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Antonio Jose Rodrigues Neto
University of Coimbra, neto@student.uc.pt

Maria Manuel Borges
University of Coimbra, mmb@fl.uc.pt

Licinio Roque
University of Coimbra, lir@dei.uc.pt

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DEVELOPING A PROOF-OF-CONCEPT PRACTICES CONTEXT MODEL

Research paper

Neto, Antonio Jose Rodrigues, University of Coimbra, Coimbra, Portugal, neto@student.uc.pt

Borges, Maria Manuel, University of Coimbra, Coimbra, Portugal, mmb@fl.uc.pt

Roque, Licinio, University of Coimbra, Coimbra, Portugal, lir@dei.uc.pt

Abstract

In this study, we worked in collaboration with ninety-seven Proof-of-Concept (PoC) practitioners in the development and execution of thirty different activities to map PoC practices and their relationships. Adopting a practitioner and designer mindsets, we used a Design Science Research approach to model PoC practices and their interactions, apply and study the model influence in practitioners understanding of context. We identified how practitioners incorporated model concepts and discovered interactions between practices, fostering their co-evolution. As practitioners, we framed practices in the context of activity systems, grounded in sociotechnical phenomena and used Activity Theory to substantiate our reflections on PoC practices and map mediators flowing between them. The paper contributes a conceptual-relational PoC practices context model, as a language contribution to improve reflection on practice, and to further enable the study the role of emergent practices in system design.

Keywords: Proof-of-Concept Practices, Context Model, Design Science Research, Knowledge Management.

1 Introduction

We present this work as an advanced stage of our initial research in the identification and characterization of practices in the Proof-of-Concept (PoC) context (Neto, Borges and Roque, 2018, 2019). We understand PoC in the same research sense as Kendig (2016, p. 736): “articulated in situ, through the activities of scientific investigation”. However, we study PoC as an activity domain composed of a set of tacit and explicit movements. These movements may constitute several practices practitioners perform across organizational networks, for learning about, experimenting and evaluating, new products or technologies, in the domain of IT data infrastructures. In such context, PoCs often evaluate performance, resilience, and data protection capabilities of enterprise data storage subsystems, usually in the acquisition phase. To our knowledge, there is a lack of studies, combined with gaps in the knowledge of PoC context practices, in the body of scientific literature. We observed several PoC studies (but we were not limited to these), in the domain of IT as per: Simitci, Malakapalli and Gunturu (2001); Neto (2004); Neto and Da Fonseca (2007); Hirata and Bernal (2009); Silva (2012), Chaim, Oliveira and Araujo (2017), among others, within their final results demonstrate the need for further contextualization, as well as more grounded and detailed analysis of practices than success or failure of experiments, e.g., such as in a proposed block diagram model in sequence by Barnes, Katzer, Potluri and Stone (2009).

Several studies in the body of scientific literature refer to the term proof-of-concept, PoC and its variations, as part of a research methodology, an auxiliary and support method for its object of study. But those studies: i) do not identify or characterize the actual practices in the context of PoC; ii) do not clarify why and how these practices appear or relate during PoC; and iii) do not model or conceptually map practitioners during the PoC development and execution. In our initial research (Neto, Borges and Roque, 2019) we conducted a field research across five IT companies that develop PoC activities,

observing, documenting and interviewing PoC practitioners and their ‘way-of-doing’, eliciting the knowledge of practices in their natural habitat, in a non-interventionist way. The adoption of those five IT companies was opportunistically based on their recognized know-how in executing PoC activities for different organizations, providing a diversity of cases of PoC activities and performing many activities in parallel and recurrently, not just ‘one now and the others at some later stage’. The research method used was based on documenting experiences of direct personal participation in PoC of one of the authors, to gain access to a diversity of narratives from other PoC activities experienced by different practitioners (Angrosino, 2007; Lazar, Feng and Hochheiser, 2017). The data collected was analyzed based on our observations of two groups of PoC practitioners – (i) PoC specialists – those who execute PoC for high-performance IT data infrastructure organizations; and (ii) PoC participants – non-specialist actors interacting along with the PoC specialists in diverse roles (e.g., customers, solutions architects, database administrators). Based on fifty PoC activities and sixteen narratives, we identified several recurrent movements performed by the practitioners – mapping *what, how, where, and when they perform movements* – which could constitute several practices. Through content analysis, we could identify ten practice categories in the PoC context: (i) Exploring; (ii) Comprehending; (iii) Modeling; (iv) Specifying; (v) Executing; (vi) Negotiating; (vii) Improvising; (viii) Reflecting; (ix) Describing; and (x) Documenting (Neto et al., 2019). However, this work still misses a deeper characterization of each specific category, which instruments are involved, how it relates to neighbor activities and the flows involved. This will constitute the main motive and purpose the current investigation.

