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Characterizing Proof-of-Concept Practices using the lens of Context Engineering

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Abstract

In this study, a Proof-of-Concept (PoC) context is acknowledged as an activity system with a set of practices performed by diverse practitioners, aiming to produce knowledge about performance of the technological artifacts under study. Ten PoC practices were identified through content analysis of narratives and observations, supported by the lens of Context Engineering (CE) from Information Systems (IS). CE introduces a framework of problems that help to understand the relevance of context as a fundamental factor in PoC, emphasizing the importance and need for reflection in action, for PoC practitioners. These practices are characterized as a cycle of knowledge production in the PoC context. The authors also identify the hermeneutic character of PoC activities, indicating a need to understand the whole activity system in relation to its constituent parts, while finding the meaning of the parts in the whole PoC context.

Keywords: Proof-of-Concept, Practices, Information Systems, Context Engineering.

1. Introduction – The context of Proof-of-Concept (PoC)

In an unrelenting search for technological innovation and knowledge, organizations resort to Proof-of-Concept (PoC), which serves as an instrument of knowledge construction and dissemination in the study and understanding of certain objects, that is, artifacts and phenomena. We visualize a PoC as activities undertaken by organizations with an aim of experimenting, to compare and validate new products and technologies, with the main goal of searching for technology-based innovation. PoC activities are typically required so that their technology providers can use this activity in order to 'prove some concepts'. However, we identify that PoC has several interpretations and terminological definitions in the scientific literature, therefore, the term PoC is not presenting a consensus in its definition [15, 19].

From a different perspective, Vygotsky [28], Leontyev [17], and Engeström [10], in Activity Theory (AT), "saw learning, development and work as holistic human activity, which both mediates and is mediated by, the tools used and the social context of the activity. This two-way concept of mediation implies that the capability and availability of tools mediate what can be done and the tool, in turn, evolves to hold the historical knowledge of how the community works and is organized. It is through the dynamic process of mediation that learning and development occurs, both in the individual and in the society as a whole" [14]. According to Hasan [14], Information Systems Development (ISD) has a "socio-technical composition with hardware, software, people and processes [activities] integrated into a complex, purposeful whole […] as a field of study, [which] draws its significance from the uniqueness of computer-based information and communication tools and their place in shaping recent human, social and organisational

history". Also, according to Almeida & Roque [1], the concept of an activity in AT can be applied to the study of societal contexts such as organizational contexts, communities of practice and the activity of ISD itself.

Thus, we define PoC as an activity system, supported by AT [7–10] in a socio-technical context, with the purpose of evaluation, understanding, validation and exploration, and with the aim of learning about technological artifacts and their phenomena under study by organizations and PoC practitioners. We also observe a set of movements performed by its practitioners during this activity as a 'way of doing something and seeing things', which we recognize as 'practices' in the same sense that was given by: (i) Bourdieu [4] as a "result of strategies consciously and unconsciously directed towards the satisfaction of a determinate type of material and symbolic interests"; (ii) Schatzki [25] as being "generally construed as materially mediated nexuses of activity"; (iii) Macintyre [18] as if "by a 'practice' I am going to mean any coherent and complex form of socially established cooperative human activity through which goods internal to that form of activity are realized in the course of trying to achieve those standards of excellence which are appropriate to, and partially definitive of, that form of activity"; and (iv) Schön [26, 27] "on a close examination of what some practitioners – architects, psychotherapists, engineers, planners, and managers – actually do".

A well-planned PoC activity allows those organizations, their actors or PoC practitioners, to evaluate, reflect, understand, validate and learn so that they can construct, acquire, or disseminate knowledge of the products or technologies under study. We understand and we also highlight that the lack of characterization of those activities may impact the knowledge of the whole activity, thereby increasing the possibility of compromising the reliability, reproducibility and reusability of the knowledge of the whole PoC [19]. PoC has often been used in descriptions of research in various fields, both scientific and corporate [15, 19]. However, several studies in the scientific literature present and substantiate their respective research projects in a PoC activity, but they do not present: (i) 'the why and the how' of those practices that were used in their research; (ii) a conceptual model, in order to guide the reader, and clarify the role of those practices for a practitioner, in their context; (iii) how those practices could be interpreted, understood, represented, modeled and organized in the context of their research. To our knowledge, there is a lack of studies, combined with gaps in the knowledge of PoC practices, in the body of scientific literature. The lack of characterization of those practices, even as a conceptual framework, can also intensify the difficulty to reflect upon and to understand these practices, thus increasing the probability of (i) inefficient knowledge construction and dissemination, or the probability of (ii) the presence of knowledge that is not contextualized and which is subsequently being misinterpreted by organizations and their actors [19]. The motivation for the present study was driven by the opportunity to introduce a characterization of the Proof-of-Concept context, thus providing a structured perspective of its practices and their implications for PoC practitioners as knowledge producers. We begin with the question of "How can we identify and characterize PoC context practices?".

