

# LEARNING BETWEEN PROJECTS: AN ACCOMPLISHMENT OF SOCIAL-MATERIAL PRACTICES IN PROJECTS

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The one-off nature of projects represents both a source for creating new knowledge and a barrier to continuously improving organisational routines. The temporary configuration of task-dependent resources appears to stimulate learning within projects but limits the dissemination of this learning between projects and the broader organisation. This paradoxical learning potential of projects has attracted much attention in the literature. However, learning from and between projects is still predominantly seen as the inflow and outflow of knowledge possessed by individuals or stored in databases or documents. Such a narrow view of project-based learning neglects the social-material complexity of project practices. In this paper, the argument is put forward that learning between projects is foremost an accomplishment of social-material practices in the context of projects. By adopting a practice theory lens and based on an illustrative case of railway viaduct construction, we will show how cross-project learning trajectories emerge from the social-material practices in projects.

Keywords: project-based learning; socio-materiality

## INTRODUCTION

The construction industry is witnessing a far-reaching transformation from transitioning towards a sustainable, circular, and digitalised economy. As a result, more than ever, construction organisations need to be able to adapt, change and innovate their business practices; or, put differently, they need to learn.

Since the construction industry has been blamed for its low productivity and innovativeness, its learning capability has gained much interest in the industry itself but also in academia. Here, structuring construction activities around projects is seen as the primary learning challenge (Hartmann and Doree, 2015). Although the idiosyncratic nature of projects with their demand-specific activation and configuration of resources creates a fertile ground for generating new knowledge, the intrinsic temporality of projects appears to discontinue learning processes beyond project fences. Compared to other industries where projects are organisational vehicles for separating explorative activities from main business processes, in construction, the main business processes are realised through projects. Project-based learning in the context of construction then does not primarily mean to convert new

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practices developed in projects into repetitive organisational routines but rather to develop and establish reproducible practices through a series of projects. Learning is something that spans projects rather than occurring from projects.

The learning challenge of project-based organisations has attracted much research over the years. For instance, the ARCOM conference 2022 included several contributions on the topic. All contributions implicitly or explicitly understand learning as a process of knowledge acquisition, creation, storage, and utilisation. On the epistemological ground of such understanding, knowledge is codifiable and transferable from projects to the organisation or other projects. The main locus of learning becomes the intersection of projects. The following expressions are paradigmatic for this: "[...] interdisciplinary teams make it possible to work closely together with one another and use the knowledge from others for the sake of the project" (Kamphuis *et al.*, 2022, p.137); "[...] social housing associations need to effectively coordinate the flow of knowledge in and about the inter-organizational collaboration with long-term partners" (Kamphuis *et al.*, 2022, p.92); "[...] the temporal nature of construction projects inherently results in newly acquired knowledge not being captured, transferred, and retained" (Boerkoel *et al.*, 2022, p.422).

The notion of knowledge as a commodity existing independent from the knowing subject is very prominent in the literature on learning in project-based organisations. However, such unilateral understanding reduces project-based learning to a context-independent knowledge transfer problem and the widely shared perception that the construction sector insufficiently learns from previous projects. Moving away from such an ontological view of knowledge to one that considers knowledge as a process of knowing and collective competence realised through the situated interplay of human and non-human actors (e.g., tools, technologies) in project work (Kokkonen and Alin, 2015) can shed a different light on the learning capability of the construction sector. Learning then does not hinge on knowledge as a transferable commodity between projects but emerges from and is embedded in the social-material context of project practices. It becomes a practical and collective accomplishment in projects with the aim "to discover what to do; when and how to do it, using specific routines and artefacts; and how to give, finally, a reasonable account of why it was done" (Gherardi *et al.*, 1998, p.274). Such a practice perspective does not deny the potential of translating practical knowing through reflexive activities into explicit knowledge that can be made accessible to others through documents, models, and other forms of transmittal artefacts. Reflexivity is even recognised as a mechanism for opening practical knowing to discourse and negotiation and enabling its change and institutionalisation (Gherardi and Nicolini, 2001). The practice perspective stresses, however, that any form of knowledge and knowing is enacted in a process of doing and the result of collective participation in project practice. Project-based learning then emerges in projects as social sites where knowing and doing are inseparable in the engagement of the social and the material, and knowledge of the social-material relationship constituting the project practice is constantly (re)produced. This knowledge gets inscribed in material characteristics and unconsciously internalised by individuals.

In this paper, we argue that project-based learning emerges from socio-material practices within projects that (re)produce the knowledge and knowing of the relationship between the social and the material of these practices across projects through which the practices endure, change, or are institutionalised. In the following,

we further elaborate on the understanding of learning as a socio-material practice of projects, followed by an illustrative case and some discussion and conclusions.