We notice an analogy between: (i) the learning process in the PoC context, including the actors involved and their set of movements during the development and execution, and (ii) the model of expansive learning (Engeström, 2000, 2001, 2007) that “focuses on learning processes in which the very subject of learning is transformed from isolated individuals to collectives and networks. As activity systems [across enterprise networks get] increasingly interconnected and interdependent, forming producer-client relationship, a partnership, a network, or some other pattern of multi-activity collaboration” (Engeström, 2011, p. 78). We also identified that PoC practitioners are in constant transition within practical worlds (e.g., the world in which they live, the ‘PoC world’, and the customer’s world, a complex world composed by IT applications and artifacts to be evaluated in the ‘PoC world’, as well as conceiving problems, questions or doubts that arise in several practical situations. When practitioners act in the PoC, they adopt a particular worldview (situated in a PoC context) and a way to build and maintain this world as they ‘perceive’ and ‘understand’ it. When they respond to indeterminate or unknown areas of practice, they sustain a reflexive conversation with the materials of their situations, e.g., exploring or reflecting on other complex worlds, such as IT applications and artifacts to be reproduced in a PoC context. They tend to remake part of their practical world that could reveal a set of as yet tacit new practices and interactions in the context of PoC, to build a worldview upon which all of their practice is based, thus contributing to the construction and dissemination of knowledge in the context of PoC. Furthermore, in this particular world (PoC context), practitioners acted naturally without an explicit or rationalized catalog of activities being performed: such as dialogues, researching, preparing testing infrastructure, documenting the results, re-running experiments, reflecting on the artifacts or the results, discussing the requirements with other actors involved, presenting the results to different actors, among others. Based on such sociotechnical phenomenon, we envisioned the relevance of a introducing a conceptual-relational model of PoC activities, as well as its relations, for understanding how they co-evolve in the PoC context. Such a model, “mapping” practices and their role in PoC activities, could provide a much-needed language and act as a compass for its practitioners, enabling a better understanding of where they are or will be acting in the future.

The motivation for this work is to *advance* research in the context of PoC practices, with the aim to contribute set of conceptual and relational categories to the body of knowledge, while modeling the Proof-of-Concept context. Thus, we immerse ourselves again in the natural habitat of PoC, working collaboratively with practitioners, with a practitioner and designer mindset, to develop, propose and test the influence of a conceptual context model of PoC practices. Based on a characterization of previously identified practices (Neto et al., 2019), we now aim to further map how practices can interact, whether

in current context or future contexts. We also aim to trace how the proposed model empowered practitioners to reflect on their practices and help them revise or evolve development goals in context.

2 Research method

In this study, we aim to characterize and model the interactions between ten practices previously identified in the PoC context (Neto et al., 2019) representing them as a conceptual-relational Context Model of PoC practices. In a second immersion in the PoC habitat, we acted not only as observer but also as: i) a practitioner in collaboration with other practitioners in the research context and, as ii) a design-researcher, with the aim to develop a “working context model of PoC practices”. In doing so, we highlight the importance of researchers’ immersion in the actual context to gain domain knowledge and experience with PoC (in the case, the domain of data and IT infrastructures). We adopted a research method based on two approaches: i) acting as a practitioner in the researched context aiming to reflect on the sociotechnical phenomena in PoC and understand a ‘particular way of doing things’ in the PoC context, especially mapping the relationships between PoC practices, and also ii) acting as a designer, aiming to model how PoC practices interact and evolve in the actual activity system’s sociotechnical milieu. Therefore, we return to the research context, following a set of activities evaluating performance, resilience, and data protection capabilities of enterprise data storage subsystems.

As practitioners, we participated actively in this context as a practitioner in thirty new PoC activities. On each PoC we had interactions with an average of 3.2 different practitioners, with a total number of ninety-seven PoC participants. It is also noteworthy that we chose not to participate alone in PoCs, involving at least one other PoC practitioner, and acting collaboratively and dialoging along the development and execution of these PoC activities. In this process, model concepts were used to communicate with other practitioners, while referring explicitly to the practices and activities involved. We observed how other practitioners performed in the context of PoC while, at the same time, those practitioners observed how we acted, incorporating in language, the ten model categories to refer to practices in the PoC context. As researchers, we were interested in tracing how these concepts could help make explicit reflections and our method was based on interactive observations and constructions on how those practices evolve and relate in the flow across the activity system. With this socially constructed context our aim was to further characterize the practices involved, describe them, and map their interactions in the context of PoC. While proceeding in this way we seek to empower practitioners by enriching their language of PoC, by giving substance and support to the emergence of a discourse on practice, that can reinforce or revise the context model and its interpretation of practice.

2.1 Using a designer mindset in the context of PoC

According to Gregor (2006), a characteristic that distinguishes IS from other fields is that “it concerns the use of artifacts in a human-machine system” (Gregor, 2006, p. 613), i.e., a research in the IS field “examines more than just the technological system, or just the social system, or even the two side by side; in addition, it investigates the phenomena that emerge when the two interact” (Lee, 2001, p. iii). During this immersion in the PoC habitat, we considered how this might adapt in the context of PoC. As Carlsson, Henningsson, Hrastinski and Keller (2011, p. 2) present Design Science Research (DSR) in IS that is “concerned with theory and knowledge for action”, we attempted a similar approach to the study of the context of PoC, resulting in a field study of the model in practice. We draw from the body of DSR literature, a structuring process to propose and study the application of the PoC practice content model. According to Vaishnavi and Kuechler (2004, p. 4), DSR pursues “knowledge in the form of constructs, techniques and methods, models, and/or well-developed theory for performing this mapping – the know-how for creating artifacts that satisfy given sets of functional requirements”. By proposing a context model of PoC practices we aim to map practices as emergent forms of situated knowledge, arising in context. With model application we assess how it structures the phenomena under study.

From Hevner (2007) we draw guidelines concerning three cycles in DSR that contribute to the identification and characterization of interactions between practices and the proposed context model of PoC: the Relevance Cycle, the Rigor Cycle, and the Design Cycle. According to Hevner (2007, p. 3), the

Relevance Cycle initiates DSR with an **application context** that “not only provides the requirements for the research (e.g., the opportunity/problem to be addressed) as inputs but also defines acceptance criteria for the ultimate evaluation of the research results”. From this cycle, we contextualize the PoC environment during the i) translation phase, when a PoC practitioner translates the phenomena of a world to be reproduced in the PoC world, and ii) transition phase, when a practitioner changes, combines, or improvises the phenomena in the PoC world, between practices. In summary, for relevance, we aim to **characterize** the practices in a manner relevant to interpret and structure action in the context.

