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Knowledge Management in Human-Computer Interaction Design: A Mapping Study

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Abstract. Developing interactive systems is a challenging task. It involves concerns related to the human-computer interaction (HCI), such as usability and user experience. Therefore, HCI design must be addressed when developing such systems. HCI design often involves people with different backgrounds, what makes communication and knowledge transfer a challenging issue. In this scenario, knowledge management can support understanding concepts from different knowledge areas and help learn from previous experiences. Aiming at investigating how knowledge management has supported HCI design and contributed to the development of interactive systems, we performed a mapping study and analyzed 15 studies reporting the use of knowledge management in HCI design. In this paper, we present our study and discuss its main findings.

Keywords: HCI Design · Mapping Study · Knowledge Management · Interactive Systems.

1 Introduction

The interest in interactive systems and their impact on people's life has promoted the study and practice of usability [2]. Usability is a key aspect to a successful interactive system and is related to user efficiency and satisfaction when interacting with the system. To an interactive system reach high usability levels, it is necessary to take human-computer interaction (HCI) design aspects into account during its development process [2].

HCI is concerned with usability and other aspects related to the interaction between users and computer systems, necessary to produce more usable software [2]. It involves knowledge from multiple fields, such as ergonomics, cognitive science, user experience, human factors, among others [23]. Due to the diverse body of knowledge involved when designing interactive systems, interactive system development teams are frequently multidisciplinary, joining people from different backgrounds, with their own technical language, terms and knowledge. Even the conceptualization about the product may be conflicting, what can hamper communication and knowledge transfer [2,15].

Developing software is a knowledge-intensive task. Knowledge Management (KM) principles and practices have been successfully applied to support knowledge capture, storage, use and transfer in the software development context in general [16,24]. KM can also be helpful to address challenges in the design of interactive systems, since it might provide support to capture and represent knowledge in an accessible and reusable way. As a result, the team can learn from previous experiences and share a common understanding about the system, contributing to produce better products and perform processes more efficiently.

Considering the challenges of designing interactive systems, mainly due to the diversity of knowledge and people involved, and the potential of KM to help address those challenges, we performed a mapping study to investigate the use of KM in HCI design. Before performing our study, we searched for secondary studies addressing the research topic. Since we did not find any, we decided to carry out the study addressed in this paper. A mapping study is a secondary study designed to give an overview of a research area through classification and counting contributions in relation to the categories of that classification. It makes a broad study in a topic of a specific theme and aims to identify available evidence about that topic [14]. Moreover, the panorama provided by a mapping study allows identifying issues in the researched topic that could be addressed in future research. In our study, we analyzed 12 different KM approaches used in HCI design, identified from 15 publications. In general, KM has aided in HCI design mainly by enabling replicability of knowledge and solutions, improving product quality and communication. However, difficulty to generalize knowledge, issues related to features of the system and low engagement of the team have been pointed out as challenges to implement KM in the HCI design context.

This paper is organized as follows: Section 2 provides the background for the paper, addressing HCI design and KM; Section 3 presents the research protocol used in our study; Section 4 summarizes the obtained results; Section 5 discusses the results; Section 6 presents some of the limitations of the study; and Section 7 presents our final considerations.

2 Background

2.1 HCI Design

HCI design focuses on how to design a system to support the user to achieve her goals through the interaction between her and the system [23]. It is concerned with usability and other important attributes such as user experience, accessibility and communicability. Usability is the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use [10]. It addresses the effort and ease of the user during the interaction, considering her cognitive, perceptive and motor skills. User experience relates to users' emotions and feelings and is essential for interaction design because it takes into account how a product behaves and is used by people in the real world [15]. Accessibility refers to the removal of barriers that prevent interface and interaction access.

Finally, communicability concerns the ability of the interface to communicate design logic to the user [6].

HCI design is user-centered, hence it is said User-Centered Design (UCD) [3]. UCD is based on ergonomics, usability and human factors. It focuses on the use and development of interactive systems, with emphasis on making products usable and understandable. It puts human needs, capabilities and behavior first, then designs the system to accommodate them. Its main principles are user focus (its characteristics, needs and objectives), observable metrics (user performance and reactions) and iterative design (repeat as often as needed) [3,10]. The term Human Centered Design (HCD) has been adopted in place of UCD to emphasize the impact on all stakeholders and not just on those considered users [10].

