4 | Development of engineering students' adaptive performance using agile methods: The case of Drees & Sommer SE

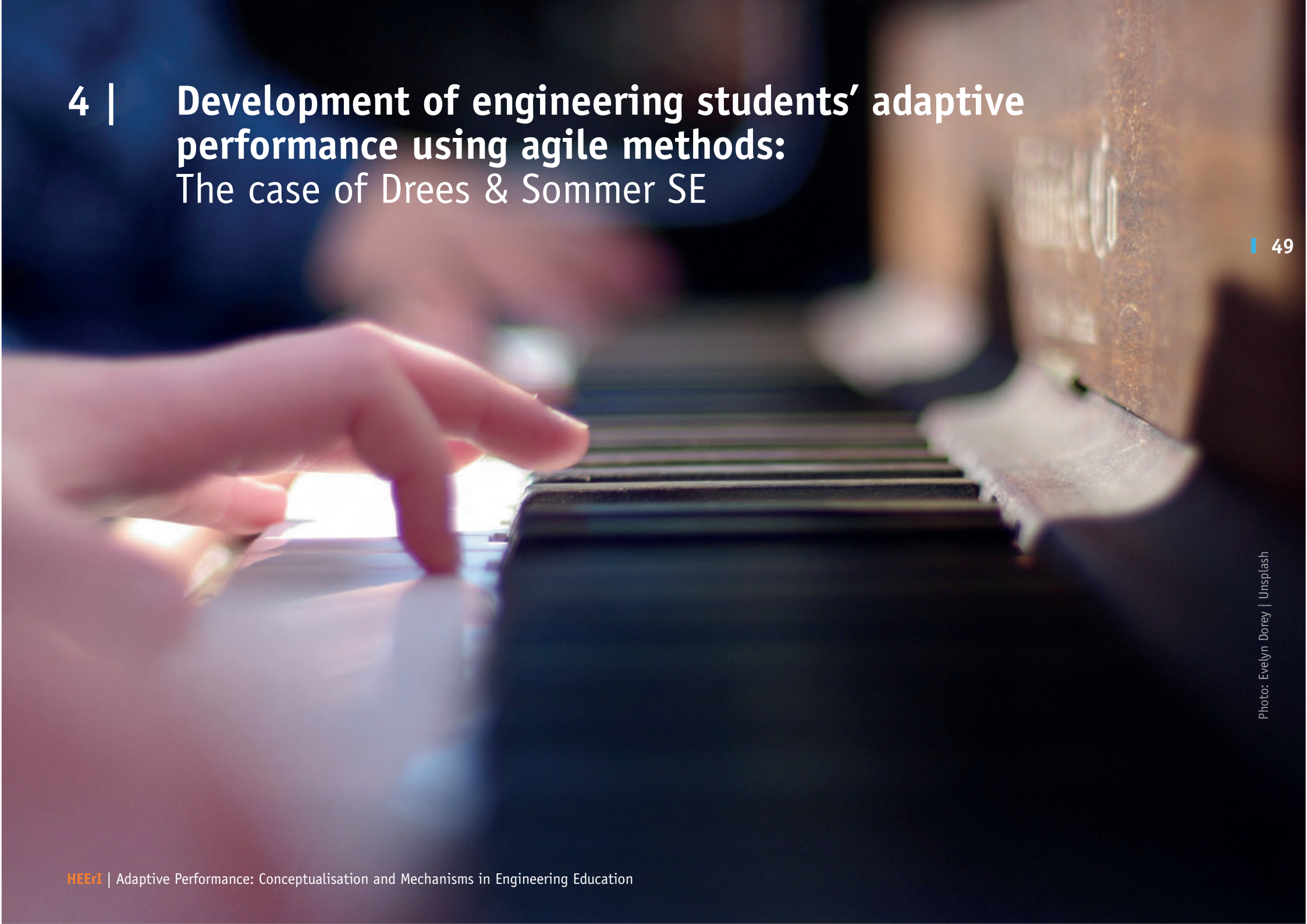

Photo: Evelyn Dorey | Unsplash

4 | Development of engineering students' adaptive performance using agile methods: The case of Drees & Sommer SE

G.A. Kaffka [1], J.O. Backhaus [2]

ABSTRACT

Agile methods contribute to flexible, iterative project management in large building construction projects. In this chapter, we examine the role of agile methods in workplace learning in developing engineering students' adaptive performance. To do so, we focus on studying the micro-level, cognitive processes by which agile methods enable engineering students' adaptive performance development.

Analysis of an internship programme using agile methods – by means of lean project management - at a large German construction firm shows that agile methods function to develop adaptive performance by means of two mechanisms. One, such methods train students' ability for perspective-taking. Second, they develop students' metacognitive skills. Both are relevant for adaptive performance.

We discuss our findings and address practical implications as well as some limitations of using agile methods in higher education.

1 Department of Strategy and Entrepreneurship, Tilburg School of Economics and Management, Tilburg University, The Netherlands

2 Drees & Sommer SE, Germany

Corresponding author:
G.A. Kaffka, g.a.kaffka@tilburguniversity.edu

https://doi.org/10.59490/mt.246.33

KEYWORDS AGILE METHODS, WORKPLACE LEARNING, PROJECT MANAGEMENT, METACOGNITION

Introduction

Adaptivity enables professionals to tackle non-routine, complex problems in the workplace (Inagaki & Miyake, 2007). Their adaptive performance reflects the ability to adjust cognitive, emotional, motivational, and behavioural responses to shifting task demands or unfamiliar situations (Baard et al., 2014). This capacity manifests in their advanced problem-solving, social, and intercultural skills (Oprins et al., 2018; Pelgrim et al., 2022).

Adaptive performance is highly valued by employers (Hawse & Wood, 2018). Given that adaptive skills rank among the most important qualities sought in graduates (Arce et al., 2022; Nandini, Gustomo, & Sushandoyo, 2022), fostering adaptive performance in higher education has become increasingly important (Kua et al., 2021). This is also the case in the field of engineering education (Hicks et al., 2014).