The Rigor Cycle considers “grounding theories and methods along with domain experience and expertise from the foundations knowledge base into the research and **adds the new knowledge** generated by the research to the growing knowledge base” (Hevner, 2007). Thus, we employ previous model concepts as a basis for this work, and Activity Theory as a framework to look for and map activities and their model elements. This cycle helps **predict** what are the next steps in modeling the context of PoC, helping to perceive potential practice categories and relations, based on underlying theoretical lenses.

The Design Cycle, as the core of any DSR initiative, “**iterates** more rapidly between **the construction of an artifact**, its evaluation, and subsequent feedback **to refine the design further**” (Hevner, 2007). However, the same author states that it is fundamental to maintain a balance between “the efforts spent in constructing and evaluating the evolving design artifact” whereby those activities must be convincingly based on the other previous cycles. In the context of this study, we aim to **substantiate** the model proposal in the context of PoC by realizing multiple iterations of model application and assessment “before contributions are output into the relevance cycle and the rigor cycle” (Hevner, 2007, p. 5). This view on DSR helps us to understand and reflect on the potential developments of the PoC context model.

With a design mindset in the context of PoC, we went through the performance of several PoCs, based on the characteristics of the proposed model, with the aim of characterizing (Relevance Cycle), predicting (Rigor Cycle), and substantiating (Design Cycle) the relationships between the ten practices in the context of PoC. As a research output, the context model becomes a conceptual artifact enabling the dialectic between the concrete practices and the interpretive model of practice, for the actors involved.

2.2 Adopting a practitioner mindset with an AT perspective

Adopting a practitioner mindset, we worked collaboratively with different practitioners, adopting the proposed model through the PoC activities in order to promote reflections on how those practices relate and evolve during the execution. After participating and documenting more than half of the 30 PoC activities followed, we begun using the model to map ‘where are we?’ within the PoC development process and ‘where we could go next?’ for future movements in PoC. Another interesting approach as a result from our participation as a practitioner in the context of PoC, is that we envision those practices and their interactions as being the development of language and ‘psychological’ functions, resulting from a process of model appropriation which transforms the external activity through social interaction, into an internal activity, i.e., doing something concrete in the PoC context, grounded in the sociotechnical milieu. We view practices as shaping an **activity system**, and view practitioners’ movements grounded by the development of sociotechnical relations to be studied in PoC context. Activity Theory (AT) (Engeström, 1987; Kuutti, 1999) focus leads us to reflect on practice interactions between **activity structures**, following interactions in a sociotechnical context between activities to be represented in a PoC context model. In the context of PoC, each activity structure relates practitioners to an object or motive of each activity in the PoC context. PoC practices play an important role in mediating between practitioners (as subjects) and how they organize, regulate and use instruments, to achieve the PoC result. Through these mediations, results must be obtained, knowledge about the object of the PoC gets produced. Thus, turning the PoC object into knowledge is a shared motive across all PoC activities, motivates their realization and the creation and refinement of new activities. Therefore, we can expect an improvement of practice through accumulated practice knowledge and vice versa.

We should aim to learn to recognize dialectic interactions between the practices in co-evolution, with the activity itself, thus creating knowledge and transforming the activity system as a whole. This continuous and circular aspect of learning through emergent PoC practice emphasizes the critical role of

sociotechnical movements such as dialogue, reflections, improvisations, negotiations, etc. PoC as a social space, gets built as a form of expansive learning, to be analyzed and understood in the activity context itself (Nardi, 1996) as it cannot be analyzed in an isolated manner. For a practitioner, PoC activities are all but static, rather, they are experiences as ever evolving, where each activity has its own history, embedding ‘past’ phases and future client expectations. Hence, we envision activity structure in a PoC, as that which is conceived of at a given moment, and then it undergoes a process of evolution, where old and new practices cohabitate, might be created and transformed so that the activity reaches its pragmatic ‘format’. Activities also evolve with the improvement of mediators and object definition, inducing changes in PoC practices. According to Almeida and Roque (2002, p. 546), within the AT framework, “the development of IS, being an activity that relies heavily in the creation of mediators, aims to design and build artefacts for another activity (target) and, direct or indirectly, also for the set of associated activities”.

In summary, AT proposes a particular and useful notion of context, drawing attention towards the structure of activities, tracing their intervening elements, that can contribute to better identify the emerging patterns of practice, and learn to anticipate and recognize their interactions. In order to strengthen our observations based on a designer mindset, we developed conversations supported on the model, and mapped activity structures and mediators across the ten categories previous identified in the PoC habitat. As we progressed through thirty PoCs, we could document what distinguishes practice and mapped flows of mediating elements (specifications, test scripts, metrics, messages and agreements, etc.) between practices, as they continuously contribute to engineer a sociotechnical context (Roque, 2004).

3 A proposed conceptual PoC context practices model

Our proposal to develop a conceptual PoC context practices model was based on the two immersions in the natural habitat of PoC, one as a non-interventionist – fifty (50) PoC activities and sixteen (16) narratives – and the other as a practitioner and designer – thirty (30) PoC activities interacting with a total number of ninety-seven (97) PoC practitioners. Our two immersions totaled an extended period of approximately twenty-four (24) months in the world of PoC, resulting in four-hundred-and-ten (410) data collections and observations, specifically three-hundred-and-ninety-one (391) scenarios, i.e., situations in PoC, and nineteen (19) sketches. Furthermore, we present our proposal for a conceptual model of PoC practices as presented in Figure 1.