In general, UCD involves: *understand and specify context of use*, which aims to study the product users and intended uses; *specify requirements*, which aims to identify user needs and specify functional and other requirements for the product; *produce design solutions*, which aims to achieve the best user experience and includes the production of artifacts such as prototypes and mock-ups that will be used in the future as a basis for developing the system; and *evaluation*, when the user evaluates the results produced in the previous activities [10].

HCI design can be understood as an intensive knowledge process, requiring effective mechanisms to collaboratively create and support a shared understanding about users, the system, its purposes, context of use and the design necessary for the user to achieve her goals. Therefore, HCI design could take advantages of KM solutions.

2.2 Knowledge Management

According to [17], knowledge is a human specialty stored in people's minds, acquired through experience and interaction with their environment. Historically, organization's knowledge was undocumented, being represented through the skills, experience and knowledge of its professionals, typically tacit knowledge [16], which made its use and access limited and difficult [13].

Knowledge Management (KM) aims to transform tacit and individual knowledge into explicit and shared knowledge. By raising individual knowledge to the organizational level, KM promotes knowledge propagation and learning, making knowledge accessible and reusable across the entire organization [13,16,17]. Knowledge helps software organizations to react faster and better, supporting more accurate and precise responses, which contributes to increase software quality and client satisfaction [17].

When an organization implements KM, its experiences and knowledge are recorded, evaluated, preserved, designed and systematically propagated to solve problems [17]. Thus, KM addresses knowledge in its evolution cycle, which consists in creating, capturing, transforming, accessing and applying knowledge [16,17].

In the software process context, KM works for explicitly and systematically managing knowledge, addressing knowledge acquisition, storage, organization, evolution, retrieval and usage. Among other aspects, KM has been applied in

the software development context to support document management, competence management, experts identification, software reuse, support learning and product and project memory [16].

3 Research Protocol

Considering the challenges involving knowledge transfer and sharing in the HCI design context and the benefits of using KM in software development context, we decided to investigate the use of KM in HCI design through a mapping study. We followed the process defined in [11], which comprises: planning, when the research protocol is defined with the purpose of supporting study replicability as well as helping researchers to avoid bias when conducting the study; conducting, when the protocol is executed and data are extracted, analyzed and recorded; and reporting, when the results are recorded and made available to potential interested parties.

The study ***goal*** was to investigate the use of KM in HCI design context. For achieving this goal, we defined the research questions presented in Table 1.

Table 1: Research questions and their rationale.

ID	Research Question	Rationale
RQ1	*When and where have publications been published?*	Give an understanding on when and where (journal / conference / workshop) publications about KM in HCI design context have been published.
RQ2	*Which types of research have been done?*	Investigate which type of research is reported in each selected publication. We consider the classification defined in [27]. This question is useful to evaluate the maturity stage of the research topic.
RQ3	*Why has KM been used in the HCI design context?*	Understand the purposes and reasons of using KM in the HCI design and verify if there have been predominant motivations.
RQ4	*Which knowledge has been managed in the HCI design context?*	Investigate which knowledge items have been managed in the HCI design context, aiming to verify if some of them have been managed more frequently and if there has been more interest in certain HCI design aspects.
RQ5	*How is the managed knowledge related to the HCI design process?*	Understand, in the context of the HCI design process, from where the managed knowledge has coming from and where it has been used.
RQ6	*How has KM been implemented in the HCI design context?*	Investigate how KM has been implemented in HCI context in terms of the adopted technologies.
RQ7	*Which benefits and difficulties have been noticed when using KM in the HCI design context?*	Identify benefits and difficulties of using KM in HCI design context and analyze if there is relation between them.

The ***search string*** adopted in the study contains two groups of terms joined with the operator AND. The first group includes terms related to *HCI design*. The general term "Human-Computer Interaction" was used to provide wider search results. The second group includes terms related to *Knowledge Management*. Within the groups, we used the OR operator to allow synonyms. The following search string was used:*("human-computer interaction" OR "user interface design" OR "user interaction design" OR "user centered design" OR "human-centered design" OR "UI design" OR "HCI design") AND ("knowledge management" OR "knowledge reuse" OR "knowledge sharing")*. For establish-

ing the string, we performed tests using different terms, logical connectors, and combinations among them, and selected the string that provided better results in terms of the number of publications and their relevance. More restrictive strings excluded important publications identified during the informal literature review that preceded the study. More comprehensive strings (e.g, those including "usability") returned too many publications out of the scope of interest.