A study among 71 agile teams showed that agile contributes to team adaptive performance (Steegh, Van de Voorde, Paauwe & Peeters, 2025). Agile methods relate to communication, stakeholder involvement, and adaptivity of professionals (Owen et al., 2006; Ribeiro & Fernandes, 2010). Arce et al. (2022) showed an improvement in engineering students' grades, their complex problem-solving skills, and their own satisfaction with the learning process after learning the use of agile methods. As complex problem-solving skills are characteristic of adaptivity in professionals, these findings indicate that agile methods benefit the development of students' skills relevant for adaptive performance. Similarly, Longmuß & Höhne (2017) found positive results of using agile methods in the workplace learning of students.

Meanwhile, we know little about the micro-level mechanisms by which agile methods used during workplace learning facilitate the development of adaptive performance among students. The objective of this chapter is the identification of mechanisms by which agile methods enable engineering students' adaptive performance development. In this chapter, we seek to answer the following research question: *How does the use of agile methods during workplace learning contribute to the development of adaptive performance among engineering students?* To do so, we examine an internship programme at a large German construction consultancy company which trains students in agile project management (APM).

First, this chapter introduces relevant theory on adaptive performance, its development, and assessment in higher education. Then we describe the concept of agile and how agile methods are used in the workplace. Next, we present the Context, Intervention, Mechanism, and Outcome (CIMO) framework. This framework is used for the analysis of students' use of agile methods in the workplace and how this contributes to the

development of students' adaptive performance. The analysis shows that there are two mechanisms by which agile methods contribute to developing engineering students' adaptive performance. For one, agile methods provide students with exercise in perspective-taking. Second, agile methods train important metacognitive skills. We then discuss theoretical and practical implications of our findings, address limitations of using agile methods in higher education, and make suggestions for future research on this topic. The chapter ends with a short conclusion.

Adaptive performance

Adaptivity enables professionals to handle stress, have superior social skills, and innovative, creative problem-solving skills (Pulakos et al., 2000; Fisher, 2001; Oprins et al., 2018). Adaptive employees are highly sought-after in the contemporary economy (Baard et al., 2014). Small, Shacklock and Marchant (2018) explicitly mentioned the trait of adaptability in their definition of higher education graduates' employability. Adaptive performance of professionals stems from their conceptual knowledge, which goes beyond declarative knowledge (knowing 'what') or procedural knowledge (knowing 'how to').

Declarative and procedural knowledge enable routine expert performance and is based on years of practice in domain-relevant tasks. Conceptual knowledge allows professionals to know 'why' and when to transfer existing knowledge and skills to achieve their task under conditions of uncertainty or novelty (Pelgrim et al., 2022).

Scholars have argued that it is important to develop conceptual knowledge among engineering students - alongside their declarative and procedural knowledge - to build students' adaptive performance (Hicks, Bumbaco, & Douglas, 2014).

Developing adaptive performance in higher education

Education aimed at developing students' conceptual knowledge, i.e. adaptive performance, should emphasise understanding rather than performance, by providing ample opportunity to make inquiries or asking questions, to struggle, risk-taking and failure – all of which in a safe learning environment (Kua et al., 2021). Such education provides opportunities for meaningful variation around conceptual or procedural knowledge (Bransford & Schwarz, 1999; Myopolous et al., 2018).

Generally, students can train adaptive performance with active learning activities that help to develop their learning orientation (Bransford & Schwarz, 1999). Curriculum design which stimulates the development of adaptive performance in higher education includes variability of practice, interdisciplinarity, open learning tasks, use of simulation and cases, and self-directed task selection (Bohle Carbonell & Dailey-Hebert, 2014; Bohle Carbonell & Van Merriënboer, 2020; Van der Schaaf, Schuurmans, Van Tartwijk, 2020).

Teachers can build adaptive performance among students with case-based learning (Ward et al., 2020), by encouraging students to use questions, and by students' engagement in feedback (Charbonnier-Voirin & Roussel,

2012). An orientation towards such feedback-seeking activities is also reflected in the agile method.

Agile methods

The use of agile methods in higher education has increased, notably also in engineering sciences (Neumann & Baumann, 2021). Agile methods are plan-based rather than planning-driven (Malik et al., 2021) because they emphasise iterative and flexible planning but also highly structured project communication. In other words, agile emphasises the importance of planning, but it allows for divergence and adaptation of the course set out, hence stressing the role of flexibility in task performance of professionals (Demir 2019).

Agile project management relates to flexibility in proactive adaptation to dynamic project environments (Sanchez & Nagi, 2001). The Agile Manifesto published in 2001 presents the core ideas of agile methods[1]. This manifesto contains essential principles which emphasise individuals and interactions (instead of lengthy documentation and reports), pragmatism ('what works'), customer collaboration, and being responsive to change (Abbas, Gravel & Wills, 2008).

Abbas, Greve & Wills (2008) described agile project management as adaptive, iterative, incremental, and people-oriented, emphasizing its communicative and collaborative nature. Agile is used as a method for the *"iterative and incremental development [of] short cycle project outcomes"*, a process which requires both *"communication within the agile team and with the stakeholders"* (Malik, Sawar & Orr, 2021: 12).

Agile requires feedback engagement in task achievement, by means of communication with customers and stakeholders, but also within the team. To achieve this, Williams & Cockburn (2003) suggested that agile methods *"necessitate short "inspect-and-adapt" cycles and frequent, short feedback loops"* which help to better handle an *"industry's conflicting and unpredictable demands"*, enabling teams' complex problem-solving (Malik et al., 2021: 12).

