Understanding and supporting skill development within teams and collectives, by capturing, packaging, and sharing procedures.

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Context

The development of skills is often mastered through informal learning, with the help of peers, by capturing know-how about a given practice. For instance by overhearing about a procedure, by noticing the existence of an unknown tool, by observing a given practice or "*tour de main*". In the digital realm such informal learning can be challenging. Distance clearly hinders visibility and sharing. But even in co-located spaces, most activities involve the same physical tools: a keyboard and a mouse, leaving very little hints for observers to guess the type of activity unfolding, whether it is worth paying attention to or not, and if something could be learnt from it.

However digital environments come with other properties: recording and documenting procedures is much easier, sharing such procedures can happen almost instantly, they can also be archived for later reference. Far away from formal tutorials and training sessions, informal sharing can happen by sending an annotated screenshot, or a screen recording made on the spot.

Capturing and sharing digital procedures suffers from two main limitations. First, producing them is often tedious and time consuming. Second, procedures differ from one situation to the next (often conceptualized as the difference between process and practice). These discrepancies between a generic procedure, and the specifics of a situation requires some levels of interpretation from learners. This may vary depending on his or her own skills. Procedures must be interpreted because users' context may vary, the software used may be slightly different because of languages, software or OS versions, customizations, or the assemblage of software may be different for more complex workflows. In the context of remote collaboration, it becomes crucial to facilitate the packaging and sharing of such procedures, as co-located forms of learning leveraging tacit knowledge and over the shoulder discoveries are more challenging to develop.

Objectives & research questions

This PhD will tackle the work outlined in **WP2.4 of PC2 "Collaborative Interaction Histories"**. It focuses on the following objectives:

Assist practitioners in identifying relevant skills worth sharing, and infer the corresponding procedures. It is important for users to identify which procedures they master on their system that could be useful to other users, such as colleagues, members of a community of practice, or other people involved in an open collective. This PhD will investigate how to delineate what makes a digital skill, and under which conditions it would be worth sharing. Rabardel's work on instrumental genesis[1] will guide our investigation. We will focus on professional practices, with sharing happening within teams or across teams, in an asynchronous fashion.

Identify what it takes to "package" a digital procedure. In order to facilitate sharing of digital procedures, we will investigate what makes a digital procedure and what are the elementary components necessary to share these procedures so they can be "compiled" and shared with others (potentially running a different version of the software, or in a different context). This will require understanding how to create interaction histories upon which different actors can collaborate: create them, edit them, annotate them as they evolve over time to reflect changes in practices. This is a socio-technical and design challenge. As practices vary, change or evolve, one generic procedure is unlikely to be

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[1] Verillon, P., & Rabardel, P. (1995). Cognition and artifacts: A contribution to the study of thought in relation to instrumented activity. European journal of psychology of education, 77-101.

definitive, this raises questions of what is relevant and worth sharing within complex procedures. Activity theory[2] and activity-based computing[3] are promising candidates to guide this line of work.

Design and evaluate interfaces that assist teachers and learners. Finally, it will investigate different designs of interfaces that can assist teachers in "packaging", "collaboratively editing", and learners in "playing back" these digital procedures so they can be more easily understood and learnt, adapting to the expertise and skill level of the user, and possibly "contributing" back.

Brief overview of the state of the art

Sharing and learning new digital skills is increasingly done through video tutorials[4], with platforms such as Youtube playing an important role in their diffusion. Millions are now turning to such tutorials when they need to share procedures and develop new skills[5]. Their popularity can be explained by the procedural nature of the tutorials[6]. By sharing detailed steps in context, they support more efficient learning compared to conceptual knowledge sharing.

They still however suffer from limitations on their own. They can for instance be hard to navigate or contain portions that are not relevant to the learner[7]. Another problem is that software and operating systems are malleable[8] and subject to variations due to updates, customization of the interface, localization, themes, etc. Tutorials therefore remain hard to follow as soon as they were not produced with the correct version[9]. Solutions to alleviate these problems consist either in enriching tutorials at consumption time, thanks to community content[10],[11]. Another approach aims at facilitating the production of tutorials by demonstration, but they require the teacher to explicitly perform the actions again[12],[13]. Instead, we are interested in studying how to better capture, edit and share the underlying interaction histories to avoid these issues.

Theoretical foundations

This PhD will build upon diverse theoretical foundations :

Maeva Calmettes already conducted an extensive exploration of the literature on skill acquisition. She identified models of skill acquisition upon which to build : Piaget[14] and Bartlett[15] concept of *schema,* Fitts and Posner work on *motor skill acquisition[16]*, Ericsson work on *deliberate practice[17]* for experts and Sweller's *Cognitive Load Theory[18]*.