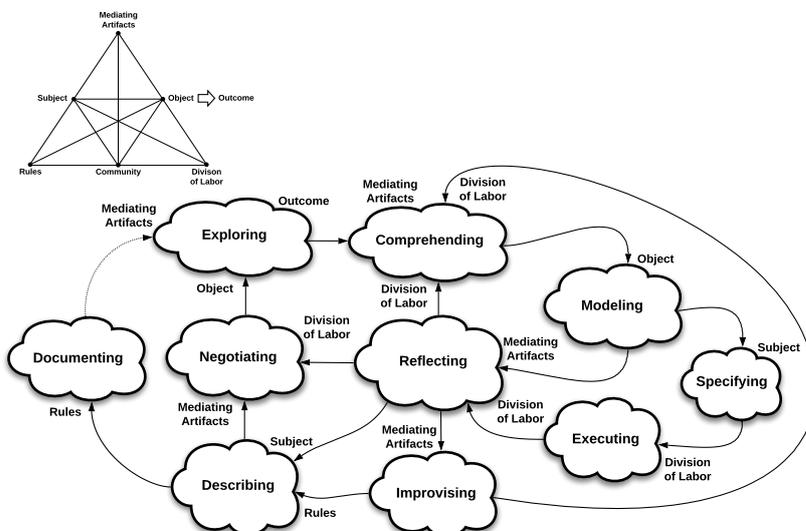


Figure 1. The proposed PoC practices context model

Note that the proposed model presents ten (10) practices and their interactions in the context of the development and execution of PoC, whereby our goal with this proposal is to provide a model that can map the movements, whether they are acting currently or will be acting in the future, so that its

practitioners can reflect on “where they are and what they have done to take further their development goals” (Roque, Almeida and Figueiredo, 2004).

In Figure 1, we represent each practice in a cloud (e.g., Exploring). The set of straight lines represents the interactions between those practices which translates to some way of transporting information and knowledge and its ways of obtaining it among those interactions, i.e., we highlight this transport of information and knowledge in our PoC context practices model as “a fluid mix of framed experience, values, **contextual information**, and expert insight that provides a framework for evaluating and incorporating new experiences and information” (Davenport and Prusak, 1998, p. 5) (our emphasis). The dotted line in Figure 1 represents a phenomenon that we observed in a PoC context which we call a ‘restart of the PoC cycle’, i.e., we observed several misunderstandings and misconceptions during a PoC, where many practitioners think that a PoC ‘ends’ with the documentation practice. However, the documentation practice only represents and characterizes one more movement, like a consolidation movement, in the context of PoC. Thus, depending on several situations in the PoC context, as a simple misunderstanding of the PoC requirements during the exploration practice or a lack of knowledge during the PoC execution practice, the cycle [may] restarts. We emphasize the **contingent occurrence** of those practices in the proposed PoC context practices model, many times in a recursive way and with no explicit framing by their practitioners. In other words, our proposed PoC context practices model does not necessarily ‘start’ with the practice of Exploring, that is, for example, the conversations could start based on different practices (e.g., practice of executing), e.g., based on the following excerpt, PoC just ‘started’ with the practice of executing: “*Let me explain how we can get the ball rolling in this PoC. Let’s run some tests, present to them [customer], and voilà*”. Therefore, with a designer mindset, we analyzed the scenarios, specifically more than half of them and all the sketches, in order to characterize the existing movements within the context of the PoC (Relevance Cycle), aiming to predict where those movements could go (Rigor Cycle). After creating a representative structure about the movement (the nature of its current state and where it could go), we seek to substantiate (Design Cycle) and reflect on that ‘representative structure’ grounded by a sociotechnical context based on the structure of the activity using AT, e.g., (i) who are the subjects involved and which of them could be existing in the future?; (ii) what are the current and future objectives within the movement?; (iii) what are the existing tools and what could be the next tool?; and (iv) what is the outcome and what could be expected as an outcome? Next, we present in different subsections a description of each practice and its interactions within the proposed PoC context practices model.

3.1 Exploring

This practice materializes during PoC when its practitioners establish a conversation to explore, aiming to know a little more about the artifacts to be used or studied in PoC, i.e., we visualize this practice when the actors involved in PoC *get introduced to a puzzle and all its pieces* from one different world (e.g., customer IT world) to be ‘replicated’ (simulated) in a different context (‘PoC world’). That is, it happens when the PoC specialists, participants or collective get in contact with the technological artifacts, customer requirements, ‘questions, wishes, (pre)concepts, (mis)concepts, beliefs’, among others. For example, in the following excerpt – “*My customer wants to test the maximum IOPS achieved within 1 ms latency using batman [anonymized name] 1.0 storage equipment. Profile: 100% random, 4 KB size, R/W=10/90*”. Based on the above excerpt, the practitioner was introduced to several pieces (e.g., batman 1.0 as the data storage solution, profile 100% random 4 KB data block size, read and write percentage), but there is a lack of meaning, i.e., the practitioners can ‘see’ all the pieces, but there is not an understanding about its meaning and how to plug (connect) in the PoC context – ‘Why those pieces and not others?’. We visualize the connection (pathway) between this practice and the practice of comprehending grounded in the transition (and the need) for interpretation and comprehension of all those puzzles and its pieces, typically from a customer world (original world) and what is the meaning to a ‘PoC world’ (new context). Thus, this practice connects to the practice of comprehension aiming to encourage and enable a transition from ‘here are the pieces’ to ‘here are the pieces and also whatever are the potential interpretations and comprehension for them to interlock and function’.

