INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED23
24-28 JULY 2023, BORDEAUX, FRANCE

EVALUATING REFLECTIVE BEHAVIOR IN ENGINEERING DESIGN RETROSPECTIVES: AN INITIAL CODING SCHEME

Ammersdörfer, Theresa (1);
Tartler, Darien (2);
Kauffeld, Simone (2);
Inkermann, David (1)

1: Technische Universität Clausthal, Institute of Mechanical Engineering (IMW), Robert-Koch-Str. 32, 38678 Clausthal-Zellerfeld, Germany;
2: Technische Universität Braunschweig, Institute of Work, Organizational and Social Psychology (AOS), Spielmannstraße 19, 38106 Braunschweig, Germany

ABSTRACT

Considering transformation processes within organizations, reflection is an enabler for learning and adaption of engineering processes, methods, and tools. Moreover, reflection as a core element of agile engineering approaches. However, a sound understanding of reflection behaviors of engineers or engineering teams is lacking. In this paper we proposed a structured reflection procedure including different dimensions to reflect on. To analyse reflection behavior of engineers and engineering teams we propose a coding scheme comprising of nine behaviors. The coding scheme allows to evaluate the reflection behavior in real time and give feedbacks to improve the quality of reflection. The proposed coding scheme is initially tested within a workshop with industry partners.

Keywords: Organisation of product development, Human behaviour in design, Design process, Collaborative design

Contact:
Ammersdörfer, Theresa
Technische Universität Clausthal
Germany
ammersdoerfer@imw.tu-clausthal.de

Cite this article: Ammersdörfer, T., Tartler, D., Kauffeld, S., Inkermann, D. (2023) 'Evaluating Reflective Behavior in Engineering Design Retrospectives: An Initial Coding Scheme', in *Proceedings of the International Conference on Engineering Design (ICED23),* Bordeaux, France, 24-28 July 2023. DOI:10.1017/pds.2023.169

1 INTRODUCTION

Digital transformation as well as changes towards more interdisciplinary and distributed engineering call engineers to adapt to new environments (Daudelin, 1996; Dumitrescu et al., 2021). The need for continuous adaption induced by reduced planning reliability is reflected in an increasing use of agile management frameworks like SCRUM (Atzberger and Paetzold, 2019). Key elements of these frameworks are retrospectives, enabling reflective learning and adaption within engineering projects and organisations (Daudelin, 1996). Systematic reflection is seen as a suitable tool for learning from experience (successes and failures) and to support engineers in complex und uncertain engineering projects (Ellis et al., 2014). Although reflection has been used more frequently in recent years, the evaluation of reflection quality is often based on subjective assessment rather than objective criteria. In this paper we propose a reflection analysis based on a behavior coding scheme to measure the effectiveness and quality of reflection processes and the associated behaviors in engineering design teams.

1.1 Motivation and acceptance for reflection in engineering design

While reflection is not a new aspect of organizational cooperation, structured reflective methods have found little application in practice. Previous studies suggest that effective reflection requires both acceptance of the method and participant's motivation to use it. In work context, Decius et al. (2019) show the relevance of intent in learning from reflective processes. Kelloway and Barling (2000) further identified *ability* and *opportunity* as relevant factors for engaging in reflective activities, in addition to *motivation*. *Opportunity* refers to the contextual factors of reflective activities. For example, a suitable organizational climate as well as stable interpersonal structures have be to given to successfully apply reflection (Kelloway and Barling, 2000; Knipfer et al., 2013). *Abilities* refer to personal characteristics that enable employees to reflect, such as the mental capabilities to abstract or general reflective competence (Knipfer et al., 2013; Kröll, 2020). *Motivation* reflects the willingness of employees to engage with their own thoughts and share them with others (Knipfer et al., 2013). A classic model for measuring acceptance towards new technologies is the Technology Acceptance Model (TAM; Davis, 1989). We argue that these acceptance factors can also be applied to the introduction of new methods, in this case reflection, due to situational similarity. In the TAM, three aspects are important (Taherdoost, 2018): *Perceived usefulness* (extent to which employees feel something new would improve their work performance), *ease of use* (how much effort employees have to invest to use something new) and *attitudes towards technology* (how employees feel about the something new; Mlekus et al., 2020; Taherdoost, 2018). For successful implementation of reflection, this implies that, on the one hand, motivation, and skills as well as organizational conditions for the creation of reflection opportunities have to be promoted. On the other hand, it is important to communicate to employees how the reflective activity is useful and easy for them to apply on the job.