### **Project-Based Learning as Socio-Material Practice**

From a practice theoretical perspective, project-based learning is not a mere cognitive exercise of individuals but occurs through the participation of individuals in the collective processes of a project. Learning is always situated in the context of projects and the communities of these practices (e.g., project team) establishing them. Projects are the social sites where project team members interact with each other based on specific institutional rules, professional norms and language, assigned roles, and power relations. Knowing these rules, norms, language, roles, and relations is through enacting them in daily work. Project team members constantly (re)produce them and rather non-deliberately internalise their meanings and recognisable patterns in the long run, leading to habitual acting (Figueiredo *et al.*, 2021). Particularly in the project context, this emerging process of knowing is often challenged by virtue of the temporary nature of projects and their changing social constellations cutting through routine and habitual behaviour.

At the same time, project team members also engage with material artefacts in project work, including tangible objects such as construction machinery, tools, and building elements, and intangible entities such as digital models, software, and designs. By using these artefacts in their work, project team members experience the artefacts' features, working principles, and constraints. What can be done in project work by whom, and how the work should be structured is not least constituted by material resources. In project work, the social and the material are interwoven or imbricated, as Leonardi (2011) puts it. The imbrication metaphor implies that both entities can exist independently from each other and only come into relationships in the practice work of projects. Such an ontological view deviates from the understanding of socio-materiality formulated by Orlikowski (2007), who, based on the work of Barad (2003), argues that the social cannot be ontologically separated from the material. Both are entangled in the sense that there is "no social that is not material and no material that is not social" (Orlikowski, 2007, p.1437). Practices are constantly evolving and becoming, and so is learning. Knowledge is embedded in socio-material relations, and knowing is bound to the social and material and cannot be separated from practising (Gherardi and Miele, 2018).

We agree with the understanding of knowledge and knowing embedded in the socio-materiality of practices. However, we follow Leonardi's ontological understanding of the social and the material as independent entities. Material artefacts used in projects carry in their structural properties the knowledge and knowing of previous practices that enable or constrain project teams to do their current work in a particular manner. The structural properties of artefacts remain unchanged across contexts, but what artefacts do and which properties are activated depends on how they are used and how people perceive the possibilities of what they can do for them (Leonardi, 2013). This can also mean that they are used differently than intended, and their structural properties are modified. Learning occurs through this mutual constitution of the social and the material; the structural properties of artefacts afford or constrain the way they are used, while the way they are used can reconfigure or change their structural properties. With the notion that the social and the material are separate and come into a relationship in project practices, the temporal dimension of learning is put forward (Kringelum and Brix, 2020). The social and material imbrication in current

project work is preceded by socio-material relationships of previous practices, which endure in the structural properties of artefacts and the habitual acting of people.

With the previous, we have localised project-based learning in the social-material context of projects. However, the learning cannot be limited to the temporal boundaries of a project. Social and material structures precede and affect the becoming of social-material relationships in projects, and the practices in the projects elaborating these structures (Leonardi, 2011). Project-based learning, then, is a trajectory of socio-material practices of projects where the (re)production of the knowledge and knowing of the socio-materiality in one project predates and affects the (re)production in another project. Therefore, understanding the learning in a project needs to consider the social and material historicity of the project practice and how the structural elaborations in previous projects ripple through and affect the current practice.

### **Illustration**

In the following, we present a illustrative case to underpin our argumentation that the learning between projects is an accomplishment of social-material practices in projects constituting a learning trajectory.

Our case comprises the practice of designing and constructing a railway viaduct with a focus on two activities. Both activities are one of the most reoccurring in construction practices: pouring concrete and providing auxiliary construction. Although these activities appear very routine and repetitive, their social and material imbrication can differ between project contexts and lead to the emergence of learning.

In our case, the context is the design and construction of railway viaducts by a contractor for the railway agency in the Netherlands. Based on the availability requirement of the agency, the contractor first renewed the deck of the viaduct temporarily supported by an auxiliary construction called the sand pot (Figure 1). The sand pot consists of two steel plates, two steel strips, and two steel cams filled with sand. The size is 290 cm wide, and the length depends on the width of the rail deck, which rests on the sand pot. After the walls and floor of the underpass have been created, the sandbox can be removed. This is achieved by high-pressure jetting of the sand under the steel plate; the steel support plate falls on the steel cams. Then the permanent viaduct walls were constructed under the deck by placing a formwork that was filled with concrete (Figure 2). Here, we adopt a broader understanding of the two activities than only their actual realisation. We consider the preparation and design as part of the activities.