Notably, agile encourages team reflection, i.e. teams should pose the question of what can be done better in the future and act upon/implement accordingly (Malik, Sawar & Orr, 2021; Demir 2019). This implies that using agile methods requires the exercise of professionals' metacognitive skills related to the ability to critically monitor and evaluate stakeholders' feedback as well as gauge and possibly plan for ensuing reiterations in project planning.

Research points to the benefits of agile methods for students' learning in software engineering and other engineering disciplines (Arce et al., 2022). This might be explained by the fact that agile methods provide an instrument to deal with complexity and uncertainty.

1 https://agilemanifesto.org

This is particularly relevant in real-life practice of skills. Namely, in the context of workplace learning.

Workplace learning: Using agile for (developing) adaptive performance

Longmuß & Höhne (2017) studied how agile methods facilitated workplace learning of students and found *"very encouraging results" […] "The agile learning approach provides a focused and work-embedded learning context as opposed to traditional training courses. This allows for a tailor-made competence development that is aimed at specific future work requirements within company lines."* (pp. 266-267) Similarly, Zehr & Korte proposed that an *"important outcome of workplace learning is learning that work encompasses not only disciplinary knowledge but also adapting to ambiguity, uncertainty, complexity and social working relationships"* (Zehr & Korte, 2020). The adaptivity mentioned here links workplace learning and adaptive performance.

To clarify the role of agile in the development of students' adaptive performance, in this chapter, we examine an exemplary case of workplace learning in which engineering students use agile methods.

Analysis: The Example of Drees & Sommer SE

In this section, we examine an example of workplace learning at Drees & Sommer SE in which students acquire and apply agile project management skills. To show how agile methods enable exercise of adaptive performance during workplace learning, we draw on the Context, Intervention, Mechanism and Outcomes (CIMO) framework. We first describe the *context* focusing particularly on the learning environment. Then we address the *intervention* of the workplace-learning internship programme (its characteristics), followed by an examination of *its mechanisms and outcomes* in terms of their contribution to building students' adaptive performance. The data was collected by means of participant observation, secondary data (internal evaluations), and five interviews carried out with the project leader about this workplace learning programme.

Context

Drees & Sommer SE (Dreso) is an international consultancy company for consulting, planning, building and operating in the construction sector. In 2022, the company had more than 5100 employees at 59 international locations, made an operating result of more than 84 million, and almost two-thirds of a billion in sales[2]. Dreso has emerged from mergers and acquisitions of various smaller companies. As a result of the different company cultures Dreso brings together, Dreso seeks to standardise its work processes, but also to internationalise its business. To achieve these structural changes, Dreso has adopted agile methods in its business processes.

2 Drees & Sommer, Annual Report. Turn-over as sales. See for full report: https://cdn.dreso.com/fileadmin/media/06_Presse/Media_Center/Jahresberichte/JB_2022_01_162_en_final.pdf

Dreso considers communication skills to be crucial in construction work, e.g., for negotiation of contracts, customer acquisition, and provision of services in projects. The latter is key to avoiding miscommunication with the customer or contractors regarding the project process and outcome. Agile (project) management has proven successful in increasing customer satisfaction and decreasing time and cost to market under uncertain conditions (Ribeiro & Fernandes, 2010).

The learning environment of workplace learning analysed in this study includes large engineering projects. A large engineering project at Dreso can include over 60 contractors with their counterparts. In these projects, Dreso uses the Lean Construction Methodology (see VDI2553 or Dreso-Website), favouring synchronous communication to avoid inefficiency (misunderstandings or confusion) in the acquisition and transfer of project-related information. Lean refers to process optimalisation aimed at increasing customer value and delivery efficiency. In this case, it constitutes an example of agile work as it is aimed at flexibility and quick adaptation in project management and execution, where required.

In the exemplary case examined here, the project deals with the construction of a major railway hub with a planned construction volume of more than 540 million euros and a planned construction time of roughly 6 years. During this period, a railway station with several tracks, a connection to local public transport and the associated auxiliary structures (such as bridges, electronical interlockings, drainage structures, pedestrian subways, etc.) was built. The estimated number of passengers who are to benefit from the success of the project is about 130,000 passengers per day.

The lean construction managers on-site rely on students' tasks of obtaining, sharing, and aggregating information about the progress of the project(parts). By training students in agile project management, Dreso aims for the successful execution of large and complex construction projects, while avoiding extra work due to poorly executed project management, causing costly delays.

Students are charged with collecting and aggregating information during meetings with the stakeholders. During these meetings, information about the project (progress) is transferred and acquired, aimed at unearthing complexities which might arise, for example, from one contracted stakeholder's delay. To avoid such delays, interdependencies of time-lines must be understood by the student (teams), the building owner, its representatives, and all contractors, and continuously re-iterated.

Intervention

Students participated in the internship programme as part of a six-month full-time internship at Dreso. Other participants have temporary contracts for 16 to 20 hours a week at Dreso for varying lengths of time (some students for more than two years during their study). Both groups are informally referred to as 'interns'. Most students participating in this internship programme have an academic background in civil engineering or urban planning, some participants come from the field of industrial engineering.

At regular intervals, batches of six to eight interns start working on the examined project, with about eight students participating simultaneously at any given time. 12 students per year are involved in this programme. At the time of this study, six students from higher education engineering programmes participated in this form of workplace learning.

Students' workplace learning and agile methods-based tasks

Whether students are working in teams or only with stakeholders strongly depends on the required tasks. For example, there are tasks associated with the organisation of workshops which involve engagement with non-Dreso stakeholders. Meanwhile, the development of visuals is Dreso internal and requires collaboration only with company-internal stakeholders.