The search was performed in four ***sources***, selected based on other secondary studies recorded in the literature and on other experiences in our research group: Scopus, Science Direct, Engineering Village and Web of Science.

Publications selection was performed in five steps. In *Preliminary Selection and Cataloging (S1)*, the search string was applied in the search mechanism of each digital library used as source of publications (we limited the search scope to title, abstract and keywords metadata fields). After that, in *Duplications Removal (S2)*, publications indexed in more than one digital library were identified and duplications were removed. In *Selection of Relevant Publications - 1st filter (S3)*, the abstracts of the selected publications were analyzed considering the following inclusion (IC) and exclusion (EC) criteria: (IC1) the publication addresses KM in the HCI design context; (EC1) the publication does not have an abstract; (EC2) the paper was published only as an abstract; (EC3) the publication is not written in English; (EC4) the publication is a secondary study, a tertiary study, a summary, an editorial or a tutorial. In *Selection of Relevant Publications - 2nd filter (S4)*, the full text of the publications selected in S3 were read and analyzed considering the cited inclusion and exclusion criteria. In this step, to avoid study repetition, we considered another exclusion criterion: (EC5) the publication is an older version of an already selected publication. When the full text of a publication was not available either from the Brazilian Portal of Journals, from other Internet sources or by contacting its authors, the publication was also excluded (EC6). Finally, in *Snowballing (S5)*, as suggested in [11], the references of publications selected in S4 were analyzed by applying the first and second filters and, the ones presenting results related to the research topic were included in the study.

We used the StArt tool (`https://bit.ly/3bW3Mo6`) to support publications selection. To consolidate data, publications returned in the publication selection steps were cataloged and stored in spreadsheets. We defined an id for each publication and recorded the publication title, authors, year, and vehicle of publication. Data from publications returned in S4 and S5 were extracted and organized into a data extraction table oriented to the research questions. The spreadsheets produced during the study can be found in `https://bit.ly/36nXUAw`.

The first and second authors performed publication selection and data extraction. The third and fourth authors reviewed both. Once data has been validated, the first and the second authors carried out data interpretation and analysis, and again third and fourth authors reviewed the results. Discordances were discussed and resolved. Quantitative data were tabulated and used in graphs and statistical analysis. Finally, the four authors performed qualitative analysis considering the findings, their relation to the research questions and the study purpose.

4 Data Extraction and Synthesis

The study considered papers published until July 2019. Searches were conducted for the last time in September 2019. Figure 1 illustrates the followed process and the number of publications selected in each step.

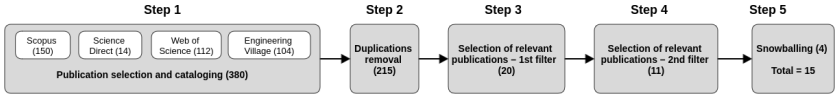

Fig. 1. Publications selection process.

In the 1st step, as a result of searching the selected sources, a total of 380 publications was returned. In the 2nd step, we eliminated duplicates, achieving 215 publications (reduction of approximately 43%). In the 3rd step, we applied the selection criteria over the abstract, resulting in 20 papers (reduction of approximately 90%). At this step, we only excluded publications that were clearly unrelated to the subject of interest. In case of doubt, the paper was taken to the next step. In the 4th step, the selection criteria were applied considering the full text, resulting in 11 publications (reduction of approximately 45%). Finally, in the 5th step, we performed snowballing technique by checking the references of the 11 selected publications and identified 4 more publications, which in total added up to 15 publications. When analyzing the publications to identify the KM approaches applied in HCI design context, we noticed that some publications addressed complementary works from a same research group. Hence, we considered complementary works as a single KM approach when extracting data about RQs 3, 4, 5, 6 and 7. Table 2 shows the list of identified KM approaches and corresponding publications. Two papers were grouped into a KM approach and three other papers were grouped in another KM approach. Thus, we considered a total of 12 different KM approaches found in 15 studies. Along this and the next section we refer to the approaches by using the id listed in the table. Detailed information about the selected publications, including a brief description and extracted data, can be found in `https://bit.ly/36nXUAw`. After Table 2, we present the data synthesis for each research question.