Our retrospective analysis covers four projects stretching over five years. Data was collected through interviews with staff members of the contractor involved in the four projects. These included two design managers, two design engineers, two project managers, and one construction manager. It should be noted that the original aim of the research was to gain a deeper understanding of technology development processes. However, while analysing our data, we recognised the role of technologies or materials in the development process and the interaction with project actors. We, thus, revisited our data from a learning perspective focusing on the socio-material relationship in the learning process. We were specifically interested in how different material artefacts were used in the projects, how they constrain or afford activities, how actors relate to each other while using or modifying artefacts, and how activities in previous projects affect socio-material configuration in current projects.

## Project 1

Project 1 was not the first construction of a railway viaduct with similar requirements. In a previous project, both activities were already applied.

In Project 1, the calculation and implementation methods for the sand pot were further developed based on the previous project. Design engineer B and construction manager A discussed the points for improvement together with design engineer A who was responsible for the engineering in the previous project. This link was made by design manager A, who had confidence in the principle of the sand pot. The development focused on the settlements, tolerances, and construction method. Design engineer B continued with the calculations of design engineer A and elaborated on these more clearly. This resulted in a more detailed description of how the geometry of the sand pot needed to be determined. This calculation was internally checked by design engineer A. The assembly method was also further developed by exploiting the experiences of the previous project. Construction manager A was responsible for the assembly during the possession. Via design manager A, construction manager A contacted the previous construction manager. His predecessor indicated that the performed assembly method was much work due to the multiple small elements. Therefore, construction manager A prepared a method to simplify the construction during the hectic period of possession. As a result, the sand pot was assembled with just one underlay plate (around 18 meters) instead of single elements of 3 meters. Eventually, this method performed well.

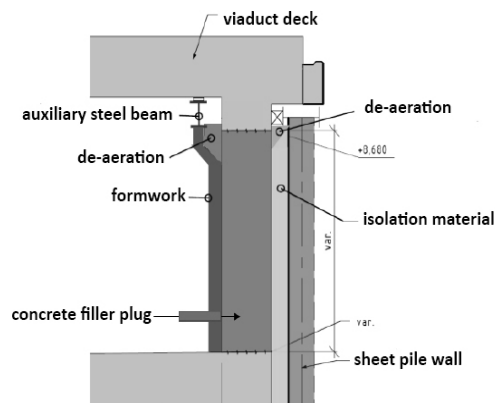


Figure 1: Principle of sand pot concrete

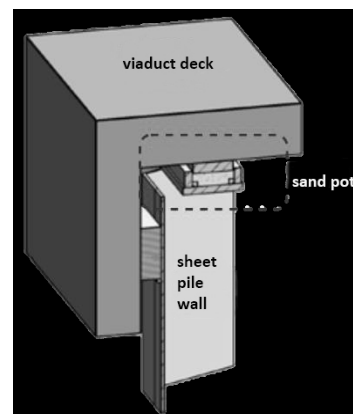


Figure 2: Principle of pouring under a viaduct deck

Construction manager A was also responsible for emptying the sand pot after completing the walls and floor. The sand pot is filled with sand, which needs to be removed to take the sand pot out of operation. To catch the cover plate during the removal of the sand, studs were welded in the corner of the construction in the previous project. Construction manager A tried to reduce the costs for this construction and replaced the welded studs with wooden laths. Eventually, the wooden laths did not work correctly. They started to float while removing the sand with water, obstructing the water flow.

For pouring the entire wall under the railway deck, self-compacting concrete (SCC) was used since SCC was regarded as an appropriate mixture to guarantee a completely filled and compacted concrete wall. However, the final wall showed many cracks and was not watertight as required. The construction manager responsible for Project 1 was aware of the outcomes of the previous project. While preparing for the new project, he contacted the previous construction manager to exchange details of the

work method and experiences. As a result, the work method was modified. Only a small part around the joint between the deck and wall was filled with SCC, and extra reinforcement was applied to mitigate the risk of cracks around this critical part. Because the work method needed to be assessed by the client, an engineering report was drafted by design engineer B. Eventually, this work method resulted again in cracks and leaks in the wall and a laborious rework through injections.