Students are expected to deal with a variety of tasks during projects. The following (non-exhaustive) list contains agile methods-based tasks which students carry out during workplace learning at Dreso:

- Development and continuous updating of visuals for the Obeya room – a collaborative workspace commonly used in lean construction projects – on the construction site, e.g., a project calendar, a visual showing the important locations on the over 3 km long construction site, and developing communication rules;
- Improvement of the project management handbook, e.g., pages explaining project specific terms and abbreviations, standardised processes such as the onboarding or the documentation process after meetings, workarounds for known software bugs;
- Development of a complex Excel sheets including VBA programming, e.g.,
  - to support the building managers and the construction companies for their reporting, and
  - to ease the invitation management for the many meetings of the project;
- Organisation of workshops. This includes the invitation management, preparation of visuals for the workshops, the follow-up documentation, supporting the moderator during the workshop, preparing the room before the workshop (so everything except doing the talking during the workshop);
- Conducting the daily standup-meetings with the construction managers and representatives of the construction companies;
- Conducting task-list meeting during which representatives of the owner are being asked to give feedback to their tasks and escalate problems if necessary.
- Improvement of the methodology according to which the daily standup-meetings are being moderated and the software tools are being used;
- Advising on internal and external process optimisation, including the visualisation and presentation of the improved processes. Once accepted by the team, the improvement for the process is being documented in the project management handbook, e.g. for conducting daily meetings or the process on how to survey and analyse Key Performance Indicators (KPI's);
- Collecting, evaluating and visualising KPIs.

The construction project is structured around regular project team meetings (from the onset throughout the project), in the setting of so-called brown paper workshops, preferably with key stakeholders being brought together in the same physical space (Backhaus, 2022; Backhaus & Dahm, 2022).

During brown paper workshops, students observe and engage with the process of the project team's joint development of the execution planning. Representatives of each trade are involved in the construction project (e.g. steel construction, earthworks, 50Hz electricians or experts for electronic interlocking) and are asked to write their processes on coloured post-its. Then the post-its are glued on the brown paper in the order of their execution to identify interdependencies (and potential issues in delays).

The brown paper workshops are preparation- and follow-up intensive endeavours. The same accounts for the regular and frequent (daily) meetings, the dailies or stand-up meetings, during which the construction planning is kept up-to-date. Materials for the brown paper and other workshops must be brought to the place of the workshop. Information which is already available must be visualised before the workshop (for instance, available schedules and known tasks can be plotted on the brown paper already written on the post-its to save time during the workshop, plans of the construction site should be plotted and brought to the workshop). Long workshops (duration of more than three hours) require a catering concept (cookies for sugar and coffee for caffeine; full meals if the workshop exceeds the duration of four hours).

During regular Dreso internal stand-up meetings, students self-organise in teams of two to six students. These teams usually last up to twee weeks, until the team members have achieved the task which they had set out for. The student teams pick their task from a task pool written on an online whiteboard. The Dreso project consultant or Dreso project team member can add tasks to the task pool, simply by writing them on the digital whiteboard. Students then pull tasks from this task pool and self-organise those tasks among themselves. During their regular stand-up meetings, students can signal issues to the project consultant which they encountered the preceding week or ask the project consultant for help with tasks.

Resources are provided to the students in the form of opportunities for reflection. The project used as example here has a weekly team meeting. During this meeting, tasks are distributed and followed up using a Kanban board, the duty roster is being completed, the personal well-being of the team is being surveyed anonymously, and support is offered afterwards, e.g., in the form of a one-on-one meeting if a team member desires guidance. Parts of this team meeting (the duty roster) are moderated by team members. One student is responsible for the organisation and improvement of the meeting (which is held online), e.g., the meeting working materials, such as visualisations used for the online whiteboard.

Every four months the project team organises a workshop around the lessons learned during the previous period. This workshop is aimed at internal process optimisation and is mandatory for all team members, i.e. mostly students. During the workshop all project team members, including

students, are asked to give feedback on internal project processes and to make suggestions for improvements. The lessons learned workshop is prepared and moderated by one of the students. During the preparatory process, the project manager offers guidance for the preparation process and during the lessons learned itself to ensure a smooth, timely and productive lessons learned workshop. During the workshop, specific improvement measures are identified and those responsible for their implementation are appointed. If the implementation of an improvement takes more than one person, the appointed responsible automatically becomes the leader of that group. After the workshop, the student who had organised the workshop has a one-on-one meeting with the project leader. During this mandatory meeting, the project leader or coach gives feedback on the students' moderating and presenting skills.

Guiding and supervision of students at Dreso

Internships at Dreso (but also all regular employment) start with a Welcome Day. In the example case, the construction project employs internship students from the area of northern Germany. The Welcome Day consists of a one-day programme during which students learn the mission, vision, and strategy of Dreso; they then get their IT equipment and learn the basic administration software and associated rules.

During the Welcome Day, the department managers from Dreso in the area are present and give a short introduction of their department to all participants. During this day, students are explicitly encouraged to network with their new colleagues – which includes both students and full-time professionals of all career levels. Furthermore, all students receive safety training, i.e. appropriate behaviour in the case of a fire.

In addition, Dreso offers a formal eight-hour training programme - the "Lean Practitioners Training" - through its own training body, the Drees and Sommer Academy. While all Dreso employees are required to partake in the training to become Lean Practitioners, the programme is mandatory for the students in the project under review. It trains the participants in lean and agile methods and prepares them to take on tasks as moderators in lean and agile workshops. To improve learning, half of the time is spent on a simulation of a typical lean and agile project. During the simulation, students take the role of contractor, owner or lean coach to build a typical structure from past Dreso projects and acquire hands-on experience in lean and agile methods.

To provide guidance and support to students in their task achievement as well as personal development, the company has designed and tests agile goals-management frameworks. These frameworks support students in the identification and formulation of personal objectives as well as key results (OKR) (Doerr, 2018; Taipel & Alberti, 2019). At the surveyed project team, such an OKR-framework is currently in the test phase.