1.2 Structured reflection in engineering design

Reflection is a complex process involving different individual thought processes (e.g., recapitulation of past actions, root cause analysis, solution search, decisions, etc.) in the various process steps. Accordingly, for an effective reflection process, different time horizons (e.g., past, present, future) and dimensions (e.g., social, process, goal) need to be considered and a systematization of the processes involved in reflection is necessary (Weixelbaum, 2016). Since the timing of reflection is critical to its effectiveness, Schön (1987) recommends reflecting on the course of an activity situationally either by "reflection-in-action" or by "reflection-on-action". Structured reflection in this research is understood as a reflection process, carried out regularly and systematically. This structured reflection is more likely to address all aspects throughout the technical design process. Practical reflection in engineering design includes reflection on perceived design situations and reflection on past design activities and can be supported by reflection methods. Regular reflection helps engineers to identify and correct deviations from target goals at an early stage. However, this is only possible if reflection is integrated into the engineering design process (Reymen and Hammer, 2002). In order to guide transformation and adaption processes, reflection must consider different dimensions: *Social* (e.g., communication), *Process* (e.g., procedure), *Goal* (e.g., partial solutions) as well as different levels, namely *strategic*, *tactical*, and *operational*. The three dimensions (social, process, goal) are derived from the objects of reflection, which indicate the purpose ("why") of the reflection activity (Inkermann et al., 2020). West

https://doi.org/10.1017/pds.2023.169 Published online by Cambridge University Press

(2000) uses a triad for the reflection process in which he suggests the reflection cycle of reflection, planning, and action/adaption as a procedure and Jobst et al. (2020) focuses on awareness and reflective activity. In Figure 1 the proposed reflection procedure is illustrated. This procedure links the procedures according to West (2000) and Jobst et al. (2020) and considers the social-, process- and goal dimension. However, the application of reflection should be supported both procedurally and methodologically. To be able to support engineers in the proposed reflection procedure and the individual reflection process steps, suitable reflection methods (e.g., debriefing, daily meetings, or retrospectives) are therefore required to support engineers in effective reflection.

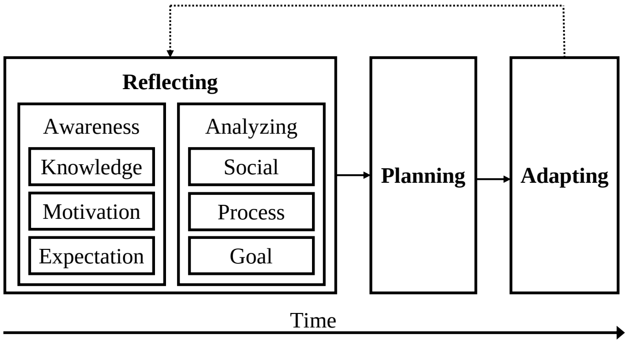

Figure 1. Proposed reflection procedure based on Ammersdörfer et al. (2022)

1.3 Objectives and focus of research

To improve engineering design, it is necessary to integrate reflection into the development process and workflows of engineers and to be able to measure and improve the reflective behavior in meetings. The experience from research projects shows that reflection takes place, but no criteria for the evaluation of the reflection results are defined. In practice, reflection tends to take the form of "return on experience", "lessons learned" or "capitalization" and is not further evaluated in terms of success. As the quality of reflection is crucial, this paper proposes a coding scheme to analyse reflection meetings. Thus, it contributes to a better understanding of the quality of reflection and allows assessments of the reflective behavior present in the engineering team. These objectives result in the following research questions:

- What are existing evaluation approaches for reflection in engineering design and how can reflection behaviors in engineering design processes be measured?
- What is a useful structure for a reflection coding scheme to be successfully applied in industrial practice?

To answer these research questions, we first analyze reflection behavior in engineering design and provide an overview of existing reflection evaluation approaches in Section 2. To support the analysis of reflection behaviours in teams, a coding scheme for reflection in engineering design is proposed in Section 3. The developed coding scheme for reflection called "reflAct4teams-short" is subjected to a first test in industrial practice. Results and findings are presented in Section 4. Section 5 discusses further possibilities to support structured reflection in engineering teams and provides an outlook on future research.

2 OVERVIEW AND APPROXIMATIONS OF REFLECTION BEHAVIOR IN ENGINEERING DESIGN

Section 2 provides an overview of existing evaluation approaches for reflection and shows how observational studies from other disciplines can be used for reflection in engineering design.

2.1 Evaluation approaches for reflection in engineering design

There are different approaches to apply reflection in practice. Across all of them, it is difficult to make reflection measurable in tangible terms, as the definition of reflection often varies widely. Ammersdörfer et al. (2022), for example, refer to different approaches to reflection in terms of timing, level of detail, content, and process steps and, following Inkermann et al. (2020), distinguish between conceptual and generic reflection procedures. Kalk et al. (2014) further differentiate between various methodological approaches that have been used. For example, quantitative studies on reflection in the form of scale

https://doi.org/10.1017/pds.2023.169 Published online by Cambridge University Press

developments (e.g., Otte et al., 2017), qualitative studies based on, for example, interviews or tool studies (e.g., Maaranen and Krokfors, 2007) or mixed studies with a combination of qualitative and quantitative content (e.g., Killeavy and Moloney, 2010) have already been conducted (Kalk et al., 2014). So far, the focus on actual behavior has always come up lacking in studies of this kind. Both self-reports (e.g., questionnaires) and qualitative methods (e.g., interviews) rely on individual statements and are subjective in nature. To analyze behavior more objectively, Kauffeld et al. (2009) developed the behavior coding scheme act4teams (Kauffeld, 2006; Kauffeld and Lehmann-Willenbrock, 2012) and later the short version in the form of the live coding tool act4teams-short (Klünder et al., 2020). Act4teams-short maps typical behaviors like cooperation or proactivity in meetings in nine differentiated codes (cf. Figure 3) and allows the quick analysis of displayed behavior. In this study, the act4teams-short coding scheme was adapted to the reflection context and for use in reflection meetings, which led to the development of reflAct4teams-short, see Section 3. This tool enables an objective observation and analysis of reflective behaviors in meetings and thus gives insights into the quantity and quality of reflection.