2. Methodology

During our observations, we visualized a relevant phenomenon that exists, and it is implicit in the PoC activity, involving its practitioners, organizations and their actors, artifacts, interpretations, comprehension, requirements, pre-conceptions, pre-assumptions, beliefs, past-experiences, among others. This phenomenon represents one or more ways of seeing, interpreting, and doing things in the world of PoC, thus resulting in problems of development (design) in a socio-technical context, as well as increasing the probability of compromising the reliability, reproducibility and reusability of the knowledge in this activity, which may affect the proper utilization of that knowledge by the organizations and PoC practitioners [19].

We identified and adopted the Context Engineering (CE) framework [21–23] that proposes a set of movements which frame developmental problems in a socio-technical context, thus, supporting our data analysis and coding process in our study, with the aim of contributing to the characterization of PoC practices. CE was introduced as a lens over the Information Systems Development (ISD) action-oriented body of knowledge, with a discussion on the relevance of the context as a "fundamental topic in engineering and design and its complex set of conditions

to be understood and reflected in the modeling and development of artifacts" [21]. Considering the socio-technical context should also be essential in an effort to study and characterize PoC and in this study we adopted the lens of CE to support the identification and characterization of PoC practices. Based on the concept of reflection in action [27], which we found to be fundamental in PoC practices, the 'conversation' which the professional [PoC practitioner] establishes with the situation turns PoC engineering [development] into a movement-testing and knowledge-generating experience.

During PoC development activities, the practitioner "takes a constructivist position in relation to their knowledge of both the concrete situation and their discipline, making use of the construction of models" [21]. Therefore, during the collecting of narratives and according to our observations, we identified that a clarification of current practices in the PoC context is essential to address the needs of information systems and opportunities for innovation. Hence, by collecting narratives, recording our observations, using conceptual coding and mapping PoC practices, and by relating practices to development problems in CE, we expect to facilitate the comprehension of PoC practices and to contribute to 'knowledge about the practice', which is essential for PoC development. An iterative axial coding, using the CE movements as lenses for development problems, has led to a progressive simplification that allowed us to make inferences about PoC practices according to their goal or contribution in developing a better understanding of the target context and of the proposed solution. Thus, finally, supported by CE approach, we identify ten (10) PoC practices, which we present in this study.

Our research was based mainly on field research, where five (5) different Information Technology (IT) companies, their PoC practitioners and their 'way of doing something' were observed and collected in their 'natural PoC habitat', in a non-interventionist way. The methodology used for data collection was based on the experiences of direct personal participation in PoC of one of the authors', to gain access to a diversity of other PoC narratives experienced by PoC practitioners [2, 16]. The data that were collected and analyzed in the exercise reported here, was based on our observations and the narratives of two groups of PoC practitioners: (i) PoC specialists – actors who run PoC for high-performance IT data infrastructure customers; and (ii) PoC participants – non-specialist actors interacting along with the PoC specialists in diverse roles, such as customers, systems engineers, solutions architects, cloud architects, professional services consultants, site reliability engineers, database administrators, among others. These observations and PoC narratives were then narrated and stored in non-technical language, through familiar concepts and the language of the practitioners, in order to more closely represent their understanding of the phenomena under study, thus, minimizing potential a priori presuppositions [2, 3, 12, 16].

Our immersion in the PoC field was based on previous studies in the literature [2, 3, 13, 16, 24], where a combination of observations and acquiring narratives were performed. This ethnographic exercise aimed to take a deep dive into, and to participate in, the specific research context of PoC practices in the domain of IT data infrastructures, to "develop an understanding that would not be achievable with other, more limited research approaches" [16]. Our objective was to analyze and understand how PoC phenomena manifest themselves in the activities, procedures and daily interactions of these actors; and our study maintained an inductive focus on the analysis of the data, whereby our study started from general questions about the structure of PoC activities, which became more direct and specific throughout the investigation. In collecting narratives and in our observations, we adopted a view of ethnography as "the art and science of describing a human group—its institutions, interpersonal behaviors, material productions, and beliefs" and "the notion that true understanding of complex human practices and contexts requires in-depth, engaged study" [16], where its individuals often describe what they do in a way that is not accurate, possibly due to a lack of awareness or understanding of what they are trying to accomplish, which we assume may also be happening with current PoC practitioners and their movements. Prior to presenting our analysis and coding, we believe it is important to present the CE framework, and the reasons for this choice as a helpful lens in our aim to contribute to the characterization of PoC practices.

3. The Context Engineering (CE) framework

We adopted the CE approach to contribute in characterizing PoC practices because, during our observations and narrative collection, we viewed PoC as socio-technical phenomena. In that, we regarded not only the social interaction between PoC practitioners but also their "interaction with artifacts and of its influence on the emerging organizational patterns of behavior – of the socio-technical constitution and genesis of those collective patterns of behavior that we chose to understand as the object of ISD" [21, 23].