With regard to collaborative contexts, the candidate plans to build upon classics of the CSCW literature: Wenger and Lave empirical work and theories on situated learning[19], as well as the rich body of scholarship on Activity Theory. Both Vygotsky's work on cognitive development and learning, such as his concept of the zone of proximal

[2] Kaptelinin, V., & Nardi, B. A. (2006). Acting with technology: Activity theory and interaction design. MIT press.

[3] Bardram, J. E., Jeuris, S., Tell, P., Houben, S., & Voida, S. (2019). Activity-centric computing systems. CACM, 62(8), 72-81.

[4] Lange, P. G. (2018). Informal Learning on YouTube. In The International Encyclopedia of Media Literacy (1 ed.), Renee Hobbs and Paul Mihailidis (Eds.). Wiley, 1–11.

[5] Kiani K, Cui G., Bunt A., McGrenere J., and Chilana Parmit (2019). Beyond "One-Size-Fits-All": Understanding the Diversity in How Software Newcomers Discover and Make Use of Help Resources. ACM CHI 2019.

[6] Zacks, J. M., & Tversky, B. (2003). Structuring information interfaces for procedural learning. Journal of Experimental Psychology: Applied, 9(2), 88.

[7] Fraser C. Ailie, Ngoon Tricia, Dontcheva Mira, and Klemmer Scott. (2019). RePlay: Contextually Presenting Learning Videos Across Software Applications. ACM CHI 2019

[8] Cabitza F. and Simone C. (2017) Malleability in the Hands of End-Users. New Perspectives in End-User Development

[9] Perraud R., Tabard. A, and Malacria, S. (2024) Tutorial Mismatches: Investigating the Frictions due to Interface Differences when Following Software Video Tutorials. ACM DIS 2024.

[10] Vermette L., Dembla S., Wang A., McGrenere J. and Chilana P. (2017). Social CheatSheet: An Interactive Community-Curated Information Overlay for Web Applications. ACM CSCW 2017.

[11] Xu Wang, Benjamin Lafreniere, and Tovi Grossman. (2018). Leveraging Community-Generated Videos and Command Logs to Classify and Recommend Software Workflows. ACM CHI 2018

[12] Wang C., Chu W., Chen H., Hsu C., Chen M. (2014) EverTutor: Automatically Creating Interactive Guided Tutorials on Smartphones by User Demonstration. ACM CHI 2014.

[13] Chi P., Ahn S., Ren A., Hartmann B., Dontcheva B., and Li W. (2012) MixT: automatic generation of step-by-step mixed media tutorials. ACM CHI EA 2012.

[14] Piaget, J. (1952). The origins of intelligence in children. (M. Cook, Trans.). W W Norton & Co

[15] Bartlett, F. C. (1932). Remembering: A study in experimental and social psychology. Cambridge University Press.

[16] Fitts, P.M., & Posner, M.I. (1967). Human performance. Brooks/Cole.

[17] Ericsson, K. Anders et al. (1993). The role of deliberate practice in the acquisition of expert performance. Psychological Review 100 : 363-406.

[18] Sweller; J. (1994). Cognitive load theory, learning difficulty, and instructional design. Learning and Instruction (4-4), 295-312,

[19] Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge university press.

development[20], and the rich body of work on Activity theory, up to its recent developments. Aurélien Tabard, already advised a PhD thesis[21] tying Activity Theory and learning theories (e.g. Dillenbourg's Orchestration[22]) through technical implementations. He will bring expertise on Activity Theory and Activity Based Computing.

Finally the candidate is already familiar with social theories of cognition, such as the work of Bandura on social cognitive theory[23], Clark & Chalmers work on Memory externalization[24] or Hutchins et al. work on distributed cognition[25] (A. Tabard has been collaborating for more than 10 years with James Hollan who contributed to this theory and its applications to the design of interactive systems).

Mathieu Nancel and Sylvain Malacria will bring technical and methodological expertise. Mathieu Nancel has experience in designing histories of commands for new use-cases[26], for which he obtained an ANR JCJC grant and supervised a PhD[27] defended in 2023 about a novel software architecture for command histories in applications. These contributions will serve as a technical basis for the work in this PhD. Sylvain Malacria has expertise in skill development with interactive systems and graphical interfaces[28] and reflective interfaces to improve performance[29], including when attempting to reproduce a task on a different platform or interface[30,9].

Approach and methods

Our overall approach will consist in triangulating between field observations of skill sharing practices, studying the impact of design interventions, and abstracting both at a technical level and a theoretical what we derived from the field work and experimental studies.

The first six months of the PhD will be dedicated to consolidating the conceptual basis of the thesis through literature review. The candidate will also explore relevant field work of relevance. In Lyon, we have contacts with design teams at SEB, Frog Design, and smaller agencies, as well as Decathlon in Grenoble and Lille. We have a strong relationship with the library network of Lyon (the largest in France) which we know faces challenges in sharing procedures among its various libraries and workers.