2.2 Observation studies in engineering design

Due to the complex of investigations and the high demands on the observation system, observation as a method for recording work processes in engineering design is used rarely. Therefore, before using the observation as a method, an introduction or some kind of training is useful. The competence level and the understanding of the work processes of the observed engineering teams also affect the quality of the observation. Observation is considered one of the elementary procedures for recording a specific behavior, its frequency, intensity, and duration, and thus for analysing complex behavioral processes. Observation can be used as a method for recording activities in engineering design (Badke-Schaub and Frankenberger, 2004). In engineering design, most researchers studying interactions in design teams must choose between observational study of *real* teams in the corporate environment and *artificial* teams in the laboratory. A study of real teams has the advantage that external validity of the results is given. The disadvantage is that because of the different contexts (in which the teams are observed), it is often difficult to separate the phenomena of interest from the context. In contrast, when studying laboratory teams, it is easier to isolate the phenomena of interest, but it is questionable how meaningful and realistic the findings are when teams only exist for a certain duration of a study (Jung and Leifer, 2011). Once the observation environment has been defined, it is necessary to determine whether the observation should be unsystematic or systematic (Badke-Schaub and Frankenberger, 2004). In Figure 2, observation is shown in the two forms of unsystematic (no restrictions) and systematic (concretization via observation plan) observation.

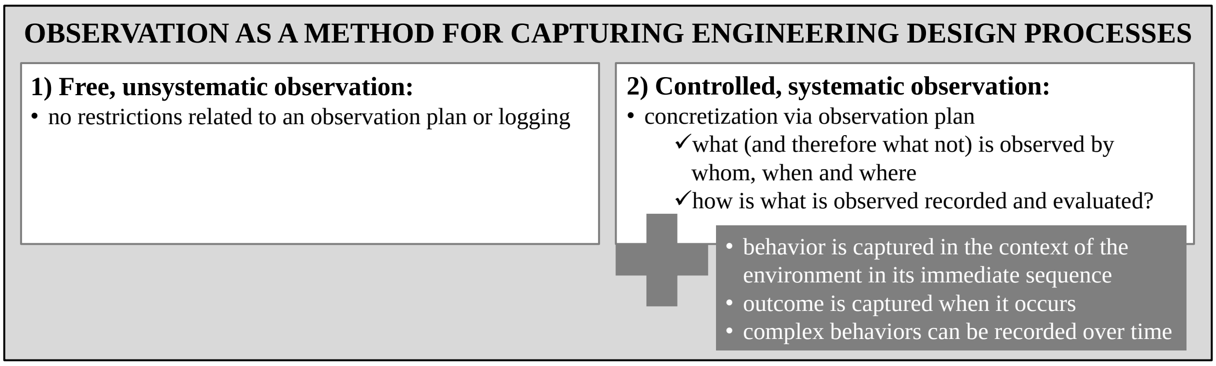

Figure 2. Observation as a method in engineering design based on Badke-Schaub and Frankenberger (2004)

The objective of systematic observation is for well-trained observers (e.g., organizational psychologists) to produce identical protocols that evidence the same observed behaviors. The advantage is that behavior is recorded in the context of the environment in its immediate sequence and the outcome is recorded immediately when it occurs. Furthermore, systematic observation is advantageous because complex behaviors can be recorded over time (Jung and Leifer, 2011). In order to categorize behavior and make it tangible, a coding scheme (catalogue of behavioral codes) has to be developed in advance that allows observers to quantify the occurrence of specific behaviors (Bakeman

https://doi.org/10.1017/pds.2023.169 Published online by Cambridge University Press

and Gottman, 1997). According to Jung and Leifer (2011), the development of the coding scheme can be derived either from existing theory ("top down") or from close observation of the behavior itself ("bottom up") (Kauffeld and Meinecke, 2018).

3 PROPOSED CODING OF REFLECTION IN ENGINEERING DESIGN

From a scientific perspective, investigating how to assess the quality of reflection and how to identify measures to improve engineering design projects is necessary to target reflection for specific contexts. Therefore, this paper proposes a coding scheme for reflection in engineering design.

3.1 Structure of coding for reflection

The development of reflAct4teams-short was based on the previous act4teams-short categories (Klünder et al., 2020) and on the reflection procedure according to Ammersdörfer et al. (2022; cf. Section 1.2) and validated by comparison with previous instruments for capturing reflection (cf. Carter and West, 1998; Konradt et al., 2016; Schippers et al., 2007) and expert workshops. The nine categories of act4teams (Kauffeld, 2006; Kauffeld and Lehmann-Willenbrock, 2012; Kauffeld et al., 2018) and reflAct4teams are displayed in Figure 3.