3.2 Comprehending

This practice materializes when the actor involved in a collaborative way aims to conceptualize the puzzle and its pieces into the context of PoC, i.e., a constant searching mode in interpreting and understanding the different combinations and mutations of the artifacts in the original context, seeking to understand the pieces (artifacts) and their combinations so that the actor can frame it and contextualize it from the original context including all artifacts within a new representation of the context in a PoC (i.e., the PoC world). In short, we visualize this practice in the way that one practitioner would ‘see and think’ concerning this piece and how the other practitioners would ‘see and think’ concerning this piece, in the context of PoC. For example, in the following excerpt, the PoC practitioners can ‘see’ the pieces, but lack a comprehension and a contextualization, i.e., the comprehension and the construction of a projective representation [model] of the context – the original context with respect to a future context (PoC) – *“Also, if you look at the workload profile carefully, customer is using eight parallel jobs with an exponential queue (starting from 1 to 32 – step 2). But the devil is in the details. Their profile is based on 64 outstanding IOs (not sure why) per job with 10,000,000 blocks of 512 bytes, in a total of 5 GB per job. I really don’t see a point in collecting performance numbers with such a small working set of data”*. We visualize the connection (pathway) between this practice and the practice of modeling grounded in the transition (and the need) for interpretation and modeling of all those puzzles and its pieces to a certain representative model in ‘PoC world’ (new context). We have seen this practice connected to the practice of modeling, whereby, prior to modeling a PoC, its practitioners relied on constant and recursive developmental (loop) movements supported by the practices of comprehension, modeling, and reflection. In other words, behaviors, i.e., practitioners’ workflows related to the search for understanding and reflecting on the various points of view of other PoC practitioners with the aim of developing a representation of a projective context (PoC) based on the use of multiple types of mediating instruments and their interdependence.

3.3 Modeling

We visualize this practice as being materialized when PoC practitioners or collectives are in constant cycles of developing, modeling, framing, and contextualizing a puzzle and its pieces in the context of PoC. In other words, modeling and contextualizing all the technological artifacts from an original context to a new context, based on a comprehensive (or a tentative) understanding of their ‘original world’ (e.g., IT application and its technological artifacts to be studied in PoC) to be reproduced in PoC, and not just a technological aggregation of hundreds of pieces in order to produce some results. During PoC, organizations, as potential or existing customers, aim to experiment, validate and learn about the behavior and performance of technological artifacts in order to make a comparison with their ‘original world’ in the search for knowledge, technological innovation, validation of organizational and technological procedures, performance improvement of their information systems, reduction of operational and technological costs, among others. However, we understand that, in the majority of cases, it is not possible to ‘clone’ or ‘transport’ the ‘original world’ completely into the PoC context, due to several factors such as: (i) the original world’s complexity in relation to their world and technological artifacts; (ii) difficulty in fully understanding relationships and how all those IS ‘communicate’ and ‘interact’ in the organization; (iii) inability to ‘carry’ all-consuming actors, i.e., users who ‘absorb’ these IS into the PoC context, whether they are PoCs within the organization itself or PoCs that are externally executed; (iv) the volume of data from these information systems in which we may be handling hundreds of thousands of data units; (v) confidentiality of the information used by these information systems; among many others. Therefore, during the PoC, its practitioners construct a [new] representation of this ‘original world’, that is, a construction that is not identical, but rather a construction that represents proximity and relevance to its original reality. For example, in the following excerpt, in the ‘original world’, the request was to use fifty (50) servers to produce a certain performance number (IOPS – Input/output per second), but in the context of PoC, this practice points to using one server – *“Those servers are way more powerful than we thought. We [PoC practitioners] showed some numbers to the customer, and he got really impressed with the results. We never thought we could push 1.6 M IOPS from a single server. The funny*

thing is that their original request was asking for fifty servers”. Thus, this practice aims to start a reflection on the potential development scenarios and solutions in PoC, whereby in this case we make an analogy regarding how to build a puzzle. In other words, this practice seeks to analyze and reflect on how all the puzzle pieces (both social and technological) originating from an original context to a new context (PoC) can connect. We emphasize that the PoC practitioners do not entirely own the pieces of the original context. In fact, they believe that they have ‘the right knowledge’ regarding the puzzle pieces as a result of the practices of exploration and comprehension. Similarly, this applies to a new PoC context, where this context often presents itself as original, challenging, unknown, and untapped, thereby enhancing the difficulties and puzzles in PoC development. That is, the outcome lies in the model of a context in PoC, which may be and often is transformed during its specification (practice of specifying – the translation from conceptual models to specific and technological models in the context of PoC), and this helps to elucidate on: (i) what to think (or could have thought) and (ii) how to connect (or how they could have been connected regarding) those pieces in the puzzle (PoC context). Therefore, presenting a possibility to consider and confronting alternative representations (models) in the PoC (before and during its specification and execution).

