue (Name of the journal/ conference published)
6. Authors' Affiliation

Key Areas of the Study:

7. Type of Study: Journal Publication/ Conference Paper/ Workshop Paper
8. Source Type: ACM Digital Library/ IEEE Xplore/ Wiley/ SpringerLink/ ScienceDirect/ Snowballing - Backward/ Snowballing - Forward
9. What is the motivation/ goals/ objectives of the paper?
10. What are the Keywords of the paper?
11. Paper Abstract
12. Key research questions addressed in the paper
13. Whose human aspects are analysed in the study: Developers/ End Users/ Other
14. What are the human aspects considered in the study: Communication/ Perception/ Collaboration/ Emotions/ Human values/ Motivation/ Culture/ Other
15. What are the definitions used for each of the studied human aspects?
16. What phases of the SE are considered in the study: Planning/ Requirement Elicitation/ Design Phase/ Development Phase/ Testing Phase/ Maintenance Phase/ Unspecified/ Other
17. Does the study identify the most affected SE phase by human aspects: Yes/No
18. If Yes, what is/are the most affected SE phases: Planning/ Requirement Elicitation/ Design Phase/ Development Phase/ Testing Phase/ Maintenance Phase/ Other

Research Methodology:

19. How many participants are considered for the study?
20. Who are the participants considered for the study (i.e. subset of 'developers' and 'stakeholders' eg. 'requirements engineers' and 'end-users')?
21. What is/are the role(s) of the developers in the paper?
22. What is/are the role(s) of the end-users in the paper?
23. How do the developers and end-users interact with each other: User Feedback, Via documentation, Direct Meetings between developers & users, Meetings with customer representatives, Communication in Feature requests via Jira or any similar platform, Communication in Defects via Jira or any similar platform, Via Emails, Via App Reviews, Unclear, Other
24. Are there any middle people who facilitate user-developer interactions: Yes/ No/ Unspecified
25. If Yes, explain the roles of the middle people who facilitate user-developer interactions?
26. Does the study use any existing domain models related to human aspects: Yes/No/ Unspecified/ Other
27. If Yes, What are the existing domain models used to identify the human aspects? Describe the used models.
28. If Other, Please explain the reason for selecting "Other" option (eg: Do they use any other models in the study which are not used to capture human aspects).
29. What research design methods/data collection methods are used in the study: Case studies/ Document analysis/ Surveys or Reviews/ Interviews/ Modelling or Frameworks/ Observations/ Unspecified/ Other
30. What is the application domain of the study: Tele-Communication (Telco) Software/ Financial Software/ Travel & Tourism Software/ ERP Applications/ Field service management/ Aviation/ Inventory Management/ AI/ Unspecified/ Other
31. Is the study conducted based in Academia or Industry: Academia/ Industry/ Mixed/ Unspecified
32. What type of data analysis used in the study: Quantitative/ Qualitative/ Mixed/ Other

Research Gaps, Limitations & Future Work:

33. What are the main limitations of the study?

34. What are the key research gaps/ future work identified by each study?

Research Findings:

35. Does the research include how the human aspect(s) impact on SE field: Yes/ No/ Unspecified
36. If Yes, what is the nature of the impact of the human aspect(s) on SE: Positive/ Negative/ Undetermined/ Mixed
37. If Positive, does the study mention the benefits of promoting the human aspect(s)?
38. If Negative, how it will impact on SE?
39. Does the study suggest any approach to mitigate the negative impact? Explain.
40. If Undetermined/Mixed or Other, explain the what kind of impact is there on SE?
41. Does the research focus on identifying the relationship between different human aspect(s)?
42. If Yes, what are the identified relationships between different human aspect(s)?
43. Main outcome/ Results of the study?
44. Does the study come up with any framework/ model/theory/a set of guidelines as the final outcome: Yes/ No/ Other
45. If Yes, explain the developed framework/ model/theory/a set of guidelines?
46. How do they evaluate their results/ framework/ model?
47. What are the major recommendations of the study?