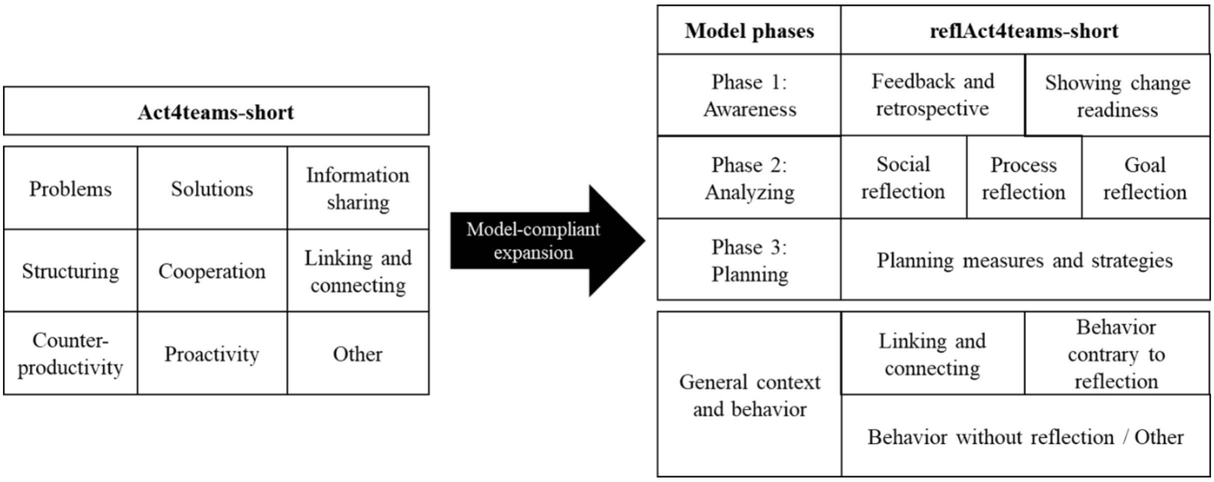

Figure 3. Proposed coding scheme reflAct4teams-short based on the act4teams-short-coding scheme

The *awareness* domain is represented by the codes 'feedback and retrospective' (knowledge and expectation, i.e., sharing work-related information within the team, as well as looking back at past work processes together) and 'showing change readiness' (motivation, i.e., actively showing commitment to change and proactively signaling readiness for development to others). The area of *analyzing* is covered by three reflection codes, which already give the reflection process a content-related attribution. 'Social reflection' describes statements on the analysis of interpersonal processes within the working group (How did the group members get along with each other? How did social processes influence the results?). 'Process reflection' focuses on the close examination of work processes that are recapitulated during a reflection session (What helped to achieve the goals? Which processes and methods can be maintained / need to be optimized?). 'Goal reflection' is about the possible correction and adjustment of work goals that the working group has set for the collaboration in engineering design projects and for the development of solutions (What is the current goal of the collaboration? To what extent does the goal need to be adjusted?). The *planning* aspect of the model is covered by the 'planning measures and strategy' code. This code describes the derivation of measures and recommendations for action based on previous reflection findings. The remaining three codes represent contextual and general factors that may be relevant to reflection. 'Linking and Connecting' serves as a code that links different instances with each other. Behavior that hinders reflection (e.g., uncooperative behavior such as whining or interrupting) is covered by the code 'behavior contrary to reflection'. Behavior that does not serve reflection can be coded via the 'other' code (behavior without reflection).

https://doi.org/10.1017/pds.2023.169 Published online by Cambridge University Press

3.2 Procedure of coding for reflection

The observation and measurement of interactions enables an accurate representation of the course of a discussion and the associated behavior (Klünder et al., 2020; Kauffeld et al., 2018). Interaction analysis allows for a detailed and objective content and temporal examination of behaviors over the course of a discussion, detaching from subjective assessments of participants (Kauffeld et al., 2018). Previous research with the coding scheme act4teams has shown, for example, new insights into humor patterns (Lehmann-Willenbrock and Allen, 2014), complaining cycles (Kauffeld, 2007; Kauffeld and Meyers, 2009; Lehmann-Willenbrock and Kauffeld, 2010) or intercultural differences in group interactions (Lehmann-Willenbrock et al., 2014). Coding schemes with a high level of detail like act4teams further require a very precise and time-consuming evaluation, as well as video or audio files of the interactions to be analyzed and extensive training of the person coding. For this reason, act4teams-short and thus reflAct4teams-short were developed as short versions suitable for live coding. Accordingly, researchers can use the coding scheme to participate in interactions, e.g., reflection meetings, and code them in real time.

Beginning of the meeting: ____:____ (time)

Examples	1-10	11-20	21-30
Social reflection - The team looks more closely at social aspects of their cooperation (conflicts, relationships, group effects).			
Process reflection - The team takes a closer look at the procedural aspects of their cooperation (processes, task handling, organizational processes).			
Goal reflection - The team looks more closely at goal-oriented aspects of their cooperation (achieving or adjusting goals).			

Figure 4. Excerpt (30 minutes) of the tally sheet used during the observation procedure (The original observation sheet further includes the nine reflAct4teams codes and 60 minutes of meeting time)

Therefore, the coding of the interaction takes only as long as the interaction itself. The coding is event-based, meaning as soon as a behavior emerges, it is coded. In addition, feedback on the results can be given directly after the coded interaction. A tool has already been developed for act4teams-short, which displays the descriptive assessment of the codes directly after the end of the coding. As no final version of reflAct4teams is available yet, the first studies are still being conducted with a tally sheet (cf. Figure 4). The results of reflAct4teams-short are based on the relative frequencies of the codes in ten-minute time segments. In this way, it is possible to compare which codes were used in different phases of the interaction. The frequencies can be related to each other or to other data, for example from questionnaires. For instance, the frequency of certain behaviors on outcomes such as performance or satisfaction can be determined. In the case of relflAct4teams-short, a statement can also be made about the quality of the reflection.