3.4 Specifying

We visualize this practice being materialized when PoC specialists, participants or collective aim at the transformation of a representative model (e.g., related to one or several proposals for a specification of a new context in PoC and contrasting it with various forms of reflection on potential scenarios and combinations of the different mediation tools in PoC) to a particular set of combinations in a new context with new and different technological artifacts to be used and explored in PoC. In other words, this practice is the transformation from an imaginary model to a materialized creation to be known and studied while being performed in this activity. For example, in the following excerpt, we visualize a dialog between two practitioners (e.g., partner and PoC specialist) aiming to specify the current modeling to a specific outline (i.e., the workload for 10,000 IOPS), predicting it for the next cycle, the practice of execution – “[Partner] The goal is to make a database copy (clone) based on the storage system functionality from one machine to another in < 60 minutes and using a minimal storage area. [PoC specialist] I think as an initial plan, it is ok. However, I don’t think it is a good idea to propose a database PoC without any workload running. Let’s propose a PoC doing two database clones of 1 TB each, under a workload of 10,000 IOPS. I believe this will make the customer more comfortable with our solution showing some scalability for their future requirements”. Thus, the definition, even if premature, of a starting point in the assembly of a PoC, where we highlight the passage of a drawing, usually built in the practice of modeling, that represents an inevitable sociotechnical reality (i.e., IT artifact to be explored) in a construction of a new set of artifacts and their combinations in this new reality. We envision the combination of two distinct worlds, the original world – which represents a reality that we are not involved in and do not fully understand its context and its singularities – to the PoC world. In the same way, we highlight the construction of this world, something that we do not fully understand, due to the complexity of the sociotechnical relations, such as the actors involved, their different needs and aspirations, all various forms of interpretation and understanding, and an almost endless number of combinations and mutations of the technological artifacts in use and to be explored in this new world, i.e., the ‘PoC world’.

3.5 Executing

This practice materializes with the real and concrete realization of a design (ideally created in the practice of modeling and improved in the practice of specification), as well as the eventual construction of mediators for a modeled context, that is the PoC context through the production of various mediation models. In other words, the PoC practitioner or collective undertaking a PoC, that is, specific and specialized technical activities determined by the PoC technology and context. Thus, this practice is characterized by the transformation of representative models through a realization of social and technological functioning and interaction during PoC.

In the context of PoC, social interactions could be represented through the execution of a technological artifact by one PoC practitioner versus a distinct execution by a different PoC practitioner. Could we expect the same execution by both practitioners if the artifact is the same? We understand that it will not be the same because the context model and the mediators are quite different. For example, during our immersion in the context of PoC, we posed the following question to several PoC practitioners during a PoC execution: *“Please look at the experiments below and tell me right away which experiment (A or B) you think is faster? (A) Experiment A – Total I/O 1,056,892.65 – Avg. MB/s 4,128.50 – Avg. Latency (ms) 1.054 versus (B) Experiment B – Total I/O 1,056,942.10 – Avg. MB/s 4,128.68 – Avg. Latency (ms) 1.120”*. The first half of the practitioners responded that the fastest experiment was experiment A because the response time (Avg. Latency) was shorter compared to experiment B (e.g., *“straight away I’d choose A for the best performance, you can’t notice the throughput difference, but latency is obvious”*). The second half of the practitioners responded that experiment B was faster because it transmitted more information (total I/O) than experiment A (e.g., *“the difference between the two bandwidth numbers is almost exactly 0.01%. I say there’s a legit answer B – if more throughput means ... faster”*). However, regarding a practitioner mindset, we cannot answer without some contextualization, i.e., whether experiment A translates to a random application within which the response time for every data block counts due to its randomness, I tend to answer experiment A is faster. On the other hand, if the context lies in a streaming application where ‘every single byte counts’, i.e., what is the maximum throughput the application can generate in a second, I tend to go with experiment B. Hence, a question arises: Why [usually] did the PoC practitioners make one particular adoption, or usage, or configuration, or decision, or answer and not another ‘in their way of seeing and doing things’ for certain artifacts, their combinations, and experiments in PoC **without reflecting on the context** (our emphasis)? That is, we could picture an interaction ‘between’ this practice and the practice of improvising, but during our observations, we understand based on the continuous and recurrent movements (mostly unconsciously) by its practitioners, that this practice has a pathway to the practice of reflecting, i.e., indeed, there is a ‘virtual connection between’ the practices of executing and improvising, but it goes through the practice of reflecting first. Thus, we visualize that this practice aims to contribute to the creation of mediators and the undertaking of the PoC activity, which is composed of: a set of artifacts to be used and explored in a PoC, the design of experiments and plans of intentions, systems architectures, and sociotechnical analysis based on the interpretation and comprehension of the actors involved in this activity and the performance of technological artifacts under study in the PoC, the results and the forms of presentation and documentation regarding the organizations, among others.

3.6 Reflecting

We visualize this practice being materialized based on Schön (1983, 2007) through the constant and recurrent reflection-in-action movements by practitioners in the context of PoC. In other words, this reflection on the action provokes the creativity and insight of practitioners through the construction of new ideas, new thoughts and new modeling of context and artifacts, thus promoting new knowledge in the combinations and variations of the artifacts in the context of PoC and vice versa. For example, in the following excerpt, we highlight a dialog between practitioners reflecting on the modeling and specification about some experiments in a PoC – *“Basically, the customer is not using parallelism. The customer is using 2 threads to run the IO. Using Little’s law, there is no way to achieve 8 GB/s based on that. Also, I doubt they have achieved 8 GB/s with other vendors based on the same workload pattern”*. This practice in the context of PoC underlies a decisive intention, which corresponds to judging the course to be followed in conducting development or in emancipated and recurrent movements in the practices of comprehension, modeling, improvisation, description or negotiation. In other words, this practice helps PoC practitioners to review knowledge about the idealized context expressed in the corresponding model, or to adapt the mediator to the context already modeled, or to attempt to generalize the new form of context. Therefore, this decision depends on the knowledge gained from the performance of the execution practice, which in turn may depend on the interpretation and understanding of the exploration, modeling and specification practices that were followed, i.e., this practice aims to establish an evaluation through a reflection on the action of a set of pre-developed models. Hence, through

reflection on the movements of a mediator, it would correspond to thinking about and validating potential adequacy (or inadequacy) in the face of a set of situations, desires, curiosities or constraints expressed by the idealized context model. This evaluation implies some form of verification or experimentation of the artifacts, as well as their various combinations, allowing us to make this reflection. Depending on the type of results obtained, a decision should then be made as to what is the next step in PoC (e.g., a pathway to the practice of comprehending or negotiating). In this way, PoC practitioners may ask themselves this question – How do we contextualize the results in PoC and how can we view potential and different outcomes if the context changes?