Characterizing PoC practices through the lens of CE aims to use those practices to reflect upon and to guide PoC practitioners and other actors in this activity with respect to "where they are and what they have done at a moment in development and to consider what next move they wish to take to further their development goals" [23], i.e., in PoC activity. Therefore, CE movements and their objectives can be summarized as: **(i) Diagnostic:** the purpose or motivation of the diagnostic movement is to obtain a model of the current context, where the result is a representation of the current or idealized context that is taken as a starting point for an intentional process of transformation; **(ii) Innovation:** The innovation activity aims at reconceptualizing or expanding the context where this movement is. The explanation of the context model opens the possibility of considering and confronting alternative views or the 'thinking-outside-of-the-box' space. We model context to allow reflection in the present about a future that is not yet instantiated; **(iii) Creation:** The objective of the creation movement is the production of mediators for new activities idealized in the new context model. Thus, this is the role of the various disciplinary agencies that, in the context of the development of IS, may intervene with the formulation of new technical systems as forms of mediation; **(iv) Evaluation:** We can understand the evaluation movement as the discovery and verification of a set of criteria, where its purpose is to underpin a decision-making intention, judging about the course to follow in driving development; **(v) Adaptation:** with the adaptation movement, we recognize the innovation that occurs almost silently and very often (on a daily basis), and that we only notice when its products have become unavoidable. It designates the activity developed to produce changes to a mediator, for better adaptation to performing the activities in the concrete context and, therefore, that does not usually imply a rewriting of the context model. Thus, adaptations are reifications of the currently shared model of context, in practice; **(vi) Generalization:** the purpose of the generalization movement is to transpose the mediators from the microcosm where they were developed to the context of the community concerned, meaning the generalization of their use and, in dialectics with them, the emergence of the new forms of activity; and **(vii) Consolidation:** represents the new form of activity as suggested in the Expansive Learning Cycle proposed by Engeström [7, 9, 10]. With the consolidation phase, the activity undergoes a set of steps: (i) new artifacts are systematically applied (or used) repetitively and explicitly; (ii) the use of artifacts varies, and the new activity performed adjusts to the system of neighboring activities; and (iii) the new activity is affirmed in the context of the network of activities, possibly resolving or generating contradictions, since the new activity has to compete with, and adjust to, the dynamics of the neighboring activities. Thus, this activity does not correspond to a final state therefore the development will continue with recurrent cycles of expansion. In conclusion, CE proposes "a set of fundamental movements to be performed as the situation and development intentions call for" [20], a lens we found helpful to support our identification and characterization of PoC practices.

4. Characterizing PoC practices supported by the lens of CE

After the narrative collection and our observations, we began the analysis by coding segments of the narratives and our observations, aiming to identify specific practices or their variants. Actually, "coding is much more than paraphrasing and key word counts" [16], whereby according to Corbin and Strauss [5], coding "involves interacting with data, making comparisons between data, and so on, and in doing so, deriving concepts to stand for those data, then developing those concepts in terms of their properties and dimensions". For the coding process, we followed the recommendation provided by Lazar, Feng, & Hochheiser [16] which suggests the following steps for coding: (i) look for specific items; (ii) constantly ask questions about the data; and (iii) constantly make comparisons at various levels, whereby we have added

the support of the lens of CE in aiming to contribute with the identification and characterization of those codes to PoC practices.

Our initial analyses were designed to code (highlight, classify, aggregate, and categorize) excerpts from the transcribed narratives and from our observation notes about the PoC natural habitat. We began by grouping all the narratives and our observations. Later, we started a reflection process in a paragraph by paragraph mode and searched for dialogues that we consider relevant (i.e., conversations on how to define a model for PoC execution, negotiating PoC requirements, discussing PoC results, among others) with the aim to contribute with respect to the identification and characterization of PoC practices among their practitioners. Thus, we identified in all narratives and our observations two hundred and forty-eight (248) dialogs (paragraphs). Afterwards, we began by ordering these dialogs into alphabetical order, and we started an iterative process of consolidation plus iterative attempts at coding those dialogs into actions/movements (either consciously or unconsciously) that were performed by PoC participants. We strived to code all of those actions/movements related to either (i) the development of information systems, (ii) actions for knowledge construction and dissemination during the PoC activity, or (iii) dialogs in a socio-technical context. During this phase, we aimed to assign one code to each relevant dialog for our research, consolidating the similar dialogs and removing those dialogs that we considered as non-relevant for our study. Thus, based on the coding categories that "may come from several sources: an existing theoretical framework, the researcher's interpretation (research-denoted concepts), and original terms provided by the participants (in vivo codes)" [16], we identified one hundred and ten (110) action codes (Appendix A). For each identified code, we identified and classified the competencies of PoC practitioners. After a progressive condensation of these codes, we identified 22 sets of competencies that are relevant to our research, whereby we can see these 22 sets as the skills of the PoC practitioner, which are developed from the range of actions that were identified (110 action codes). Thus, based on this set of twenty-two (22) competencies by PoC practitioners, we identified through the lens of CE, ten (10) PoC practices. In Figure 1, we present the action codes and their relationship with the set of competencies of PoC practitioners. In the same figure, we also present the mapping of these competencies with PoC practices supported by the lens of CE [21].