4 CASE STUDY

Within a research project, a pilot project focusing on system-oriented engineering within a medium-sized company was conducted. Therefore, new engineering design methods e.g., to identify concept-defining requirements, define function breakdown structure as well as a morphological box to structure existing solution for an overall system concept were introduced and a procedure for the system definition process were worked out. Based on these methods and the proposed procedure, a design sprint was conducted involving eight people from industry partners. Goal of the design sprint was to develop solution concepts for a new motion system that would serve as the basis for further validation and costing. Moreover, practical applications of engineering design methods introduced as well as their usability for future projects were in focus. At the end of the pilot project, a reflection workshop, led by a moderator, was conducted. This reflection took place in a workshop format based on the reflection model in engineering according to Inkermann et al. (2020). The aim of the reflection workshop was to measure reflection-typical behaviors to be able to assess the quality of reflection as well as reflection competence and to evaluate the coding scheme. A total of eight people participated

https://doi.org/10.1017/pds.2023.169 Published online by Cambridge University Press

in the meeting, the duration of the meeting was 63 minutes, and the reflection was led by a facilitator from the engineering field, coded by two organizational psychologists in the background, and the responses were recorded by one person. The reflection workshop was divided into the three areas of feedback, reflection (operational and tactical), and measures and strategies according to the procedure based on the Reflection Canvas by Ammersdörfer et al. (2022). This moderation procedure according to a reflection framework, should already sensitise the participants for the structured reflection procedure and offer a certain security through the moderator that reflection will take place on several areas. Through the structure of the moderator and the selected guiding questions, the reflection can be steered in certain directions and thus specifically trigger different dimensions (social, process, goal), which may not be considered in short lessons learned sessions. At the beginning, questions about performance feedback (What was accomplished?) and process feedback (How was the task accomplished?) were asked of the engineering design team. In the second part, selected guiding questions were asked for reflection at the tactical (engineering design team) and operational (engineer as individual) levels of reflection in the dimensions of social, process, and goal, and difficulties and strategies were discussed and concretized. In the last part, alternatives (what would be alternative courses of action?) and measures (planning of next steps in future projects) were summarized and planned. To make the quality and agreement of the codes testable, the reflection meeting, in addition to being moderated by one person, was accompanied by two independent coders who observed the meeting separately using reflAct4teams-short. As a result of the coding, two differently completed versions of the observation sheet are available and were prepared for the evaluation of the meeting. The interrater reliability (cf. Koo and Li, 2016) was calculated to check the agreement between the coders. The interrater reliability was ICC = .96 and thus shows a very good agreement between the two coders (Koo and Li, 2016). Figure 5 shows the development of the absolute frequencies of the different codes averaged between the coders over the time course of the reflection meeting. Overall, 31% of the codes assigned fall into the Awareness part of the reflection model used (cf. Ammersdörfer et al., 2022). 57% fall into the analyzing part. This includes process reflection with 57%, while social reflection with 20% and goal reflection with 14% were lower. The Planning aspect of the overall model represented 13% of the codes assigned. No behavior contrary to reflection was observed during this one specific meeting. In terms of the proposed reflection procedure (cf. Figure 1), a large part of the session was spent analyzing and reflecting in different dimensions related to the work process in the system-oriented development of the pilot project. Approximately one-third of the behavior exhibited in the meeting was used for feedback and retrospective, while only a small portion was used to derive measures. A closer look at the time course of behavior in the reflection meeting reveals some distinctive features:

- First, the meeting begins with a strong focus on feedback and retrospection. Although this decreases during the meeting, it always remains in the middle range except for the last three minutes. Feedback and review thus seem to accompany the participants constantly. In addition, the meeting has a strong focus on process feedback, which is used frequently. Social reflection, on the other hand, only has a high point in the middle of the meeting and goal reflection is used occasionally but is never the focus.
- Second, it is noticeable that the planning of measures and strategies only begins later in the meeting but is then constantly represented. It is also apparent that although some linkages and connections are present at the beginning, they are used less at the end. Showing a willingness to change also occurs only sporadically.