3.7 Improvising

We visualize this practice being materialized when the PoC practitioners (specialist and participants) or collective are manipulating (or improvising with) a new version of the PoC context, thus influencing the emergence of new maneuvers in form of practices contributing to produce and disseminate knowledge in PoC. Depending on the combination of the artifacts involved, primarily associated with the new version of the context, new dialogs may be required. These dialogues are usually with PoC practitioners and organizations involved in the PoC to accommodate and adapt artifact combinations or mutations in this new version of the context. For example, in the following excerpt, a PoC practitioner suggests an improvisation in the variation in the random experiments, i.e., a development of a new context grounded by the practice of improvising – *“Instead of running all the experiments using 32 threads, why don't we suggest running those experiments in curve mode? In this way, we [PoC specialists] provide a graph where the latency is a function of the throughput; thus, we can see the point where the system starts to get saturated (knee in the curve)”*. Thus, the purpose of the practice of improvising is to transpose the mediators, that have been modeled and developed, into a new context. In the same sense, a new way of reflecting on the use and application of artifacts in the PoC, which means the widespread use and as a consequence the emergence of new forms of activity. In other words, this practice aims to objectify the new context model through an adaptation of the metrics that support the forms of activity that are idealized within it. Therefore, we must consider that we are not only interested in the adoption of each mediator, but in the emergence of the new form of activity that may serve as a potential development of a design pattern. In other words, these new instruments or precursors of the new activity are confronted with the old activity, generating a new contradiction, thus a new activity is born that was potentially not anticipated in previous practices.

3.8 Describing

The PoC practitioner or collective using the practice of describing, which includes the movements of presentation, explanation, and argumentation, are aiming to contextualize all pieces in PoC. In other words, this practice causes an exposition and description of context and artifacts, which consequently forces a deeper understanding of the context (actual and new) and the combinations of artifacts and mediation tools by the practitioners. In other words, the practice of describing is intended to establish a conversation and an understanding of what evolves the actual activity system and socio-technical milieu. We observed during this practice, an astonishing amount of information about the idealized context, mainly when performed with a new artifact for a new context. Therefore, PoC practitioners can consider the presentation of the context, the technological artifacts in use and study, as well as potential PoC conclusions and results that will not only be described by its practitioners, but will be presented in a way that enables interpretation and comprehension of this puzzle and how its pieces were defined and distributed for the production of meaning. Hence, according to Roque (2004, p. 121) “the production of the discourse on the relation of the parts as a whole, or of the mediators with their context of elements that allow the production of meaning”, e.g., in the following excerpt, the PoC practitioners describe the context confronted and challenged in PoC to another PoC specialists, which were not involved directly with this PoC – *“With our synthetic workload IO tool, from one server, we were able to see 32 GB/sec reads and 22-23 GB/sec writes. We tried to model using the same parameters (i.e., block size, randomness, etc.) used by your application and we cannot pass 22 GB/sec reads and 11 GB/sec writes”*. If we,

as practitioners in the context of PoC, understand the development of the PoC as an evolutionary process, we will be led to conclude that this practice should perform movements of presentation and characterization for all the pieces in that puzzle. During this practice, we observed that the actors involved in the PoC, who are generally associated with the production of knowledge contextualized to a model, initially imagined and then later materialized knowledge in the PoC. This practice aims to contribute and support the presenting and verifying of a set of determinations, choices, criteria, or potential standards in what was initially imagined and planned to be achieved versus the reality [i.e., of what actually occurred]. Hence, we visualize a connection between this practice and the practice of documentation, or if there is a lack of understanding, it goes back to *“let’s negotiate and maybe we need to start exploring again”*, a movement leading to the practice of negotiating.

3.9 Negotiating

This practice materializes when the PoC practitioner or collective are negotiating new and different representations (models), technological artifacts, and their new and innovative combinations and relationships in the context of PoC. Through dialogues, these subjects seek to be ‘on the same page’ concerning their intentions and the modeled and specified context, as well as the form of use, execution, configuration and parameterization (which is literally beyond comprehension) of technological artifacts in PoC, e.g., *“There are hundreds of synthetic workload generators (I/O), so pick your poison. The most important is not the tool, but how to translate desires/dreams/expectations to a performance characterization. In other words, how to translate what the customer ‘wants versus needs’ to reality, i.e., yes, let’s characterize their illusory performance numbers”*. This practice aims to adjust (and sometimes establish) conditions, expectations, parameters of the modeled and specified representation through several adaptations of the PoC context and its mediation artifacts. We emphasize the negotiations between actors involved in the PoC, such as negotiations regarding the use and parameterization of artifacts in the execution of the PoC in order not to abandon and completely discard the proposed context model. We note that this practice does not imply a complete rewriting of the context model in the PoC, but rewriting does happen sometimes, e.g., *“Bottom line: the model chosen hasn’t fit into the new performance requirements that were silently in place at the customer side. Sad to say, sometimes one discusses A and does B. We’re restarting the whole PoC from scratch to reflect the new requirements”*. Hence, the results of this practice will therefore depend on the PoC practitioner’s position, the goals set by the idealized context, and the relationships between them regardless of whether they are mediated or not, which may lead to exploring it again, or just documenting it.