The lean consultant also offers students business coaching. During a coaching session, the project manager explains the company goals and the resulting project goals, followed by a brainstorming session in which students offer ideas for "OKR Objectives" to support project goals as

well as key results to make the objectives measurable. An example of an objective is 'We have improved the internal coordination of the team', and an example of a key result is 'We have developed a visual overview for the weekly team meeting that shows who is responsible for which meeting, and what must be considered (e.g. online, offline, stand-in required, preparation required, etc.)'. The formulation of objectives and results also includes students' personal goals and objectives.

During quarterly OKR workshops, the student team and supervisors discuss the progress towards goals and results. During these 'lessons learned' sessions, the team also reflects on its over- as well as underachievement of tasks that had been in the goal pool. This reflective exercise per team aims at improving individual and team-based goal-achievement and -development for the following quarter.

Once a month, the company reserves an afternoon for training purposes of students. The topics vary. Examples are software trainings, e.g. cost control such as CORR (https://www.coor.info), Lean collaboration tools, such as LCMDigital (https://www.lcmd.io), and method trainings such as Lean Construction Management or Project Management trainings. These trainings are held online, connect students from all German-speaking subsidiaries of Dreso, and are often followed by a voluntary networking session in the evening.

Dreso holds additional student-specific networking events at irregular intervals. The nature of the networking event is instructional as well as social. Often the events take the form an afternoon workshop followed by a networking dinner. These events are area-specific events, either for one of the subsidiaries.

Mechanisms

Dalkin et al., (2015) proposed to study mechanism in terms of two constituent parts, namely 1) the resources offered by an intervention and 2) the ways in which this changes the reasoning (or response) of its participants. Following Dalkin et al. (2015)'s distinction, we describe both constituents of the mechanism in this section. Resource mechanism refers to the way in which Dreso provides students with practice in agile methods. Reasoning (or response) mechanism describes the way in which the resources are presumed to affect a change in students, i.e. towards the development of adaptive performance.

Resources

In terms of resources, in workshops and other meetings students learn about agile project management methods by means of applying them. From the first day onwards, students are required to interact with each other (in student teams in which students work together on more complex tasks that require various students), with their project manager, as well as other stakeholders, in sharing and aggregating information.

Students' participation in brown paper workshops provide them with practical exercise in team and stakeholder management. For one, the student team must organise itself, identifying a relevant task and how to

fulfil it. To achieve this, teams moderate up to three parallel meetings with customers and relevant stakeholders daily by themselves. Such workplace learning goes beyond the learner-teacher dyad, emphasising the role of context in which learning takes place. In addition, Dreso provides students with training in agile methods as well as substantial time for reflection and critical analysis on their own work. Specifically, the project manager organises regularly scheduled 'lessons learned' meetings, which are obligatory for all student teams and other project members.

Reasoning

Students acquire declarative and procedural knowledge on agile project management, for example, about how to structure a meeting, or how to take notes. Furthermore, this workplace learning involves frequent practice by students of communicative and collaborative skills. As Stasielowicz (2020) noted, *"dynamic environments require people to process new cues, learn new procedures, identify new strategies. Thus, abilities like processing speed or reasoning may be particularly relevant in the context of adaptation"* (Stasielowicz, 2020: p.166).

Agile project methods require students to frequently engage with other perspectives, up to three times a day, in meetings with their team or with other stakeholders. Similarly, the use of lessons learned engages students in additional dialogue and feedback situations, encouraging them to monitor and evaluate explicitly their learnings. In fact, Kim, Knag, Kim & Park (2023) found that learning practices which trigger reflection involve perspective-taking and immersion with others, notably their peer group.

Outcomes

Dreso assesses the outcomes of workplace learning during the OKR workshops, which are supplemented by a 'lessons learned' session which takes place quarterly. These workshops, as previously mentioned, are aimed at identifying issues from the previous annual quarter and reflecting on to draw learnings from them. All students working on the project (eight students) participated in the lessons learned workshop, as well as one moderator. Moderation was first done by the project leader, but the project leader reports that this has meanwhile been delegated to an experienced student. This student was instructed in how to moderate the OKR workshops.

In the OKR workshops, all eight students self-reported that practice in agile methods had helped them to improve their goal setting, planning, monitoring, evaluation, and social skills. Specifically, they described having become more confident in steering their professional development towards their personal areas of interest.

The project leader reported that students perform better than before in general project management (declarative and procedural) skills. For instance, students initiated additional retrospective meetings, which ultimately resulted in the development of an Excel tool to organise the invitation management for the many coordination meetings of the project. The tool assured that only those people were invited that had an actual role during the meeting – a task not to be underestimated considering that over 65 different contractors and their supervising

construction managers and owner representatives had to be coordinated. In another case, the student team developed a process handbook that assured that new student team members required less than 1 hour of training to produce standardised documentations of the regular coordination meetings or lean workshops. The standardisation enabled the team to produce said documentations shortly after the meetings themselves – a process which took up to three days before the standardised process had been introduced.

The project leader also noted an increase in motivation among students to see overarching global development goals, as opposed to only for smaller tasks within the organisation. For instance, after identifying a perceived mismatch between project-specific methods and the organisation's global goals, students began questioning the project's approaches and objectives. By using OKR as a platform for discussion, the team gained a deeper understanding of both its own goals and methods, as well as those of the organisation.These results indicate that practice in agile methods benefits conceptual knowledge building among engineering students – and hence, contributes to the development of their adaptive performance.

Ultimately, both the project and the organisation directly benefited from the students' input. As outsiders, students bring a fresh perspective, free from biases shaped by past project experience. This out-of-the-box thinking fosters valuable contributions, generating novel and unconventional ideas for project improvement.

Discussion

We draw two main findings from the CIMO analysis. Workplace learning using agile methods contributes to the development of students' adaptive performance by providing students with exercise in 1) perspective-taking skills and 2) meta-cognitive self-awareness skills. Both are relevant skill sets in adaptive performance. We discuss both findings in more detail below.

Perspective-taking

In line with other authors, we found that workplace learning using agile methods provides students with opportunities to learn about and take perspectives of others, specifically their team members, but also different stakeholders. Research shows that this develops students' adaptive performance (Fisher & Peterson, 2001).