Table 2: Selected publications.

ID	Approach	Ref.
#01	Trading off usability and security in user interface design through mental models	[12]
#02	Knowledge management challenges in collaborative design of a Virtual Call Centre	[18]
#03	Applying knowledge management in UI design process	[22]
#04	A knowledge management tool for speech interfaces	[1]
#05	Design knowledge reuse based on visualization of relationships between claims	[25,26]
#06	Design knowledge reuse and notification systems to support design in the development process	[5,4,20]
#07	Exploring knowledge processes in user-centered design process	[21]
#08	Lessons learnt from an HCI repository	[28]
#09	A pattern language approach to usability knowledge management	[9]
#10	An expert system for usability evaluations of business-to-consumer e-commerce sites	[7]

Table 2 continued from previous page

#11	A framework for developing experience-based usability guidelines	[8]
#12	Prototype evaluation and redesign: structuring the design space through contextual techniques	[19]

Publication year and type (RQ1): Figure 2 shows the distribution of the 15 selected publications over the years and their distribution considering the publication type. Papers addressing KM in HCI design context have been published since 1995 in Journals and Conferences (no Workshop publications were found). Conferences have been the main forum, encompassing 73.3% of the publications (11 out of 15). Four papers (26.78%) were published in journals.

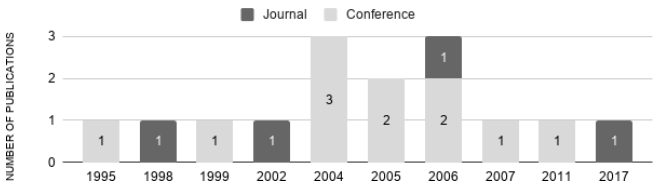

Fig. 2. Publications over the years.

Research Type (RQ2): 13 publications (86.7%) propose a solution to a problem and argue for its relevance. Thus, they were classified as *Proposal of Solution*. Five of them (33.3%) present some kind of evaluation, being one (6.7%) evaluated in practice (i.e., also classified as *Evaluation Research*), and four (26.7%) investigating the characteristics of the proposed solution not yet implemented in practice (i.e., *Validation Research*). One publication (6.7%) refers exclusively to *Evaluation Research*, discussing the evaluation of KM an industrial setting, and another is a *Personal Experience Paper*, reporting the experience of the authors in a particular project in the industry.

Motivation for using KM in HCI design (RQ3): we identified six reasons for using KM in HCI design, as shown in Table 3. Some approaches presented more than one motivation, thus the total sum is greater than 12.

Table 3: Motivations for using KM in HCI design.

Motivation	**Approaches**	**Total**
Improve product quality	#01, #02, #04, #05, #06, #07, #10, #11, #12	9
Reduce design effort	#02, #03, #08, #09, #10	5
Reduce design time	#04, #05, #08	3
Reduce design cost	#05, #10	2
Improve design team performance	#06	1
Improve HCI design learning	#06	1

Nine approaches (75%) use KM to improve product quality, most of them concerning usability. These approaches aim to provide benefits related to the quality of the interactive system in terms of its interaction with users. For example, the approach #11 is proposed to help developers to design effective, useful

and usable applications. Approach #01, in turn, aims to improve alignment between design features and users' requirements. Seven approaches (58.3%) are motivated by improving one or more aspects related to the HCI design process, namely: effort, time and cost. From these, reducing effort is highlighted. 5 approaches (41.7%) use KM to reduce manpower, mainly by not depending on internal usability experts to perform HCI design activities. The approach #02, for example, applied KM to decrease the need for experts to support the design team with their knowledge and experience, due to lack of knowledge to be reused. The approaches #04, #05 and #08 were motivated by reducing HCI design time through the reuse of previous solutions implemented for similar problems. Reducing costs in the HCI design process was the motivation for the approaches #05 and #10, which focus on minimizing the involvement of external usability experts in the process and conducting usability evaluation more effectively. The approach #06 aimed to improve design team performance by providing support for team coordination and collaboration. This approach also aimed to improve HCI learning to the students involved in the project.