## **Project 2**

In Project 2, design manager A continued with the engineering method. Design engineer C was responsible for the engineering, and design engineer B shared the engineering report of Project 1. The developed engineering method, explained in the previous engineering report, was followed by using project-specific inputs (e.g., the forces). Design engineer A conducted an internal control of the final engineering report. Construction manager A was again responsible for the assembly of the sand pot. The assembly method was prepared and implemented with inexperienced project coordinator B. The method consisted of a fully preinstalled construction (i.e., installation of the underlay plate filled with sand and cover plates) and the placement of the construction during the possession. The pre-installation required the integration of a crane company during preparation and construction. A work plan for the possession was developed that includes the ‘lifting plan’. Construction manager A was again responsible for emptying the sand pot and returning to the welded studs.

In Project 2, project coordinator A was responsible for preparing the work method for constructing the walls underneath the railway deck. He was aware of the previous problems: “If we start doing it the same way, then you can inject for 30,000 euros. Thus, you can invest quite a bit in a more expensive mixture, expensive facilities.” Therefore, together with the subcontractors, he worked on a method to prevent any cracks and leaks in the walls. This included the material engineer of the concrete plant and the formwork supplier. In cooperation with the material engineer of the concrete plant, a low-vibration mixture was developed. This mixture had the same flow features as SCC but with fewer fine additives and plasticisers. These adjustments mitigated the heat development, which reduced the risk of cracks and leaks. Furthermore, together with the formwork supplier, the formwork was adapted to allow the pouring the concrete mixture from the bottom. Eventually, this resulted in a crack-free wall.

## **Project 3**

Design manager A based the engineering of the sand pot again on the experiences from the previous projects. The previous engineering reports were transferred to the new design engineer, and the engineering was wholly adopted. This complete adoption was justified by the smaller forces on the sand pot compared to the previous projects. However, the geometry of the sand pot was adjusted due to different soil characteristics. The responsible construction manager in Project 3 could not build upon earlier experiences for the construction assembly. The experiences from the previous projects were provided by a presentation given by design manager A and through collaboration with the crane company. This method was again retained in the integral work plan, and the construction was executed within the possession.

In Project 3, the concrete walls were poured approximately two months after the construction of the walls in Project 2. A different work method was developed, although some aspects were adopted from Project 2. The construction manager from Project 1 could bring in his experiences, and with project coordinator B the work

method was developed. Project coordinator A was shortly involved during the design phase to share the work method of Project 2 with the project team. However, for Project 3, a pouring method from above was chosen since the main requirement was fair-faced concrete. This requirement was not present in Project 2. In collaboration with a concrete plant different from the one in Project 2, a concrete mixture like the one used in Project 2 was developed. Similar to Project 2, the design team was not involved because the design of the railway was already in a detailed stadium. Eventually, the developed mixture performed as an SCC, resulting in cracks and leaks in the wall. Furthermore, during the filling of the walls, the hose got stuck, resulting in a not completely filled wall.

#### **Project 4**

Project 4 will be the subsequent application of the sand pot. Although not yet prepared, it was indicated that the same approach would be followed as in the previous projects. Experiences from these projects were already integrated into the project through the involvement of design manager B and project coordinator B.

For Project 4, the work method for the walls was still under development during data collection. Through the continuation of project coordinator A, the experiences of Project 2 contributed to this project. This included the early involvement of project coordinator A in the design phase. Together with design manager A, the work method was further developed. As the design manager pointed out: "If I had not had project coordinator A, I wouldn't have thought of it [the facilities in the deck]". The work method contains two adjustments to the overall design: (1) the wall attachment is inclined outwards by two degrees so that air can escape to the backside; (2) these wall attachments are equipped with ventilation facilities. These facilities enable pouring the concrete with a surplus height and allow air movement during pouring. A similar concrete mixture used in Project 2 was developed with a new concrete plant.

## **CONCLUSIONS**

By changing the ontological perspective on project-based learning and mobilising a practice theoretical conceptualisation of learning, we developed our central argument that learning between projects is a socio-material accomplishment in projects constituting learning trajectories. The practice of constructing a railway viaduct served us as a case to support our argumentation. Of course, the case has only exemplary character since its methodological approach does not conform to the epistemological standards of practice studies. Notably, the cross-sectional data collection based on interviews cannot fully grasp the emergence of practices as a multifaceted and multidimensional phenomenon (Nicolini, 2012). In this regard, the purpose of this paper is rather modest. Its aim is, first and foremost, to endorse an alternative theoretical avenue for understanding project-based learning. Although practice theory has already found its way into construction management research in general and learning in and from projects in particular (Kokkonen and Alin, 2015), the cognitive approach to learning still dominates. One may argue that this dominance rests on the explanatory power of the approach. We cannot compare the knowledge gain from different theoretical schools and traditions here. What we can do is show that the practice theory lens can offer unique contributions to our understanding of project-based learning. While the cognitive approach boils down the learning between projects to the transfer of knowledge from one project to another, practice theory shifts the learning focus to the enactment of knowledge in the context of ongoing projects. The presented case indicates that project-based learning is not just