Overall, it appears that most reflective behaviors were used in the observed meeting. On the one hand, this is due to the moderation, as all reflective behaviours are covered with a structured reflection. On the other hand, it should also be noted that the quality of reflection in these areas also depends on the characteristics of the participants (e.g., reflective competence, motivation, acceptance). Giving and receiving feedback as well as reflecting on the work process constantly played a major role. However, Figure 5 also shows, for example, that the willingness to change is low in the last phase (action planning: measures and strategies). This should be viewed critically, as the will to change should be more pronounced here in future projects, especially regarding the adaptation and improvement of future engineering design processes. Overall, it should be clearly defined for future work with the coding scheme when which phase ends or how long which phase lasts in different meetings and companies should be compared to further develop the evaluation structure.

https://doi.org/10.1017/pds.2023.169 Published online by Cambridge University Press

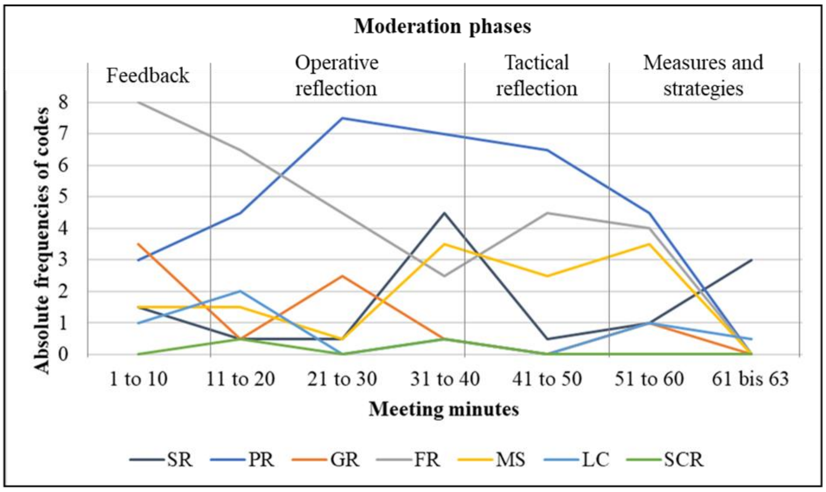

Figure 5. Absolute frequencies of the different codes averaged between the two coders over the time course of the reflection meeting (SR = Social reflection, PR = Process reflection, GR = Goal reflection, FR = Feedback and retrospective, MS = Measures and strategies, LC = Linking and connecting, SCR = Showing change readiness; the codes for behavior contrary to reflection and behavior not related to reflection were not used in the meeting)

5 CONCLUSION AND OUTLOOK TO SUPPORT STRUCTURED REFLECTION

Structured reflection is characterized by regular and systematic application. Accordingly, regular reflection serves to identify and correct deviations from goals at an early stage. The systematic implementation of reflection supports engineers in not missing important aspects of the reflection process and the dimensions of reflection. In relation to the results of the case study reported in Section 4, the feedback from participants was that a reflection structure and moderator-led reflection was more purposeful than unstructured reflection. In most cases, no further work has been done with the reflection results so far, which again illustrates the process feedback of the reflection meeting. Accordingly, no measures for future design process steps are derived or reflection results implemented in the design process in the reflection carried out independently to date. Overall, observation shows that, for the most part, reflective behavior is used. In this context, the moderation of the reflection workshop is a crucial factor, as the reflective behaviour depends on both the moderation (structured reflection) and the reflective competence of the participants. This finding shows that a well-designed reflection structure is necessary to promote reflection competence and improve the quality of reflection. This paper demonstrates in a first practice test of reflection analysis a coding scheme to capture the quantity and quality of reflection in engineering design teams. The proposed scheme enables a live coding and to feed the reflection behavior directly to a work team. In a first practical example within the scope of this paper it was shown how reflAct4teams-short can be used for the observation of reflective behavior in a small and medium sized company. In the future, reflAct4teams-short will be used in the context of a research project to measure the quality of reflection, examine engineers' reflective behaviors, and evaluate the effectiveness of structured reflection. To support inexperienced engineers in the reflection procedure (cf. Figure 1) and to examine the characteristics (e.g. reflective competence, motivation, acceptance) of the engineers, Ammersdörfer et al. (2022) propose the tool "Reflection Canvas". Through the Canvas, we encourage the reflection-typical behavior of the engineers, provide guidance for the reflection procedure, and guarantee the written documentation of the results. However, in the future, the reflection workshop will no longer be facilitated, but will be a stand-alone service using the Reflection Canvas. Accordingly, facilitation will be replaced by the Canvas so that future research can examine the effectiveness of facilitated and non-facilitated reflection. In this context, the codes can be adapted based on further research to be even better tailored to the reflective process. Furthermore, as many different reflection processes as possible should be observed (e.g., structured processes by application of the Reflection Canvas) to provide a comprehensive basis for reflection meetings. Furthermore, the behavioral codes from reflAct4teams-short should be linked to specific outcomes such as satisfaction or performance to draw conclusions about the impact of different reflection behaviors in reflection meetings. In addition, engineers should be supported in the adaption and use of structured reflection to build reflective competence and use reflection effectively in future design processes. The first practical test has shown the relevance of structured reflection and the importance of an evaluation tool to measure the quality of reflection and reflection-typical behavior. In further research, the Reflection Canvas, and the coding scheme reflAct4teams-short will be further developed and jointly evaluated in industrial practice to measure the effectiveness of structured reflection (with/ without moderation, with/ without Reflection Canvas) and to integrate reflection into engineering design processes.

ACKNOWLEDGMENTS

The research presented is part of the project RePASE - Reflective Process Development and Adaptation in Advanced Systems Engineering. This project is funded by the German Federal Ministry of Education and Research (BMBF) within the Program “Innovations for Tomorrow’s Production, Services, and Work” (02J19B149) and managed by the Project Management Agency Karlsruhe (PTKA). The author is responsible for the contents of this publication.