Managed knowledge in HCI design (RQ4): Analyzing the publications, we identified 24 different knowledge items managed by the KM approaches, as shown in Table 4. Some items are shown in the same line to safe space. The main design aspect addressed in the publications is *Usability*, being the content of all knowledge items related to it. Knowledge items managed in two approaches (#03 and #08) are also related to *Ergonomics*. Some approaches focus on particular types of design or interface. This is the case of approaches #03 and #04. The former focuses on *Task-based Design* while the latter focuses on *Speech Driven Interfaces*.

Table 4: Managed knowledge items.

Knowledge Item	**Approaches**	**Total**
Design Guidelines	#04, #08, #10, #11	4
Design Solutions	#02, #04, #07, #08	4
Test Results	#02, #04, #12	3
Claims	#05, #06	2
Design Features	#01, #12	2
Design Patterns	#09, #11	2
Lessons learned	#04, #08	2
Usability Measures	#02, #08	2
Claims Relationships	#05	1
Design Changes	#06	1
Design Feature Checklists; Design Methods; Design Processes; Design Standards; Design Templates; Interface Objects	#08	1
Interaction Model; Task Model	#03	1
Scenarios; Test Scenarios	#02	1
User Knowledge; User Needs	#07	1
User Requirements	#01	1
User Tasks	#09	1

When knowledge is captured and used (RQ5): Table 5 shows when HCI design knowledge has been captured and when it has been used along the HCI design process. Three approaches capture and use knowledge along the whole process. Eight approaches (66.7%) use knowledge when producing design solutions. A smaller number (six, 50%) capture knowledge in this activity. The

behavior is the opposite in design evaluation: there are more approaches capturing (five, 41.7%) than using (three, 25%) knowledge in this activity. Only one (8.3%) approach captures knowledge during requirements specification.

Table 5: Capture and use of knowledge along the HCI design process.

Activity [10]	**Knowledge Capture**	**Knowledge Use**
Specify requirements	1 (#01)	0
Produce design solutions	6 (#02, #03, #04, #07, #10, #11)	8 (#01, #02, #03, #04, #07, #09, #11, #12)
Design Evaluation	5 (#02, #04, #09, #10, #12)	3 (#02, #09, #10)
Whole cycle	3 (#05, #06, #08)	3 (#05, #06, #08)

Technologies used in KM approaches (RQ6): Table 6 shows the technologies used in the analyzed KM approaches. The most common technologies were knowledge-based systems and knowledge repositories, followed by knowledge management systems and knowledge-based analysis. Other technologies such as ontologies, model transformation, contextual inquiry and mental models were used in only one KM approach. Details about the KM approaches can be found in the document available at `https://bit.ly/36nXUAw`.

Table 6: Technologies used in KM approaches in HCI design context.

Technology	**Approaches**	**Total**
Knowledge-based System	#02, #04, #10	3
Knowledge Repository	#05, #06, #08	3
Knowledge Management System	#09, #11	2
Knowledge-based Analysis	#03, #07	2
Ontology; Model Transformation	#03	1
Conceptual Framework	#07	1
Contextual Inquiry; Brainstorming-based Technique	#12	1
Mental Model; Internalization Awareness; Observation; Behavioral Interviews; Absorptive Capacity; Heuristic Evaluation	#01	1

Benefits and challenges of using KM in HCI design (RQ7): Table 7 summarizes the benefits and difficulties reported in the publications. As it can be noticed more benefits than difficulties were reported.

Table 7: Benefits and difficulties of using KM in HCI design context.

Benefits	**Approaches**	**Total**
Enable replicability of domain/context knowledge	#03, #06, #07, #09, #12	5
Improve product quality	#02, #05, #06, #12	4
Improve communication	#01, #03, #11	3
Increase team engagement/empowerment	#02, #06	2
Increase organizational integration	#03, #08	2
Reduce design effort	#03, #12	2
Improve design conceptualization	#03, #07	2
Promote standardization	#02	1
Increase productivity	#11	1
Promote organizational competitive advantage	#02	1
Decrease implementation and maintenance effort	#08	1
Decrease implementation and maintenance costs	#08	1
Difficulties	**Approaches**	**Total**
Knowledge is often context-specific	#02, #06, #09, #11	4
System features issues	#05, #06, #09	3
Low team engagement/empowerment	#01, #05, #08	3
User involvement	#07, #12	2

Table 7 continued from previous page.