We observed that workplace learning using agile methods leverages the impact of high-frequency meetings with (relevant) stakeholders and peers. Such meetings offer students recurring opportunities to seek and learn about others' interests and motivations. This provides students with frequent exercise in their ability to take others' perspectives. Such engagement with stakeholders is characteristic of agile methods, and we observed that it requires students to practice a skill which is highly relevant for adaptive performance (Fisher & Peterson, 2001).

Our findings add to extant literature by showing how workplace learning using agile methods encourages students to engage in (forms of) dialogue

with different stakeholders, i.e. with different perspectives. Kaffka et al. (2021) examined the role of perspective-taking during the development of a novel business opportunity. The authors found that perspective-taking triggers reframing of currently held understanding and beliefs, which in turn facilitates deeper-level learning among novice entrepreneurs.

Engagement in dialogue has proven to increase perceptions of usefulness of feedback and correlate positively with thinking activities among secondary education students (Van der Schaaf et al., 2011). The ability for perspective-taking is crucial for successful dialogue and reflection, as it suggests sincere engagement with feedback, necessary for transformational learning as well as for adaptive performance. For example, Kim et al.'s (2023) findings on professional learning emphasised the importance of dialogue and perspective-taking in transformational learning practices.

We propose that the variability and complexity of stakeholder engagement characteristic of agile methods contributes to building students' deeper understanding of the 'why' of a certain knowledge application. In this case, using agile methods enabled students to gain a more holistic perspective on the entire construction project. This, we argue, offers an explanation as to how agile methods support the development of students' adaptive performance.

Metacognitive self-awareness

Fisher & Peterson (2001) argued that training students' metacognitive self-awareness, i.e. monitoring and evaluation of their own learning activities, is a crucial element in developing students' adaptive performance. Metacognitive self-awareness is associated with someone's ability for learning how to learn and is highly relevant for adaptive performance (Fisher & Peterson, 2001). We propose that such practice represents a mechanism which helps explain how agile methods support the development of adaptive performance.

The variability of high-frequency meetings catalysed practice in the identification of 'atypical signals', as students prepare for, coordinate, evaluate, and report on meetings with team members, other project members or stakeholders. This provided students with practice in self-evaluative skills, such as metacognitive self-awareness. The task charts on the online whiteboard and high-frequency meetings provide students with numerous opportunities to engage with 'atypical' signals – signals from stakeholders about delays which help establish when and why to adjust project planning in large construction projects. Agile methods offer students practice in the identification of these 'atypical' signals from stakeholders.

The CIMO analysis showed that the scanning for 'atypical signals' allows students to learn to adjust their performance in response to those signals, such as making reiterations in the planning of the whole project based on novel or contradictory information. By allowing students to engage in processes of identification and categorisation of 'atypical signals' to identify issues for timely project achievement, agile methods support the building of a deeper, conceptual understanding of the whole project instead of a sole focus on one activity or task. In this way, the high-frequency meetings

used in agile methods exercised students' metacognitive skills relevant for adaptive performance. Such learning is crucial for adaptive performance (Ward et al., 2018).

While 'atypical' signals in the form of negative feedback are not always liked, they offer professionals opportunities to learn important lessons (Kaffka et al., 2021; Kaffka et al., 2024). Our findings show that the use of agile methods in workplace learning enabled students to exercise metacognitive skills. As such skills are relevant for adaptive performance, we propose that agile methods deserve a more structured place in the curriculum of engineering students.

Practical relevance

In our study, we identified three principles which aid curriculum design aimed at the development of adaptive performance among students.

One, the mechanism of high-frequency meetings and feedback interaction with various stakeholders provided students with real-world cases and contributed to perspective-taking, via dialogue in the form of high-speed meetings. Generally, research recognises the role of real-world cases and experiential education, as it offers exercise in feedback engagement, reflection, as well as complex problem-solving (Martin, Rivale, and Diller, 2007).

Two, we saw that there was room for reflection and for discussion of mistakes, which also the project leaders of Dreso take part in. Scholars have found that challenge-based learning in engineering education contributes to students' development of adaptive performance, as it offers exercise in feedback engagement, reflection, as well as complex problem-solving (Martin, Rivale, and Diller, 2007). The structural integration of collaborative reflection enables students' engagement with feedback activities. We suggest that collaborative reflection, such as occurs in agile methods, can enhance the effectiveness of engineering education in general. It prepares students for the managerial aspects of large and complex engineering projects in their future career, by developing their adaptive performance.

Three, we observed that specific educational technology - such as a shared drawing (brown) paper for brainstorming, (digital) whiteboards for task overview and monitoring - play an important part in agile methods used during workplace-based learning. For example, an online whiteboard enabled students during workplace learning at Dreso to formulate and explicate their reasoning regarding planning and monitoring of their own task but also those of one's team members. Such tools or resources can be understood as artifacts, which are relevant for task achievement among learners but also for building adaptive performance (Hatano and Oura 2003; Bailey, Winchester, and Ellies 2023).

We propose that artefacts such as visualisation tools, kanban boards, or simple flip-overs should take a more prominent place in higher education, as they provide students with tools to articulate their ideas

and engage in feedback on them. This can help to develop students' adaptive performance.

A limiting disclaimer and future research opportunities

It should be noted that scholars have identified several risks for (using/learning) agile methods in engineering projects (Williams & Cockburn, 2003), namely: (1) risk stemming from the agile approach itself, for example, design simplicity or scalability issues, (2) risks stemming from a plan-driven approach, such as constant change or need for rapid results, and (3) general environmental risks associated with technology uncertainties or engagement with diverse stakeholders. In order to design educational interventions benefiting students' learning of agile methods and training their adaptive performance, future studies can examine how risk assessment can contribute to teaching and learning of agile methods in higher education curricula.