In our study, we understood the meaning of the term 'practices' in PoC to be a recurring action or movement with some objective and artifacts involved, observing some degree of regularity, that allows actors to remember and speak of it, to communicate it and to reproduce it, in the discourse among PoC practitioners. As such they can map the movements in CE, as they refer to a sub-area of developmental problems involving techniques, practices, instruments, among others, with a well-defined objective in the CE framework. In our observations during the PoC execution, in particular with respect to activities and context, we have noted different actions or movements performed by the PoC practitioners as part of the 'practice', which are mostly intuitive movements; in that they were performed naturally without an explicit rationalized catalog of movements performed in different contexts during the PoC, such as conversations, interviews, data collection, preparing the PoC infrastructure, executing the PoC, preparing the documentation, (re)doing some experiments in the PoC, presenting the results, among others. During our observations of the PoC, we also identified a non-sequential occurrence of these movements, in that we did not find a particular systematic order for these movements to occur. Also, we have realized that the practitioners tend to follow some sequence, but that sequence changes during the PoC and varies from one PoC context to another. In our analysis with the supporting lens of the CE approach, we have identified ten (10) distinct movements which we have termed as 'practices' of: **(i)** Exploring PoC Representation; **(ii)** Comprehending PoC Representation; **(iii)** Modeling PoC Representation; **(iv)** Specifying PoC Activity; **(v)** Executing PoC Activity; **(vi)** Negotiating PoC Activity; **(vii)** Improvising PoC Activity; **(viii)** Reflecting about PoC Activity; **(iv)** Describing PoC Activity; and **(x)** Documenting PoC Activity (Figure 1).

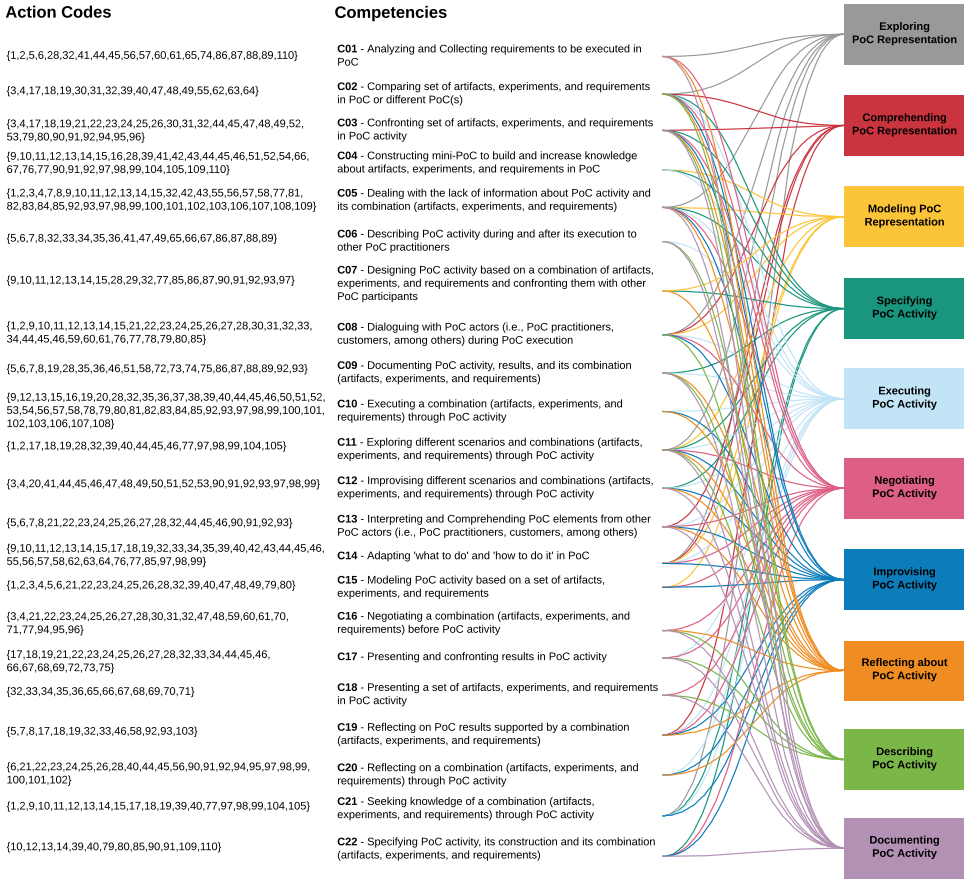

Fig. 1. Mapping 110 individual Action Codes to 22 Competencies, organized in 10 PoC Practices.