REFERENCES

Ammersdörfer, T., Tartler, D., Kauffeld, S. and Inkerman, D. (2022), “Reflection Canvas – An Approach to Structure Reflection Activities in Engineering Design”, in *Proceedings of NordDesign* 2022, Copenhagen, Denmark, 16-18 August. https://doi.org/10.35199/NORDDESIGN2022.29

Atzberger, A. and Paetzold, K. (2019), “Current Challenges of Agile Hardware Development: What are Still the Pain Points Nowadays?”, in *Proceedings of the Design Society: International Conference on Engineering Design (ICED2019)*, Vol. 1, pp. 2209–2218. https://doi.org/10.1017/dsi.2019.227

Badke-Schaub, P. and Frankenberger, E. (2004), “Produktentwicklung: normativ und empirisch”, in *Management Kritischer Situationen: Produktentwicklung erfolgreich gestalten*, *VDI-Buch*, Springer, Berlin, Heidelberg, pp. 27–52. https://doi.org/10.1007/978-3-642-18702-5_3

Bakeman, R. and Gottman, J.M. (Eds.) (1997), *Observing interaction: An introduction to sequential analysis*, 2. ed., Cambridge Univ. Press, Cambridge.

Carter, S.M. and West, M.A. (1998), “Reflexivity, effectiveness, and mental health in BBC-TV production teams”, in *Small Group Research*, 29(5), pp. 583–601.

Daudelin, M.W. (1996), “Learning from experience through reflection”, in *Organizational Dynamics, Vol. 24, Issue 3*, Vol. 24, pp. 36–48. https://doi.org/10.1016/S0090-2616(96)90004-2

Davis, F.D. (1989), “Perceived usefulness, perceived ease of use, and user acceptance of information technology”, in *MIS Quarterly*, Vol. 13, pp. 319–340.

Decius, J., Schaper, N. and Seifert, A. (2019), “Informal workplace learning: Development and validation of a measure”, in *Human Resource Development Quarterly*, 30(4), pp. 495–535. https://doi.org/10.1002/hrdq.21368

Dumitrescu, R., Albers, A., Riedel, O., Stark, R. and Gausemeier, J. (2021), *Engineering in Deutschland – Status quo in Wirtschaft und Wissenschaft: Ein Beitrag zum Advanced Systems Engineering*, Paderborn.

Ellis, S., Carette, B., Anseel, F. and Lievens, F. (2014), “Systematic Reflection: Implications for Learning from Failures and Success”, in *Current Directions in Psychological Science*, 23 (1), pp. 67–72. https://doi.org/10.1177/0963721413504106

Inkermann, D., Gürtler, M. and Seegrün, A. (2020), “RECAP – A framework to support structured reflection in engineering projects”, in *Proceedings of International Design Conference (DESIGN2020)*, Vol. 1, pp. 597–606. https://doi.org/10.1017/dsd.2020.99

Jobst, B., Thoring, K. and Badke-Schaub, P. (2020), “Introducing a tool to support reflection through sketching and prototyping during the design process”, in *Proceedings of International Design Conference (DESIGN2020)*, Vol. 1, pp. 207–214. https://doi.org/10.1017/dsd.2020.263

Jung, M.F. and Leifer, L.J. (2011), “A method to study affective dynamics and performance in engineering design teams”, in *DS 68-7: Proceedings of International Conference on Engineering Design (ICED2011)*, Vol. 7: Human Behaviour in Design, Lyngby/Copenhagen, Denmark, 15-19 August 2011, pp. 244–253.

Kalk, K., Luik, P., Taimalu, M. and Täht, K. (2014), “Validity and reliability of two instruments to measure reflection: A confirmatory study”, *TRAMES: A Journal of the Humanities & Social Sciences*, No. 18(2).

Kauffeld, S. (2006), *Kompetenzen messen, bewerten, entwickeln: Ein prozessanalytischer Ansatz für Gruppen*, Zugl.: Kassel, Univ., Habil.-Schr., 2005, *Betriebswirtschaftliche Abhandlungen*, N.F., 128, Schäffer-Poeschel, Stuttgart.

Kauffeld, S. (2007), “Jammern oder Lösungsexploration: Eine sequenzanalytische Betrachtung des Interaktionsprozesses in betrieblichen Gruppen bei der Bewältigung von Optimierungsaufgaben”, *Zeitschrift für Arbeits- und Organisationspsychologie*, Vol. 51 No. 2, pp. 55–67.

Kauffeld, S. and Lehmann-Willenbrock, N. (2012), “Meetings Matter: Effects of Team Meetings on Team and Organizational Success”, in *Small Group Research*, 43(2), pp. 130–158. https://doi.org/10.1177/1046496411429599

Kauffeld, S., Lehmann-Willenbrock, N. and Meinecke, A.L. (2018), “The Advanced Interaction Analysis for Teams (act4teams) Coding Scheme”, in *E. Brauner, M. Boos, & M. Kolbe (Eds.), The Cambridge Handbook of Group Interaction Analysis (Cambridge Handbooks in Psychology)*, Cambridge University Press, Cambridge, pp. 422–431. https://doi.org/10.1017/9781316286302.022

Kauffeld, S. and Meinecke, A.L. (2018), “The history of group interaction research”, in *E. Brauner, M. Boos, and M. Kolbe (Eds.), The Cambridge handbook of group interaction analysis*, NY: Cambridge University Press, New York, pp. 20–42.