Furthermore, the case considered in this chapter does not account for cultural differences that might arise from working with agile project management in different countries. A recent study found that feedback engagement with peers can foster dialogue and reflection essential for their transformative learning (Kim et al., 2023). Meanwhile, cultural differences have been noted with respect to uncertainty avoidance in people (Hofstede, 1980). In this sense, the cultural background of team members might affect the way that project members engage with agile methods. The iterative and open nature of agile projects, specifically frequent communication about potential issues or failures, and critical (self evaluation might feel intimidating, risky, or shameful for team members. This can jeopardise the successful application of agile methods, whether in higher education internships, traineeships, or other forms of work-based learning.

Concluding remarks

In this chapter, we analysed the role of agile project management in developing adaptive performance among construction engineering and urban planning students. We identified two mechanisms which enabled this: exercise in perspective-taking and practice of meta-cognitive skills. When students engage in dialogue and perspective-taking with stakeholders, searching for and identifying 'atypical' signals in high-frequency meetings by means of monitoring and evaluation, they develop skills relevant to adaptive performance. We propose that incorporating agile project management in education design facilitates the building of adaptive performance among students, whether in engineering programmes in higher education or beyond.

REFERENCES

Abbas, N., Gravell, A., & Wills, G. (2008). Historical roots of agile methods: Where did "agile thinking" come from? In P. Abrahamsson, R. Baskerville, K. Conboy, B. Fitzgerald, L. Morgan, & X. Wang (Eds.), *Proceedings of the International Conference on Agile Processes in Software Engineering and Extreme Programming* (pp. 94–103). Springer. https://doi.org/10.1007/978-3-540-68255-4_10

Albuquerque, F., Torres, A. S., & Berssaneti, F. T. (2020). Lean product development and agile project management in the construction industry. *Revista de Gestão, 27*(2), 135–151. https://doi.org/10.1108/REGE-01-2019-0005

Arce, E., Suárez-García, A., López-Vázquez, J. A., & Fernández-Ibáñez, M. I. (2022). Design sprint: Enhancing STEAM and engineering education through agile prototyping and testing ideas. *Thinking Skills and Creativity, 44,* 101039. https://doi.org/10.1016/j.tsc.2022.101039

Argyris, C. (2004). Double-loop learning and organizational change: Facilitating transformational change. In J. J. Boonstra (Ed.), *Dynamics of organizational change and learning* (pp. 389–402). Wiley. https://doi.org/10.1002/9780470753408.ch19

Baard, S. K., Rench, T. A., & Kozlowski, S. W. J. (2014). Performance adaptation: A theoretical integration and review. *Journal of Management, 40*(1), 48–99. https://doi.org/10.1177/0149206313488210

Backhaus, J. O. (2022). Lean construction: Bauprojekte verschwendungsarm koordinieren. *YOKOTEN Magazin,* (2), 28–31.

Backhaus, J. O., & Dahm, M. (2022). Lean construction: Schlanke Bauprojekte – für Qualität und schnellere Fertigstellung. *YOKOTEN Magazin,* (1), 30–31.

Bailey, N., Winchester, N., & Ellis, N. (2023). What is your intention? Tacit knowledge and community-based learning for collision avoidance in the global maritime industry. *Journal of Vocational Education & Training, 77*(2), 343–363. https://doi.org/10.1080/13636820.2023.2213685

Bohle-Carbonell, K., & Dailey-Hebert, A. (2014). From envisioning to managing educational development and organizational innovation. In A. Dailey-Hebert & K. S. Dennis (Eds.), *Transformative perspectives and processes in higher education* (pp. 49–74). Springer. https://doi.org/10.1007/978-3-319-09247-8_4

Chen, Q., Reichard, G., & Beliveau, Y. (2007). Interface management: A facilitator of lean construction and agile project management. *Proceedings of the International Group for Lean Construction,* 57–66.

Dalkin, S. M., Greenhalgh, J., Jones, D., Cunningham, B., & Lhussier, M. (2015). What's in a mechanism? Development of a key concept in realist evaluation. *Implementation Science, 10,* Article 49. https://doi.org/10.1186/s13012-015-0237-x

Demir, S.T. (2019). Agil sein oder nicht sein: Ist das wirklich noch die Frage? Agile Design Management in der Planungsphase von Bauvorhaben [To be agile or not to be: Is that really still the question? Agile design management in the construction projects' planning phase]. *VDI-Jahresausgabe,* 40-45. https://www.mp-gruppe.de/fileadmin/user_upload/content/blog/2019/Bau_VDI-Jahresausgabe_2019-2020f.pdf

De Rosa, A. J., Lytle, A., Fontaine, M., & Fisher, F. T. (2023). Adaptive expertise: A potential tool for supporting S-STEM student retention and graduation. In *Proceedings of the 2023 ASEE Annual Conference & Exposition.* https://doi.org/10.18260/1-2--42622

Doerr, J. (2018). *OKR: Objectives & key results.* Vahlen. https://doi.org/10.15358/9783800657742

Fisher, F., & Peterson, P. (2001). A tool to measure adaptive expertise in biomedical engineering students. In *Proceedings of the 2001 ASEE Annual Conference.*

Hatano, G., & Oura, Y. (2003). Commentary: Reconceptualizing school learning using insight from expertise research. *Educational Researcher, 32*(8), 26–29. https://doi.org/10.3102/0013189X032008026

Hawse, S., & Wood, L. N. (2018). Fostering wise judgement: Professional decisions in development programmes for early career engineers. *Journal of Vocational Education & Training, 70*(2), 297–312. https://doi.org/10.1080/13636820.2017.1392998

Hicks, N. M., Bumbaco, A. E., & Douglas, E. P. (2014, June). Critical thinking, reflective practice, and adaptive expertise in engineering. In *Proceedings of the 2014 ASEE Annual Conference & Exposition.*

Hofstede, G. (1980). *Culture's consequences: International differences in work-related values.* Sage.