Online Appendix C: Positive Effects of Human Aspects

The positive effects of human aspects identified in the primary studies are detailed in Table 2.

Table 2: Categorisation of Positive Effects by Human Aspects

Category	Human Aspect	Nature of Impact & Paper IDs	Impact on User-Developer Interactions	Impact on SE
Individual	Empathy	*P:SPR03, SBF08	Higher level of developer empathy towards users and their needs.	Increased system usability, Enhanced understanding of usability, Resource savings.
	Motivation	P:IEEE02, SBB12, SBB01. *M:CHASE02	Developer empowerment, Improved developer motivation.	Improved project success, Improved user commitment to the project.
	Perception	P:SBF06. M:SBB05	Reduced perception gap, Improved client cooperation.	Successful client involvement in software projects.
	Emotions	P:ACM01. M:IEEE04	Quality developer-user relationship due to understanding how users & developers express emotions, Increased customer satisfaction.	Increasing productivity, Contributing to research of human factors, Improved requirement quality.
	Personality	P:SBB12	-	Resolution of complex SE problems by acknowledging individual personality and organisational culture.
	Attitude	P:IEEE02	-	Better understanding on the impact of Attitude on Engagement.
	Cognitive Style	P:IEEE01, SBB04. M:IEEE04, WILEY01.	Reduced understanding gap between customers & developers.	Increased UPI in decisions about Software, More democratic organisational culture, Improved understanding of problem domain, Quality requirements.
	Competence	P:IEEE02, SBB01	-	Better understanding of the impact of competence on engagement, Improved user commitment to project team.
Skill, Experiential or Environmental - influenced	Human Values	P: ACM01, SBB12. M: IEEE04	Communication & trust relationships between users & developers.	Enhanced understanding on developer thought process, Contributing to research of human factors, Improved customer relations.
	Knowledge/ Education	P: SBB04. M: IEEE04, WILEY01	Increased knowledge sharing between employees, Effective project requirements definition.	Quality requirements, Increased customer satisfaction, Leading to better systems.
	Skills	M: WILEY01	-	Supports successful implementation of the SPI efforts.
	Performance	P: SBB01. M: SBB02, SBB05	-	Increased project performance.

*P: Positive, M: Mixed, UPI: User Participation and Involvement, Challenges: Interpersonal and Intrapersonal Challenges

Table 2 – *Continued from previous page*

Category	Human Aspect	Nature of Impact & Paper IDs	Impact on User-Developer Interactions	Impact on SE
Group Related	Communication	P: CHASE01, ACM01, SD01, SPR02, IEEE05, IEEE01, SBB09, SBB10, SBB13, SBB15, SBB14, SBB18, SBF01, SBF02 SBF04, SBF05, SBF10, IEEE02, SBB12 M: SBB05, SBF07, IEEE04	Enable a richer communication, Developing and maintaining a strong rapport, Improved developer understanding on user needs, Increased user-developer coordination, Promotes users' positive attitude towards the system, Enables users to use the system more effectively, Facilitate better information flow for users, Increased efficiency of work, Improved opportunities for learning, Improved buy-in and ownership, Improved productivity.	Improved SW & data quality, Increased system success, Increased user satisfaction, Increased team productivity & satisfaction, Better UX, Improved system usability, Increased project performance, Quality requirements, Contributing to human factors research, Assisting in guiding & justifying decision making, Encouraging users to reflect on their use of technology, Reduced defect rate, Reduced utilisation of resources.
	Collaboration	P:SD01, IEEE06, SBB07, SBB10, SBF03, SBF04, SBF05, IEEE02, SBB12, SBB01 M:SBB02,SBB05, WILEY01	Increased collaboration, Increased collaboration between management & developers, Improved Buy-in & ownership, Better developer-customer understanding, Reduced conflicts, Increased communication & coordination, Increased developer appreciation, Improved awareness on user participation & collaboration, Improved technical, soft, & project management skills of developers.	Improved system usability, Assisting & guiding decision making, Increased project performance, Increased user satisfaction, Reduced defect rate, Efficient use of resources, Improved partnership, Continuous cooperation between customer & supplier to acquire in-depth domain knowledge, Improved user engagement, Better understanding on the impact of collaboration w.r.t. other human aspects, Encouraging startup formation.
	Culture	P:SBF10, IEEE02, SBB12, SBB04 M: SBF07	Improved understanding of developer-user cultural differences, Improved communication & interaction, Reduced difficulties, Quality requirements.	Improved system success, Improved understanding of cultural variability, Resolution of inter-departmental communication problems, Better understanding on the impact of culture, Collaborative customer relationship, Leading to better systems, Improved awareness of communications strategies, Resolution of complex SE problems by relating to culture.
	Coordination	M:SBB05	Increased communication & coordination due to collaboration.	Increased project performance.
	*Challenges	P:IEEE02 M:SBB02, SBB08	Reduced developer-user conflicts, Increased awareness of developer-user differences, Improved communication & understanding.	Reduced developer-user conflicts, Increased project success, Reduced obstacles in system design and development, Better understanding of the impact of challenges on engagement.