Integration of the KM approach into the organization	#06, #11	2
Effort to implement and maintain the KM approach	#08, #09	2
Lack of consensus about HCI design conceptualization	#01, #02	2

5 Discussion

Taking the period of publications into account (RQ1), we can notice a long-term effort regarding the use of KM in HCI design, since this topic has been target of researchers for more than 20 years. However, the low average of publications per year (0.6 since 1995) shows that the topic has not been widely addressed. We can also notice that most of the publications are from the 2000s decade. The low percentage of journal publications, which generally require more mature works, can be seen as a reinforcement that the research on this topic is not mature enough yet. Besides, results about the research type (RQ2) show that only 40% of the works included some kind of evaluation, being only 13% evaluation of solutions in practice. This can be a sign of difficulty in applying the proposed approaches in industry, what reinforces that research on this topic is not mature enough yet and there seems to be a gap between theory and practice.

Concerning RQ3, we can notice that using KM in HCI design has been motivated mainly by delivering better products to users or optimizing the HCI design process in terms of effort, time and cost. Improving performance of the HCI design team was also mentioned, what is consistent with the other motivations related to the HCI design process, since increasing performance can contribute to decrease effort, time and cost. A common concern in several publications was the need for HCI design expert consultants, which can increase HCI design cost and effort. Capturing and reusing knowledge contribute to retain organizational knowledge and reduce dependence on external consultants. Another concern refers to communication problems. Smith and Dunckley [19] highlight that barriers to effective communication between designers, HCI specialists and users, due to their differing perspectives, affect product quality. KM solutions are helpful in this context.

Usability has been the focus of the KM initiatives in HCI context (RQ4). In fact, this is not a surprise, because usability has been the HCI design property more explored in the last years. Moreover, this property is quite comprehensive and includes other important aspects of HCI design, such as learnability, memorability, efficiency, safety and satisfaction [10]. However, there are other important properties not addressed in the analyzed papers, such as user experience, communicability and accessibility. The knowledge items managed by the KM approaches are quite diverse. Design solutions, guidelines, test results and design patterns are some knowledge items found in different publications. Despite the variety of knowledge items, we noticed that most of the approaches (66.7%) manage up two different knowledge items. By analyzing the coverage of the approach in terms of single or multiple projects, we found out that four approaches (#01, #03, #07 and #12) manage knowledge involved in a single project, while the other eight approaches are more extensive, accumulating

knowledge from multiple projects. In order to elevate knowledge reuse to the organizational level, it is important that a KM approach comprehends multiple projects in that organization.

Concerning knowledge use and capture (RQ5), at first, we expected that knowledge was captured and used in the same activity of the HCI design process. Therefore, results showed us that the same knowledge can be produced and consumed in different parts of HCI design process. For example, there are more approaches capturing knowledge in design evaluation activity than using in it. This reinforces the iterative characteristic of HCI design, where knowledge obtained in evaluation activity in one cycle can be used to improve the design in the next cycle.

Different technologies have been used to implement KM in HCI design context (RQ6). The most common are system-based approaches that use software to support KM process and store knowledge. We expected this result because KM systems, knowledge-based systems and knowledge repositories are widely adopted technologies in KM area. Earlier steps of the development of KM solutions, such as knowledge analysis and modeling, are also addressed in some publications. Moreover, there is also concern with latter steps, like the integration of the KM system into the organization. Some approaches combine different technologies, what can be a sign that the use of different techniques is a good strategy to address a more complete KM approach in HCI design.

As for benefits and challenges of using KM in HCI design context (RQ7), when categorizing the findings, we noticed that several of them are benefits and challenges of using KM in general. However, by analyzing the context of each KM approach, we can better understand how the findings relate to HCI design. For example, regarding the benefit *improve communication*, the works highlight the use of KM to support communication among the different actors involved in the HCI design process. In #10, communication between HCI specialists, designers and users is mediated by prototypes aiming at an agreement about the system design. In #01, KM facilitates the elicitation of the user's knowledge for the designer to apply it into the design. In #03, KM reduces errors of interpretation and contextualization among the people involved in the system design.