The set of 'practices' identified emerged recurrently, but with no explicit overall framing by their practitioners. An ordering become apparent when we characterize each practiced, with snippets of PoC narratives and observations, and we mapped each practice with development problems as organized in the CE framework of movements [21] as shown in (Figure 2):

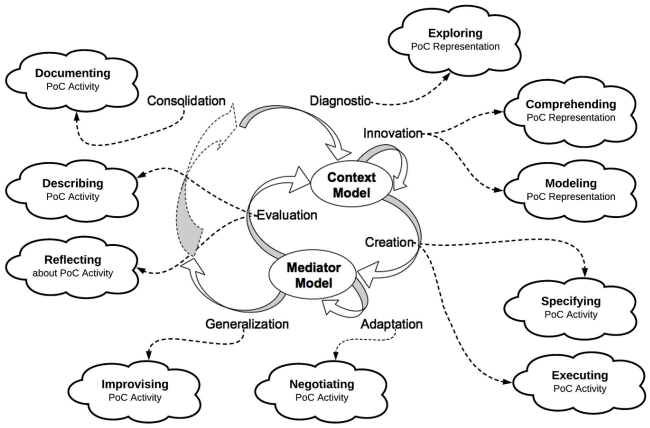

Fig. 2. Mapping PoC practices with the CE framework of problems.

- **Exploring PoC Representation (Exploration practice):** This practice materializes during PoC activity when the practitioners establish a conversation to explore and gather a better comprehension of the 'representation' to be constructed and researched in this activity. We understand 'representation' to mean: when an actor, i.e., customer, uses this activity as a support in the search for knowledge of the artifacts under study. Therefore, he/she is constructing and mentalizing a particular representation of his/her 'world' to be evaluated in this activity. The PoC practitioner aims to interpret and understand the 'world' of that actor,

thus proposing a 'new representation' to be modeled, constructed and evaluated in PoC. We also identified in this practice when PoC practitioners and participants are in an activity whereby they 'equate' and 'establish' knowledge or assumptions to be used in a PoC. Thus, this practice contributes to obtaining information about the current context, for example: '*The primary goal was to achieve the performance of 100,000 random read operations, measured in IOPS – Input / Output per second [in a data storage system] based on a data block of 32,768 bytes [32KB block size], with an average response time of less than 0.001s (i.e., one millisecond) to simulate a customer database environment*'. As a realization of Diagnostic movement (using CE), this practice aims to map the relevant context, resulting in a design of the current or idealized context which can be a starting point for framing a PoC and its multiple representations. This practice connects to Comprehending practice, where in the PoC natural habitat, when PoC practitioners explore a representation, that representation is given a natural appearance in order to comprehend it.

- **Comprehending PoC Representation (Comprehension practice):** We observed this practice during conversations where the PoC participants are in a constant mode of information comprehension, exploring different combinations or mutations of the different representations in a PoC, for example, one participant *'confirmed that the purpose of this particular experiment has no relation to the final results of the software tool. The goal is to observe, compare, and learn about the behavior of the data storage system in an abnormal situation of use. They [customer] would like to learn how the new solution [storage system] would behave under the same conditions [context]'*. Realizing the Innovation movement (using CE) is an activity which aims at (re)conceptualizing or (re)expanding the understanding of PoC representation and the context, opening the possibility for considering and confronting alternatives, essential for PoC value. During PoC observations and narratives, we verified that this practice is connected to Modeling practice, whereby, before modeling a PoC representation, the PoC practitioners were in a constant and recursive movement (Comprehending, Modeling, and Reflecting practices).
- **Modeling PoC Representation (Modeling practice):** This practice appears when a conversation starts during the representation, connection and framing or contextualizing of all artifacts in a PoC, in other words, PoC representation. We also observed during the Modeling practice, the occurrence of conversations about potential or desired results. Some PoC practitioners believed that the Modeling practice only occurred after some other practices, such as the Specification practice. We have identified a non-particular order for these practices, where on many occasions the Modeling practice occurred as the first practice performed by the PoC practitioners, for example: *'proposing a particular configuration for the execution of her [customer] PoC […] they started a new discussion to determine the number of needed flash disks [hardware] for this solution'.* Acceptable as part of the Innovation movement (using CE), this practice contributes to explaining the PoC (underlying context model), presenting the possibility of considering and confronting alternative framings for a PoC. We visualize this practice as being connected to Specification and Reflecting practices, where the PoC practitioners will first model a representation, and then they will reflect upon that representation. Later on, with a new representation, the Specifying practice begins, that is, there will be a network of technical artifacts for use in PoC.
- **Specifying PoC Activity (Specification practice):** We observed this practice as a transformation from representation to an activity, in other words, a process of 'connecting all the dots' in a PoC. The dots represent the details, combination, mutation, and relationship of all technical artifacts to be involved in a PoC, as well as, the relevant context, for example: *'the customer did not present major challenges to be demonstrated [context] […] proposed [data storage solution] a sustained performance test of 50,000 operations per second with an average response time of 5 milliseconds'*. This practice contributes to the creation of PoC artifacts with the production of mediator models that fit a particular performance and it directly connects to Execution practice, where we cannot visualize the existence of this practice without, at least, a minimum specification.
- **Executing PoC Activity (Execution practice):** Typically, this practice has specific and specialized technical activities determined by the PoC technology and context. In the PoC habitat of the present study, i.e., IT data storage systems, we observed that practitioners,

during the Execution practice, exploited a freedom of their own movements/actions. During the PoC Execution practice, we also observed the practice of reflection-in-action [26, 27] being performed by those practitioners. An example of the Execution practice is: *'After several attempts, they [PoC practitioners] discovered the relevance regarding the choice of the ideal quantity of threads [processes in parallel] to be used in the software to simulate I/O in this particular experiment'*. This practice contributes to the creation of mediators, with actual PoC artifacts, such as testbed assemblages, implemented architectures, tests, and reports. Thus, this practice aims to contribute to the production of new artifacts in a PoC, being directly connected to Reflection practice, where any result produced in this practice needs to be either Improvised (PoC Improvisation practice) (i.e., improved or re-analyzed), Negotiated (PoC Negotiation practice), or Described (PoC Description practice).