*P: Positive, M: Mixed, UPI: User Participation and Involvement, Challenges: Interpersonal and Intrapersonal Challenges

Table 2 – *Continued from previous page*

Category	Human Aspect	Nature of Impact & Paper IDs	Impact on User-Developer Interactions	Impact on SE
	Engagement	P:IEEE02, SBB01	Increased UPI, Improved involvement of leadership & employees, Improved developer-user collaboration.	Increased system success, Supports successful implementation of the SPI efforts, Improved project performance

*P: Positive, M: Mixed, UPI: User Participation and Involvement, Challenges: Interpersonal and Intrapersonal Challenges

Online Appendix D: Negative Effects of Human Aspects

The negative effects of human aspects identified in the primary studies are detailed in Table 3.

Table 3: Categorisation of Negative Effects by Human Aspects

Category	Human Aspect	Nature of Impact & Paper IDs	Impact on User-Developer Interactions	Impact on SE
Individual	Motivation	*M:CHASE02	Developer distrust in customer interactions, Customers feeling a lack of control, Weakened developer-customer interactions.	Customer frustration, Weakened developer - customer interactions.
	Perception	*N:SPR01, SBB06, SBB16. M:SBB05	Reduced user involvement, Reduced communication & collaboration, Increased perception gaps.	Requirements uncertainty, Reduced project performance, Increased project failures, Failure in meeting real user needs.
	Emotions	N:SBB16. M:IEEE04	Limited interaction, Limited developer - user communication and trust.	Poor quality requirements, Insufficient domain knowledge, Low customer satisfaction, Failed software projects.
	Cognitive Style	N:SBB16. M:IEEE04, WILEY01.	Lack of trust, Strained developer - user relationship, Failed communication between analysts and users.	Risks to project success, Failed software projects, Poorly coordinated development efforts.
Skill, Experiential or Environmental - influenced	Human Values	M: IEEE04	Limited interaction between either just one user or the incorrect users, Limited developer-user communication, Lack of trust.	Poor quality requirements, Incomplete and insufficient domain knowledge, Low customer satisfaction, Limited user involvement.
	Knowledge/ Education	M: IEEE04, WILEY01	Limited interaction between either just one user or the incorrect users, Limited developer-user communication, Lack of trust.	Reduced developer-user communication, Lack of trust, Risks to project success, Failed SPI efforts in SME software development companies.