Inagaki, K., & Miyake, N. (2007). Perspectives on the research history of Giyoo Hatano. *Human Development, 50*(1), 7–15. https://doi.org/10.1159/000097684

Kakar, A. K. (2023). A rhetorical analysis of the Agile Manifesto on its 20th anniversary. *Journal of the Southern Association for Information Systems, 10*(1), 20–29. https://doi.org/10.17705/3JSIS.00030

Kaffka, G. A., Singaram, R., Kraaijenbrink, J., & Groen, A. J. (2021). "Yes and…, but wait…, heck no!" *Journal of Small Business Management, 59*(5), 1050–1080. https://doi.org/10.1080/00472778.2020.1866186

Kaffka, G., van der Schaaf, M., Baggen, Y., Pennings, H., & van Tartwijk, J. (2025). The social forming of professionals' adaptive performance: A sensemaking perspective. *Journal of Vocational Education & Training, 77*(4), 1089–1115. https://doi.org/10.1080/13636820.2024.2426125

Longmuß, J., & Höhne, B. P. (2017). Agile learning for vocationally trained expert workers. *Procedia Manufacturing, 9,* 262–268. https://doi.org/10.1016/j.promfg.2017.04.022

Malik, M., Sarwar, S., & Orr, S. (2021). Agile practices and performance. *International Journal of Project Management, 39*(1), 10–20. https://doi.org/10.1016/j.ijproman.2020.09.002

Mylopoulos, M., Kulasegaram, K., & Woods, N. N. (2018). Developing the experts we need. *Journal of Evaluation in Clinical Practice, 24*(3), 674–677. https://doi.org/10.1111/jep.12905

Nandini, W., Gustomo, A., & Sushandoyo, D. (2022). The antecedents and consequences of individual adaptive performance. *Jurnal Ilmu Administrasi dan Organisasi, 29*(2). https://doi.org/10.20476/jbb.v29i2.1271

Neumann, M., & Baumann, L. (2021). Agile methods in higher education. In *Proceedings of the IEEE Frontiers in Education Conference (FIE)* (pp. 1–8). IEEE. https://doi.org/10.1109/FIE49875.2021.9637214

Oprins, E. A. P. B., Bosch, K. van den, & Venrooij, W. (2018). Measuring adaptability demands of jobs. *Military Psychology, 30*(6), 576–589. https://doi.org/10.1080/08995605.2018.1521689

Owen, R., Koskela, L., Henrich, G., & Codinhoto, R. (2006). Is agile project management applicable to construction? In R. Sacks & S. Bertelsen (Eds.), *Proceedings of the 14th Annual Conference of the International Group for Lean Construction* (pp. 51–66).

Pelgrim, E., Hissink, E., Bus, L., van der Schaaf, M., Nieuwenhuis, L., van Tartwijk, J., & Kuijer-Siebelink, W. (2022). Professionals' adaptive expertise and adaptive performance. *Advances in Health Sciences Education, 27*(5), 1245–1263. https://doi.org/10.1007/s10459-022-10190-y

Pulakos, E. D., Arad, S., Donovan, M. A., & Plamondon, K. E. (2000). Adaptability in the workplace. *Journal of Applied Psychology, 85*(4), 612–624. https://doi.org/10.1037/0021-9010.85.4.612

Putnik, G. D., & Putnik, Z. (2012). Lean vs agile in the context of complexity management. *The Learning Organization, 19*(3), 248–266. https://doi.org/10.1108/09696471211220046

Ribeiro, F. L., & Fernandes, M. T. (2010). Exploring agile methods in construction SMEs. *Journal of Enterprise Information Management, 23*(2), 161–180. https://doi.org/10.1108/17410391011019750

Saini, M., Arif, M., & Kulonda, D. J. (2018). Critical factors for transferring tacit knowledge. *Construction Innovation, 18*(1), 64–89. https://doi.org/10.1108/CI-06-2016-0036

Sanchez, L. M., & Nagi, R. (2001). A review of agile manufacturing systems. *International Journal of Production Research, 39*(16), 3561–3600. https://doi.org/10.1080/00207540110068790

Small, L., Shacklock, K., & Marchant, T. (2018). Employability. *Journal of Vocational Education & Training, 70*(1), 148–166. https://doi.org/10.1080/13636820.2017.1394355

Stasielowicz, L. (2020). How important is cognitive ability when adapting to changes? *Personality and Individual Differences, 166,* 110178. https://doi.org/10.1016/j.paid.2020.110178

Steegh, R., Van De Voorde, K., Paauwe, J., & Peeters, T. (2025). The agile way of working and team adaptive performance. *Journal of Business Research, 189,* 115163. https://doi.org/10.1016/j.jbusres.2024.115163

Teipel, P., & Alberti, M. (2019). Vision und Strategie verwirklichen mit OKR. *Controlling & Management Review, 63*(5), 34–39. https://doi.org/10.1007/s12176-019-0033-6

Van der Schaaf, M., Baartman, L., Prins, F., Oosterbaan, A., & Schaap, H. (2011). Feedback dialogues that stimulate students' reflective thinking. *Scandinavian Journal of Educational Research, 57*(3), 227–245. https://doi.org/10.1080/00313831.2011.628693

Ward, P., Gore, J., Hutton, R., Conway, G. E., & Hoffman, R. R. (2018). Adaptive skill as the conditio sine qua non of expertise. *Journal of Applied Research in Memory and Cognition, 7*(1), 35–50. https://doi.org/10.1016/j.jarmac.2018.01.009

Williams, L., & Cockburn, A. (2003). Agile software development: It's about feedback and change. *Computer, 36*(6), 39–43. https://doi.org/10.1109/MC.2003.1204373

Zehr, S. M., & Korte, R. (2020). Student internship experiences. *Education + Training, 62*(3), 311–324. https://doi.org/10.1108/ET-11-2018-0236