- **Negotiating PoC Activity (Negotiation practice):** In the majority of PoC cases, we observed the occurrence of a practice of Negotiation of PoC conditions or parameters, which occurred many times due to unusual requests by a customer regarding the characteristics of its representation, artifacts, or a lack of knowledge about a specific artifact in a particular context, or by the phenomenon *'I [PoC practitioner] will use it [artifact] because someone told me it is great'*. During the Negotiation practice, we also observed some siblings such as Confrontation and Convincing practices. Furthermore, we observed another phenomenon during a PoC, especially during the Negotiation practice, where PoC participants ask for a very specific representation in a combination of artifacts to be used or constructed in a PoC. However, in many situations, this request does not represent either a real concern or a lack of knowledge of operative context by these actors, including the PoC practitioners, for example: *'the customer was reluctant to change the proposed tests, especially the specific experiment related to the 65,536 threads in the generation and simulation of the performance tests. Initially, this specific experiment got rejected by the PoC group […] [and] the results obtained could express an outcome that could be misinterpreted, thus formalizing deficient knowledge based on these experiments and results'*. This practice aims to recognize the improvement of the artifact and indicates the activity developed seeking to determine a better performance of Adaptation movement (using CE), but as such it does not usually indicate a need to reconsider the context model underlying a PoC practice. We observed the occurrence of this practice after either the recursive movements of the practices of (i) Comprehending, Modeling, and Reflecting or (ii) Modeling, Specifying, Executing, and Reflecting.
- **Improvising PoC Activity (Improvisation practice):** PoC participants (i.e., customers) make choices about specific representations to be used in a PoC, such as a specific workload software tool to simulate Input/Output (I/O) that will validate throughput and response time in IT data storage systems. Depending on the combination of the artifacts involved, primarily associated with the context, another conversation may be required. This conversation is usually with the PoC specialists who improvise, with the aim to accommodate and adapt to combinations or mutations in the artifacts. In many situations, we traced a PoC specialist suggesting the use of a similar artifact, such as a workload software tool, for example: *'The PoC engineer presented some relevant points of why one should use this action, that is, the addition of the parameter [in the software]. At no time of the conversation had he mentioned the requirement of a particular version to be used. Therefore, due to this opening or lack of it, version 1.6 of the IO-Gorilla-Plus [fictional name] tool was adopted, which represents the latest version of the software'*. The Improvisation practice documented here can be understood as aiming at Generalization movement (using CE), i.e., promoting the adoption of certain artifacts as adequate in order to move on with the PoC results and its specific context.
- **Reflecting about PoC Activity (Reflection practice):** We have observed and characterized the occurrence of this practice in almost all the stages of performing a PoC, especially with respect to the Evaluation movement (using CE). Thus, we highlight and connect the importance of the work of Schön [26, 27] with our aim to contribute to the identification of PoC practices. Schön emphasizes the importance and the need for reflection on the action, and in the context of this action, on the part of the practitioners, for the definition and adjustment of their performance with respect to the objectives to be achieved, or on a meta-level, to the recontextualization and definition of PoC conditions and objectives, a reflection

that we have identified to be largely applicable in PoC practices, for instance: *'In a collective agreement [PoC practitioners and participants], it got decided that the F1+ model [storage system] could be operating at the limit of its configuration'*.

- **Describing PoC Activity (Description practice):** This practice occurs when PoC practitioners [PoC specialists and participants] and customers start a new conversation to describe and verify which direction to take in conducting the development of the PoC, or unfolding the results obtained during the Execution practice, or new discussions about the findings during Improvisation practice. During this practice, we have observed actors in PoC review activities, that are usually associated with information or knowledge, contextualizing a desired model used in a PoC, or by its artifacts, for example: *'Thus, the goal of this PoC is to have a response time of less than 0.004s (i.e., four milliseconds) in the 98th percentile for customer tests [in a data storage system]'*. This practice aims to contribute and support as a verification activity of a set of pre-established criteria or patterns, aiming at formulating a decision-making plan, especially for the goals or artifacts being tested in the PoC, thus, contributing to Documentation practice.
- **Documenting PoC Activity (Documentation practice):** During this practice, we identified the existence of a sibling, the practice of Presentation, where both Documentation and Presentation can occur in many different stages in a PoC. In our observations and narratives, some PoC participants believed that Documentation and Presentation could only happen at the end of the PoC. However, we have observed a different phenomenon where both practices occurred across all stages during the PoC, aiming to support conversations between actors, for example: *'Accordingly, Mr. X [PoC specialist] presented another tool [software] for generating and simulating performance tests in data storage systems. At the end of the PoC's execution, Mr. A [customer] was pleased with the variation of the proposed experiments and asked for more details about the tool [artifact] which were sent later via email, with all the results'*. PoC Documentation practice contributes to the consolidation of results, whereby this practice contributes to new artifacts [new knowledge] which are systematically applied or used, especially in new PoC. Also, the [new] use of these artifacts changes and the new activity adjusts to the system. Thus, we visualize this practice as not corresponding to a final state of the PoC which will continue with recurrent cycles of expansion, suggesting that the opportunity for Documentation and Presentation depends on the particular configuration of the network of elements that compose each PoC representation and the context, when Documentation and Presentation practices are understood to be essential in PoC.