Kauffeld, S. and Meyers, R.A. (2009), “Complaint and solution-oriented circles: Interaction patterns in work group discussions”, in *European Journal of Work and Organizational Psychology*, Vol. 18, pp. 267–294. https://doi.org/10.1080/13594320701693209

Kauffeld, S., Tiscar-Lorenzo, G., Montasem, K. and Lehmann-Willenbrock, N. (2009), “act4teams®: Die nächste Generation der Teamentwicklung”, in *Handbuch Kompetenzentwicklung*, pp. 191–215.

Kelloway, E.K. and Barling, J. (2000), “Knowledge work as organizational behavior”, in *International journal of management reviews*, 2(3), pp. 287–304.

Killeavy, M. and Moloney, A. (2010), “Reflection in a social space: Can blogging support reflective practice for beginning teachers?”, in *Teaching and teacher education*, 26(4), pp. 1070–1076.

Klünder, J., Prenner, N., Windmann, A.K., Stess, M., Nolting, M., Kortum, F., Handke, L., Schneider, K. and Kauffeld, S. (2020), “Do you just discuss or do you solve? meeting analysis in a software project at early stages”, in *Proceedings of the IEEE/ACM 42nd International Conference on Software Engineering Workshops*, pp. 557–562.

Knipfer, K., Kump, B., Wessel, D. and Cress, U. (2013), “Reflection as a catalyst for organisational learning”, in *Studies in continuing education*, 35(1), pp. 30–48.

Konradt, U., Otte, K.-P., Schippers, M.C. and Steenfatt, C. (2016), “Reflexivity in Teams: A Review and New Perspectives”, in *The Journal of Psychology*, 150(2), pp. 153–174. https://doi.org/10.1080/00223980.2015.1050977

Koo, T.K. and Li, M.Y. (2016), “A guideline of selecting and reporting intraclass correlation coefficients for reliability research”, in *Journal of Chiropractic Medicine*, 15(2), pp. 155–163.

Kröll, M. (2020), “Innovations, agile management methods and personnel development”, in *International Conference on Applied Human Factors and Ergonomics*, Springer, Cham, pp. 299–309.

Lehmann-Willenbrock, N. and Allen, J.A. (2014), “How fun are your meetings? Investigating the relationship between humor patterns in team interactions and team performance”, in *Journal of Applied Psychology*, Vol. 99, pp. 1278–1287. https://doi.org/10.1037/a0038083

Lehmann-Willenbrock, N., Allen, J.A. and Meinecke, A.L. (2014), “Observing culture: Differences in U.S.-American and German team meeting behaviors”, in *Group Processes & Intergroup Relations*, Vol. 17, pp. 252–271. https://doi.org/10.1177/1368430213497066

Lehmann-Willenbrock, N. and Kauffeld, S. (2010), “The downside of communication: Complaining cycles in group discussions”, in *S. Schuman (Ed.), The handbook*, CA: Jossey-Bass/Wiley, San Francisco, pp. 33–54.

Maaranen, K. and Krokfors, L. (2007), “Time to think? Primary school teacher students reflecting on their MA thesis research processes”, in *Reflective Practice*, 8(3), 359-373.

Mlekus, L., Bentler, D., Paruzel, A., Kato-Beiderwieden, A.L. and Maier, G.W. (2020), “How to raise technology acceptance: user experience characteristics as technology-inherent determinants”, in *Gruppe. Interaktion. Organisation. Zeitschrift für Angewandte Organisationspsychologie (GIO)*, 51(3), pp. 273–283.

Otte, K.P., Konradt, U., Garbers, Y. and Schippers, M.C. (2017), “Development and validation of the REMINT: a reflection measure for individuals and teams”, in *European Journal of Work and Organizational Psychology*, 26(2), pp. 299–313.

Reymen, I. M. M. J. and Hammer, D.K. (2002), “Structured reflection for improving design processes”, in *DS 30: Proceedings of DESIGN 2002, the 7th International Design Conference*, Dubrovnik, pp. 887–892.

Schippers, M.C., Hartog, D.N. and Koopman, P.L. (2007), “Reflexivity in teams: A measure and correlates”, in *Applied psychology*, 56(2), pp. 189–211.

Schön, D. (1987), *Educating the Reflective Practitioner, Towards a New Design for Teaching and Learning in the Professions*, Jossey-Bass, San Francisco.

Taherdoost, H. (2018), “A review of technology acceptance and adoption models and theories”, in *Procedia manufacturing*, Vol. 22, pp. 960–967.

Weixelbaum, I. (2016), *Mit Teamreflexion zum Teamerfolg: Analyse, Modellierung und gezielte Förderung kollektiver Reflexionsprozesse*, Schriften aus der Fakultät Humanwissenschaften der Otto-Friedrich-Universität Bamberg.

West, M.A. (2000), “Reflexivity, revolution, and innovation in work teams”, in *M.M. Beyerlein, D. Johnson, & S.T. Beyerlein (Eds.), Product development teams*, Vol. 150, CT: JAI Press, Stanford, pp. 1–29.