happening through knowledge transfer at the intersection of projects but instead emerges as an inherent part of socio-material practices in projects. From a cognitive learning perspective, one may argue that the contractor could not transfer lessons learned between the projects since similar deficits reoccurred (e.g., cracked wall). Given the multiple transfer mechanisms in place, this argument becomes weak. Project members participated in several projects bringing in their experiences gained in previous projects. Technical reports documented the engineering and implementation of work methods and were consulted on subsequent projects. Our argument here is that the reoccurrence of deficits is not signalling the inability of a contractor to learn but expresses the situated constitution or emergence of learning from socio-material practices in projects.

The emergence of project-based learning includes both synchronic and diachronic emergence (Elder-Vass, 2010). Synchronic emergence refers to the relationship between a whole (here, the practice of designing and constructing a viaduct) and its parts (here, the social and the material in pouring concrete and providing auxiliary construction) at a specific point in time. Through the interaction of different project actors, their individual experiences with the sand pot and the pouring of concrete were enacted to construct the viaduct walls and understand the construction's performance outcomes. The modified working methods express the developed collective understanding that is more than individual experiences. The situated interaction in the projects was based on the different actors' assigned roles that shaped how they built relationships with each other—for example, driven by his belief in the sand pot design manager A brought construction manager A and design engineer B in contact with design engineer A who initially develop the method. This position of design engineer A was even institutionalised through his responsibility for absolute control in subsequent projects and created social agency in the sense that there was a collective belief in the technology.

In the same manner, the interaction of the material elements of the sand pot and the concrete formwork constituted the structural properties of the overall construction, including load-bearing capacity, flushing capacity, form stability, and tightness. Changing these reconfiguration of material elements resulted in altered properties. For example, combining a concrete mixture with fewer fine additives and plasticisers with an adjusted formwork construction led to a crack-free wall. Here, the structural properties of the material used remained essentially the same across projects; mainly, the usage and structural configuration of the material changed. In Project 1, the SCC was only used for a small part of the construction compared to the complete filling of the formwork in the previous project. The concrete properties were then modified in Project 2, resulting from the unsatisfactory outcome of Project 1. However, the deviation of the concrete behaviour from the expectations also signals a limited control of what material can afford. The affordance of materials became manifest in unexpected performance outcomes. Replacing the welded sluts in the sand pot with wooden laths resulted in water blockage while removing the sand. Learning in the projects also emerges from materials that responded differently than expected. The affordance of materials operates in a particular range through which materials can possess agency and elude their control in specific contexts and applications (Leonardi, 2013). For the sand pot this meant that construction manager A returned to the welded sluts to ensure the flushing capacity of the sand pot.

These examples also indicate the imbrication of the social and material in the learning. The aim of reducing costs was the reason for replacing the welded sluts with wooden

laths. Developing the method for pouring concrete required modifications to the concrete mixture, the formwork, and the deck design realised through the collaboration between the construction manager, design engineer, material engineer, and formwork supplier. The interactive process brought up collective competence embedded in the socio-material relationships. The switch to another concrete plant shows how unique and critical this socio-material constellation is for the practice. Likewise, the engineering reports drafted in each project were used in subsequent projects and, as such, formed the interaction between design engineers and construction managers while situationally adapting the engineering. They inscribed the project-based interactions and relationships of actors stretching across projects. The socio-material imbrication within projects (re)produce the knowledge and knowing of the relationship between the social and the material of these practices across projects

The latter points to the diachronic emergence of learning which emphasises the historicity of the practice and its development over time. Both activities, the sand pot and the pouring of concrete, developed over a series of projects as the result of engaging with the outcomes of previous projects. The learning in one project was predated and affected by the socio-material relationships in another project. The learning in the projects constituted a learning trajectory across projects. This trajectory is characterised by the continued reconfiguration of the social and the material in projects through which learning emerges from the tension between what project actors intend to achieve and what material artefacts can do in the specific context of a project. This emergence of project-based learning through the situational imbrication of the social and the material in projects has a main implication for our understanding of learning in and between projects. Learning is inherent to project practices since their socio-material complexity will always require social and material reconfigurations while project actors engage with each other and their numerous artefacts. Or put differently, something like best practices are illusive. This does not mean that project activities are not repetitive. It only stresses the dynamic nature of project practices, constantly balancing social and material requirements. The reproducibility of activities then becomes a matter of the extent to which the situated socio-material imbrication in a project practice resembles previous socio-material relationships.

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