We presented our PoC practice mapping, identifying ten practices in the PoC context (Exploring, Comprehending, Modeling, Specifying, Executing, Negotiating, Improvising, Reflecting, Describing, and Documenting) and a conceptual model, mapping their relationship with the CE framework of ISD problems. Next, we will provide our conclusions and proposed future works in the study of PoC practices.

5. Conclusion

In our study, we adopted the definition of PoC context as an activity system that is characterized by a set of practices, carried out by the different actors, while dealing with diverse artifacts, involved in the execution of a PoC for producing performance knowledge about an artifact. From our literature review, there is a lack of research on PoC studies, combined with gaps in the knowledge about this activity context. The absence of characterization and shared understanding of PoC practices can compromise the authenticity, reproducibility, and (re)usability of the knowledge that is applied and built during PoC activities. The identification and characterization of PoC practices are important steps to reflect on and to strengthen the effectiveness of PoC knowledge production and dissemination, and to better recognize the needs of information systems development to support those practices.

During our observations we identified a 'confrontation', implicit in the PoC activity, involving its practitioners, organizations and their actors, artifacts, interpretations, understandings, requirements, pre-concepts and assumptions, or 'in their own way of doing and seeing things', leading to developmental problems in this socio-technical context. We identified and characterized ten practices in the PoC context as recurring movements of PoC practitioners

that were observed in their natural habitat where the current mapping includes: Exploration, Comprehension, Modeling, Specification, Execution, Negotiation, Improvisation, Reflection, Description, and Documentation. We further characterized how these practices contribute to PoC development, by mapping then to ISD problems in the CE framework.

At the end of this study, we envision the PoC context as an activity system of knowledge construction and dissemination, based on continuous and recurrent movements (consciously or unconsciously) of its practitioners as a 'way of doing something and seeing things' in a socio-technical context. In other words, each PoC builds and implements a knowledge representation of a socio-technical scenario, a product of experience, creativity, insight, among others, of their actors, individual practitioners or organizational units, towards characterizing the behavior of technological artifacts under study. PoC activity stimulates the production and consumption of knowledge of both practitioners and organizations, which typically bring tacit knowledge [20] of their world. Thus, a PoC activity becomes a fundamental tool in validating and verifying how organizations and technology can operate in new product and service contexts, allowing PoC participants to establish a progressive and interactive way of reflection and interaction, triggering new forms of knowledge production and dissemination. However, we also identify a hermeneutic nature of PoC activity, since all cases of understanding necessarily involve both interpretation and application [11]. According to Roque [21], in hermeneutics "the production of the discourse on the relation of the parts as a whole [PoC activity system], or of the mediators [the PoC practices and instruments] with their context [PoC representation] of elements that allow the production of meaning".

For future works, we believe that it is not possible to understand the whole of the Proof-of-Concept (PoC) themes and their results [artifacts related knowledge being produced] until its constituent context is fully understood. We aim to reflect on PoC in the same sense that was given by Gadamer [11] that all cases of understanding necessarily involve both interpretation and application [6]. Further, there should be an emphasis on knowledge management in this activity context, with a deliberate and systematic approach with the aim of contributing to the full utilization of a knowledge base within the PoC activity system, along with the potential for reflecting on skills, competencies, organization, thoughts and innovations of its practitioners, in order to further development of more effective and efficient PoC practices.

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Appendix A

110 Action Codes used in Content Analysis

(1) Acquiring more info about the set of artifacts for PoC; **(2)** Acquiring more info about the set of requirements for PoC; **(3)** Adjusting a set of artifacts in PoC; **(4)** Adjusting a set of experiments in PoC; **(5)** Analyzing requirements vs. obtained results in PoC; **(6)** Analyzing a set of experiments during the execution of PoC; **(7)** Analyzing unexpected results (bad) vs. requirements for execution of PoC; **(8)** Analyzing unexpected results (good) vs. requirements for execution of PoC; **(9)** Asking for assistance in PoC execution; **(10)** Asking for assistance in PoC modeling; **(11)** Asking for assistance in PoC representation; **(12)** Asking for assistance to comprehend artifacts; **(13)** Asking for assistance to comprehend experiments; **(14)** Asking for assistance to comprehend requirements; **(15)** Asking for assistance to comprehend results; **(16)** Checking PoC environment for testing; **(17)** Comparing PoC results – comparing with competitor results; **(18)** Comparing PoC results – comparing with other PoC results; **(19)**