3.10 Documenting

The aim of the PoC practitioner or collective using this practice is to register (and reflect upon afterwards) what happens (or happened) in the PoC. In other words, this practice is characterized as an object of systematization of practices in the development of the PoC, being a necessity in the life cycle of the current context, besides serving as a knowledge base for construction of new contexts in different PoCs, and it should be considered as an integral and concrete part of the PoC activity, e.g., *“I want to clarify couple points in the documentation regarding the used synthetic workload in PoC: (a) It’s optional to enable compression/dedupe of written data, but I included them in case it’s relevant; and (b) Adjust the concurrency parameter if you want to push more IO to the storage”*. In other words, the practice of documenting in the context of PoC underlies a consolidation intent that is tied to a context, provoking [new] movements of interpretation and an understanding of the current context, the use, and performance of artifacts in this context, as well as a reflection on a new context and new artifacts that could be applied (or not) systematically to the new PoC. Also, this practice naturally provokes reflections on different combinations of those artifacts in the context of PoC and vice versa, and how this could influence the PoC results. Therefore, this practice aims to materialize through documentation movements the interpretation and understanding of the current context and the arrangement of artifacts in this context, thus producing some amount of knowledge. We highlight this practice as essential in exposing the results and how those results connect to the actual context and the use and disposition of the artifacts in that

context. Therefore, we do not visualize this practice corresponding to the final state of the PoC activity, as we understand that the PoC development lifecycle will continue with recurring expansion movements in providing the actors involved in this activity with expansive learning.

4 Conclusions and future work

In this study, we worked in collaboration with ninety-seven Proof-of-Concept (PoC) practitioners in the development and execution of thirty different activities to map PoC practices and their relationships. Adopting a practitioner and designer mindsets, we used a Design Science Research approach to model PoC practices and their relations, apply and study the model influence in practitioners understanding of context. We identified how practitioners incorporated model concepts and discovered relations between practices, fostering their co-evolution. As practitioners, we framed practices in the context of activity systems, grounded in sociotechnical phenomena and used Activity Theory to substantiate our reflections on PoC practices and map mediators flowing between them. The paper contributes a conceptual-relational PoC practices context model, as a language contribution to improve reflection on practice, and to further enable the study the role of emergent practices in system design.

We understand the PoC context as a network of activity systems, performed by practitioners, reflecting and rewriting their own practices, to seek meaning and understanding, and evolve of their own practices. We a model the PoC context to represent practices as an emergent sociotechnical reality, a representation of the PoC context and its practices as ongoing forms of activity, with the aim of making it observable and an object of explicit reasoning among practitioners. In the context of PoC, we do not find practitioner movements unfolding always in a well-defined sequence. On the contrary, we observe a set of free and specialized movements that contingently recombine to form practice flows. Accordingly, the proposed context model of PoC practices does not present a strictly sequential process. Practices represented in the context model organize a set of relational flows or paths enabling the realization of a diversity of practice patterns, contingent with each PoC project demands. PoC knowledge is thus grounded in a relationship among its practices, engineering the sociotechnical context that invokes its use. By collecting and assembling fragments of practitioners' movements in context, we highlight the importance of developing this PoC context model to better understand their role in the overall activity system.

As a follow-up to this study, we envision the PoC context model contributing to a more general understanding of practice-based knowledge construction and dissemination, as continuous and recurrent movements are, consciously or unconsciously, improvised and tested by practitioners, using the model as a **compass** to reflect on the PoC context, how other practitioners act, and their role as makers of this sociotechnical PoC world.

After the development of this model, we visualized an interesting phenomenon with the presence of several loops based on the interaction between those practices (e.g., Comprehending → Modeling → Reflecting → Comprehending), i.e., we understand those loops as a “large and growing body of empirical research [*which*] shows that social relationships and the networks these relationships constitute are influential in explaining the processes of knowledge creation, diffusion, absorption, and use” (Phelps, Heidl and Wadhwa, 2012), i.e., those networks are known as **knowledge networks** (our emphasis) or in other words, “a set of nodes — individuals or higher level collectives that serve as heterogeneously distributed repositories of knowledge and agents that search for, transmit, and create knowledge — interconnected by social relationships that enable and constrain nodes' efforts to acquire, transfer, and create knowledge” (Phelps et al., 2012), which suggests an intriguing and hypothetical approach with which to reflect on this whole model and its ‘networks’ as a complex network (graph) for the knowledge production and dissemination, as well as the impact of one practice on another.

Thus, for future work, we intend to materialize this model in a software development prototype, that is, using the terminology of graph theory (Lucchesi, 1979; Feofiloff, Kohayakawa and Wakabayashi, 2011), it can be said that the distribution of $P(k)$ connectivity that gives the probability that one vertex (practice or knowledge) is connected to other k vertices, is mathematically described by a power-law $P(k) \propto k^{-\gamma}$, where the factor γ will depend on the scale of the considered grid. In this model, the network growth begins with random graphs of k_0 vertices, and each vertex k could be considered as just a

simple movement, practice, or piece of knowledge generated in a PoC context. One way to classify and quantify the generated dynamic network is to use the Percolation Theory (Stauffer and Aharony, 1992; Sahimi, 1994). However, Popescul (2012) presents a new way of thinking about the Percolation Theory, i.e., the author's study promotes "thinking regarding the relation between innovation and knowledge using a Physics-borrowed model, trying to prove whether knowledge resources can 'flow' (be percolated) in a network or a grid, in order to be transformed in technological innovation". On the other hand, another way is to use the Percolation Centrality (Piraveenan, Prokopenko and Hossain, 2013) which "measures the importance of nodes in terms of aiding the percolation through the network" and specifies in detail the importance of nodes (i.e., practices) in terms of their percolation (propagation) through the generated graph, e.g., in the whole network (PoC model) or in a specific network.

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