The candidate will then design proposals to support capturing, sharing and collaboratively editing interaction histories. This work will be done in a participatory manner with key stakeholders identified earlier. The most relevant proposals will be further studied empirically.

Finally the candidate will work on generalizing the previously validated approach and contributions, both technically and conceptually, to offer a foundation upon which others can build.

Evaluation of the contributions

We plan to contribute :
- knowledge about skill sharing within teams and across specific settings ?
- design methods on documenting skills
- empirical knowledge through experiments comparing procedure capture, sharing, and consumption. These experiments will be conducted either in the lab, online, or in-situ depending on what is most relevant and feasible.

Application areas / scenarios

Depending on the candidate's interests, the practical feasibility, and the availability of the stakeholders, the thesis will focus on one of the following areas:

Digital design*, UI/UX work, such as graphics editing* (photoshop, figma, 3D tools, etc.)

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[20] Vygotski, L. (2019) Pensée et langage. La Dispute.

[21] Lachand, V. (2020). Approche centrée activité pour la conception et l'orchestration d'activités numériques en classe, PhD thesis, Univ Lyon.

[22] Dillenbourg, P. (2009). From design to orchestration. Springer.

[23] Bandura, A. (2001). Social cognitive theory: An agentic perspective. Annual review of psychology, 52(1), 1-26.

[24] Clark, A., & Chalmers, D. (1998). The Extended Mind. Analysis, 58 (1), 7–1

[25] Hutchins, E. (1995). *Cognition in the Wild*. MIT press.

[26] Nancel, M. & Cockburn, A. (2014). Causality – A Conceptual Model of Interaction History. In ACM CHI 14.

[27] Schmid, P. (2023). Développement d'historiques de commandes avancés pour améliorer le processus d'édition numérique. PhD thesis.

[28] Cockburn A., Gutwin C., Scarr J. & Malacria S. Supporting Novice to Expert Transitions in User Interfaces. In ACM CSUR.

[29] Malacria S., Scarr J., Cockburn A., Gutwin C. & Grossman T. Skillometers: Reflective Widgets That Motivate and Help Users to Improve Performance. In ACM UIST 13

[30] Alvina J., Bunt A., Chilana P. , Malacria S. & McGrenere, J. Where is that Feature? Designing for Cross-Device Software Learnability. In ACM 20.

This relates to priority theme #1, while software engineering is mentioned, UI/UX design is an integral part of modern software production. The tools used while have the specificity of being structured around a canvas in which 2d or 3d elements are manipulated. This makes screen recordings of these activities easier to communicate visually and temporal navigation within such recordings easier. Learning can happen within distributed teams or broader communities of practice.

Domain-specific software *such as the ones found in the health sector, operator machines, or in the service industry* In workplaces with turn-over, evolving roles, and highly specialized tools, people have to be trained often on specific procedures. Same goes for learning skills related to software developed specifically or internally by/for the company where tutorials may not be available online and in-person training time-costly.

Advising team

This PhD thesis will happen between Lyon and Lille. The thesis will be supervised by Aurélien Tabard (MCF Lyon 1), Mathieu Nancel (CR Inria) and Sylvain Malacria (CR Inria, HDR).

Aurélien Tabard, has co-advised three PhD students in the domain of computer supported collaborative learning, including Valentin Lachand who studied more precisely how activity-centric computing could support packaging and sharing of learning activities. This approach has proved particularly generative by blending Activity Theory, which is a solid theoretical foundation for CSCW research, and the concepts of scripting and orchestration widely used by the CSCL community.

Mathieu Nancel led an ANR JCJC on the design and engineering of temporality in human-computer interactions, within time scales ranging from very short (psychomotor phenomena) to very large (perennial histories of commands and how to use them). He advised two PhDs on this topic, one who defended successfully and one still ongoing.

Sylvain Malacria led an ANR JCJC on how to support the discoverability of features and procedures within applications. He co-advised two PhDs on the topic, and advises one currently on the design of video tutorials and their challenges for contextual learning.