Comparing PoC results – expected vs. obtained; **(20)** Configuring artifacts in PoC; **(21)** Confronting PoC artifacts with PoC representation; **(22)** Confronting PoC experiments with PoC representation; **(23)** Confronting PoC requirements with PoC representation; **(24)** Confronting a set of artifacts in PoC; **(25)** Confronting a set of experiments in PoC; **(26)** Confronting a set of requirements in PoC; **(27)** Confronting a set of results in PoC; **(28)** Contrasting requirements and presenting a reflection in PoC execution; **(29)** Defining PoC participants by specialty; **(30)** Disagreeing with the proposed set of artifacts in PoC; **(31)** Disagreeing with the proposed set of experiments in PoC; **(32)** Discussing PoC with all participants; **(33)** Discussing results of PoC execution; **(34)** Discussing results of PoC representation; **(35)** Documenting results of PoC execution – partial; **(36)** Documenting results of PoC execution – total; **(37)** Executing PoC – non PoC specialist; **(38)** Executing PoC – PoC specialist; **(39)** Exploring different artifacts during execution of PoC; **(40)** Exploring different scenarios during execution of PoC; **(41)** Improving requirements during execution of PoC; **(42)** Insisting to continue with the proposed set of artifacts in PoC; **(43)** Insisting to continue with the proposed set of experiments in PoC; **(44)** Interpreting a set of experiments in PoC; **(45)** Interpreting a set of requirements in PoC; **(46)** Interpreting a set of results in PoC; **(47)** Introducing a set of artifacts for the PoC; **(48)** Introducing a set of experiments for the PoC; **(49)** Introducing a set of requirements for the PoC; **(50)** Invalidating results from other PoC; **(51)** Invalidating results in PoC; **(52)** Invalidating a set of artifacts in PoC; **(53)** Invalidating a set of requirements in PoC; **(54)** Making PoC environment available for testing; **(55)** Misunderstanding about technology in PoC; **(56)** Misunderstanding how to use artifacts in PoC; **(57)** Misunderstanding requirements in PoC; **(58)** Misunderstanding results in PoC; **(59)** Negotiating deadlines to document results in PoC; **(60)** Negotiating deadlines to execute PoC; **(61)** Negotiating deadlines to obtain results in PoC; **(62)** Offering a comparison of artifacts from different PoC; **(63)** Offering a comparison of experiments from different PoC; **(64)** Offering a comparison of results from different PoC; **(65)** Presenting needs to be explored in PoC; **(66)** Presenting results of PoC – final phase; **(67)** Presenting results of PoC – initial phase; **(68)** Presenting results of PoC execution – accepted; **(69)** Presenting results of PoC execution – not accepted; **(70)** Presenting results of PoC modeling; **(71)** Presenting results of PoC representation; **(72)** Presenting a set of artifacts for the PoC; **(73)** Presenting a set of experiments for the PoC; **(74)** Presenting a set of requirements for the PoC; **(75)** Presenting a set of results for the PoC; **(76)** Proposing mini-PoC (prototypes) – small-scale – execution; **(77)** Proposing mini-PoC (prototypes) – small-scale – validation; **(78)** Proposing new PoC execution based on results; **(79)** Proposing a new set of artifacts in PoC; **(80)** Proposing a new set of experiments in PoC; **(81)** Proposing re-evaluation of results in PoC; **(82)** Proposing re-evaluation set of artifacts in PoC; **(83)** Proposing re-evaluation set of requirements in PoC; **(84)** Proposing re-execution PoC execution; **(85)** Proposing redoing PoC modeling; **(86)** Providing description of artifacts to be used in PoC; **(87)** Providing description of experiments to be used in PoC; **(88)** Providing description of the acquired results in PoC; **(89)** Providing description of the expected results in PoC; **(90)** Reflecting on a set of artifacts in PoC; **(91)** Reflecting on a set of experiments in PoC; **(92)** Reflecting on a set of results in PoC; **(93)** Reflecting on a set of results in PoC compared to others; **(94)** Rejecting a set of artifacts in PoC; **(95)** Rejecting a set of experiments in PoC; **(96)** Rejecting the acceptance of PoC; **(97)** Researching for how to use a new artifact in PoC; **(98)** Researching for new artifacts to use in PoC; **(99)** Researching for new experiments to use in PoC; **(100)** Seeking culprit of potential failure – artifacts in PoC; **(101)** Seeking culprit of potential failure – execution in PoC; **(102)** Seeking culprit of potential failure – experiments in PoC; **(103)** Seeking culprit of potential failure – results in PoC; **(104)** Starting mini-PoC in order to comprehend the artifacts; **(105)** Starting mini-PoC in order to comprehend the experiments; **(106)** Starting PoC execution – requiring knowledge about artifacts; **(107)** Starting PoC execution – requiring knowledge about requirements; **(108)** Starting PoC execution – requiring knowledge about technology; **(109)** Using PoC as an exploratory exercise – with requirements; **(110)** Using PoC as an exploratory exercise – with no requirements.