*N: Negative, M: Mixed, Challenges: Interpersonal and Intrapersonal Challenges

Table 3 – *Continued from previous page*

Category	Human Aspect	Nature of Impact & Paper IDs	Impact on User-Developer Interactions	Impact on SE
	Skills	M: WILEY01	-	Failed SPI efforts in Malaysian SME software development companies.
	Performance	N: SBB06. M: SBB02, SBB05	Developer - user conflicts, Reduced user-developer communication & collaboration, Increased perception gaps, Lack of understanding among stakeholders.	Increased project failures, Requirements uncertainty, Requirements diversity, Difficulty in estimating the final project schedule and cost.
Group Related	Communication	N: SPR04, SBB06, SBB11, SBB16, SBB19, SBB17, SBF09, SBF12 M: IEEE04, SBB05, SBF07	Lack of understanding among stakeholders, Ineffective developer - user communication, Increased resistance between developers and users, Strained relationship between developers and users, Failed communication between analysts and users, Cultural gap between stakeholders, Misalignment of the stakeholders' objectives, Users seemed to lead developers astray.	Inability of information systems to meet business needs, Reduced usage of Information systems, Excessive maintenance of systems to meet requirements, Hindering effective business practices , Incurring costs to the software development organisation, Failed software projects, Poorly coordinated development efforts, Leading to unsuccessful software systems, Compromising the integration of the usability expertise in software development life cycle, Customer resistance toward software projects.
	Collaboration	N:SBB16 M:WILEY01, SBB02,SBB05	Conflicts between users and developers, Reduced user involvement, Reduced user-developer communication & collaboration, Increased perception gaps between users and developers, Strained relationship between developers and users, Failed communication between analysts and users.	Failed SPI efforts in SME software development companies, Increased project performance estimation difficulty, Reduced user-developer collaboration, Reduced project performance, Increased project failures, Requirements uncertainty, Failed software projects, Ill-specified systems, Poorly coordinated development efforts, Unrealistic specifications or failure in meeting real user needs.
	Culture	N: SBB16, SBB19 M: SBF07	Poor communication between developers and users, Increased resistance between developers and users, Strained relationship between developers and users, Failed communication between analysts and users, Cultural gap between stakeholders, Misalignment of the stakeholders' objectives.	Inability of information systems to meet business needs, Reduced usage of Information systems, Excessive maintenance of systems to meet requirements, Hindering effective business practices, Incurring costs to the software development organisations, Failed software projects, Poorly coordinated development efforts, Leading to unsuccessful software systems, Requirements uncertainty.

*N: Negative, M: Mixed, Challenges: Interpersonal and Intrapersonal Challenges

Table 3 – *Continued from previous page*

Category	**Human Aspect**	**Nature of Impact & Paper IDs**	**Impact on User-Developer Interactions**	**Impact on SE**
	Coordination	M:SBB05	Reduced user involvement, Reduced user-developer communication & collaboration, Increased perception gaps between users and developers.	Reduced project performance, Increased project failures, Requirements uncertainty.
	*Challenges	N:IEEE03, SBB03, SBB16, SBF11 M:SBB02, SBB08	Distant relationship between users and developers, Unawareness of the developers about the needs of the customers, Negative user attitude towards technology, Misunderstandings between users and developers, Developer demotivation, Lack of Empathy between users and developers, A uni-directional lack of trust towards the developers among the users, Developers' negative attitudes towards the users.	Users feeling threatened by the systems, Lack of user feedback, Reduced system usage, Obstacles in information system design and development, Negating system success, Lack of confidence in the system, Poorly coordinated development efforts, Missing the required expertise in the software development team, Reduced team cohesion, Subjective interpretations of tasks, Insufficient analysis at the beginning of a task, Missing documentation of the project, Slow decision making, Lack of balance between responsibility and authority in user and developer sides, Reduced developer performance, Resistance to suggestions.
	Engagement	M:WILEY01	-	Failed SPI efforts in SME software development companies.

*N: Negative, M: Mixed, Challenges: Interpersonal and Intrapersonal Challenges