Two PhD students from S. Malacria received the best thesis award from AFIHM. A recent master student of A. Tabard received the best master thesis award from Conseil National du numérique. The 9 PhD students that Aurélien Tabard, Mathieu Nancel, and Sylvain Malacria advised defended, with solid publications in HCI, CSCW, Design or CSCL. The advisors have no-drop outs nor experience of conflicts with their students, and take advising, training and caring for their students as important

Nature of digital collaboration

This PhD thesis will study the **co-construction and sharing of procedures**. We aim primarily at studying **team-specific procedures**, such as the ones found within design teams, or other domain specific professions. Procedures can be used to share individual skills, whether technical or methodological, but also to agree on best practice, or to establish shared rules within a team. Some procedures are strongly team-dependent, e.g. file or project organization, project update, delivery or transfer protocols. These procedures are even more bound to be collectively constructed and updated as practices change. We are also interested in procedures that go **beyond a single team**, whenever actors of different backgrounds collaborate on the same digital objects (e.g. designers, managers, software developers, and other stakeholders working on a software project), this relates to concepts of knot-working in the activity theory literature. We are also interested in sharing what is done online to broader communities of practice across organizations. Procedures will then require local adaptations to their situations of reception or anonymization. This will likely happen on longer time-scales and broader social scales.

The collaboration will center around the co-construction and consumption of procedures. This will take place **asynchronously**, with several collaborators specifying different aspects of the same shared procedure **across hours, days or weeks**. Procedures are then bound to **be updated or completed, months or even years after their initial creation**. Co-construction of these shared procedures will happen typically in a **remote** setting, between team members ranging **from two to hundreds of people** depending on the context.

Contribution to digital collaboration

Expected results and Impact

We expect to have a strong scientific impact by disseminating our results in top HCI venues such as ACM CHI (CORE A*), UIST (CORE A*) and DIS (CORE A) in which the project collaborators already have strong records. In the short and medium terms, our findings will have the potential to impact the development of interactive systems both in research and industry. First, with a theoretical contribution in the form of understanding how people currently collaborate for sharing skills and how collaborative interaction histories could be used in that context. Second, with artifact contributions, by providing specifications of what granularity of information software should provide to make collaborative interaction histories useful and exploitable, as well as novel user interface designs that can facilitate interaction with collaborative interaction histories. Third, empirical contributions by reporting experimental results of the novelly designed user interfaces and sharing collected datasets.

We believe that the potential impact of this project on the scientific field is high, and thanks to publications in highly visible HCI venues, we really hope that it will put under the spotlight the benefits collaborative interaction histories could bring to facilitate collaboration within teams and collectives.

Positioning in the eNSEMBLE program

This project is strongly aligned with WP2.4 of PC2 PILOT **Collaborative interaction histories** *:*

> *"**This WP investigates how collaborative interaction history**, i.e. the recording of the actions performed on a shared object and of its intermediate states, **could be distributed between collaborators and browsed on demand in order to learn how collaborators performed certain actions**. While professionals may work in the same domain and use similar tools, their skills and expertise with these tools may differ significantly, for instance knowledge of shortcuts or advanced features, efficient work habits. Thus, a significant opportunity of expertise transfer is lost among collaborators while working on collaborative projects. Software capacities should be created with the goal of better supporting the sharing of computing skills between collaborators"*

In the planning of PC2 - this WP is tackled in the fall of 2024, (see Gantt chart p20 of the PC2 work plan).

This relates also to the priority theme #1 for this year, **Emerging and future forms of long-term collaborative practices**. This proposal "*adopts a socio-technical perspective to discover, describe, analyze, and digitally support emerging and future forms of long-term collaborative practices*" as stated in the call. Understanding how to share digital skills requires anchoring in the domains in which those skills are relevant, understanding how they are evolving, how to describe procedures, and how to digitally support their sharing. While we are not tied to a specific domain, we plan to anchor the PhD in specific fields (explained above) close to the ones listed in the call : digital design teams (comparable to software engineering), hybrid and distance learning in informal settings.

Short description of hosting research group / lab

The candidate will join a vibrant and pluri-disciplinary group of young researchers, in the SICAL team of LIRIS (Université of Claude Bernard Lyon 1) in Lyon, and the Loki team (Inria Centre at University of Lille).

The SICAL team (**S**ituated **I**nteraction, **C**ollaboration, **A**daptation and **L**earning) has expertise at the intersection of HCI and Technology Enhanced Learning (TEL), with a strong focus on collaboration. Although in a computer science laboratory, two permanent members of SICAL have a background in Cognitive Science, another in Linguistics, half the team studies how ICT can shape learning in various contexts. PhD students have backgrounds in computer science, design, psychology, or cognitive science. The team is recognized internationally for its expertise, co-organized the Computer Supported Collaborative Learning conference in 2018.

The Loki team (techno**Lo**gy and **K**nowledge for **I**nteraction) focuses its research on producing original ideas, fundamental knowledge and practical tools to inspire, inform and support the design of HCIs. While mostly a computer science research group, they typically diversify their research by recruiting PhD students with diverse backgrounds, such as computer science, design, multimedia or user experience design. Their research outcome is published at the most established and competitive conferences at the highest international level (ACM CHI, UIST, TOCHI, DIS). The members of Loki are constantly active in professional service activities and serve on committees of the best conferences in HCI.