Some of the identified challenges and benefits are opposite each other. For example, on one hand, there is the challenge *low team engagement*. On the other hand, the benefit *increase team engagement*. We kept both because they were cited in different publications, thus under different perspectives. Moreover, we can see the challenge as a difficulty that, when overcome by the use of KM, can be turned into a benefit.

By analyzing the most cited benefit and challenge, we noticed that the generality level of the knowledge is an important question in a KM approach. The most cited benefit points to knowledge replicability in a specific context/domain. The most cited challenge points to the fact that it is difficult to generalize knowledge. Looking at data from RQ5, we noticed that approaches that reported knowledge generalization challenge handle knowledge from multiple projects, while approaches handling knowledge in a single project reported easy replica-

tion of knowledge. Thus, how general will be knowledge should be determined by the context where the KM approach will be applied. When dealing with high diversity of knowledge and contexts, it becomes harder to produce general knowledge to be widely used to solve specific problems and be adopted in different contexts. One way of achieving improvements in replicability is using knowledge-based analysis methods, as reported by the approaches #03 and #07.

Based on the panorama provided by the study results, in summary, we can say that KM has not been much explored in HCI context; it has been used mainly to improve software quality and HCI design process efficiency; it has focused on usability; and the KM approaches have been based on systems and repositories. As for benefits, KM has enabled knowledge replicability, improved product quality and communication. The main difficulties have been to generalize knowledge, address issues related to features of the system and low engagement of the team.

6 Limitations of the Study

As any study, our study has some limitations that must be considered together the results. One limitation refers to the subjectivity embedded in publication selection and data extraction. They were initially performed by the first and second authors and, to reduce subjectivity, the other two authors performed these same steps. Discordances and possible biases were discussed until reaching a consensus.

Another limitation refers to the sources. We used four digital libraries selected based on other secondary studies in Software Engineering. Although this set of digital libraries represents a comprehensive source of publications, the exclusion of other sources may have left some valuable publications out of our analysis. We performed snowballing aiming to minimize this risk. There are also limitations related to the adopted search string. Even though we have used several terms, there are still synonyms that we did not use.

Another important limitation is related to the classifications we made. We defined classification schemas for categorizing data in some research questions. Some categories were based on classifications previously proposed in the literature (e.g., type of research [27]). Others were established during data extraction, based on data provided by the analyzed publications (e.g., RQ4). Classification schemas and data categorization were done by the first and second authors and reviewed by the other two authors. However, determining the categories and how publications fit them involves a lot of judgment. Thus, different results could be obtained by other researchers.

7 Conclusion

In this paper, we presented a mapping study that investigated the use of KM in the HCI design context. The results of the mapping study provide a panorama

of research related to the topic. We noticed that, although HCI design is a favorable area to apply KM, there have been only few studies exploring this research topic. Due to the increasing importance of interactive systems and the diversity of interfaces that have been made available for people's use, we believe that there are many challenges and questions to be addressed in future research. For example: (i) The lack of a common conceptualization about HCI design (pointed in #01 and #02) leads to communication problems between the different actors involved in the HCI design process. We believe that the use of ontologies to establish this common conceptualization could help in this matter. (ii) The gap between theory and practice (RQ2 results) shows that it is necessary to take KM solutions to practical HCI design environments. For that, a divide and conquer strategy to reduce complexity of the conception, implementation and evaluation of a KM approach might be useful, allowing to provide results for the organizations in smaller periods of time and increasing benefits as the approach evolves. (iii) Other aspects besides usability (e.g., user experience, communicability) should be explored in KM initiatives to improve HCI design. (iv) The difficulties identified in RQ7 indicate issues that can be investigated in future research.

Concerning related works, we did not find any study investigating the use of KM in HCI context. As future work, we intend to carry out surveys with HCI design professionals aiming to identify which knowledge they consider important to manage when designing interactive systems. Thus, we intend to complement this study and provide an overview of how to use KM to aid in HCI design.

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