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Towards an integration of 'sense elements' into a 'focus oriented' automotive product development

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Abstract

The automotive product development is not only defined by its complexity but furthermore by the need of developing creative ideas and innovative solution in a highly competitive field. Here, the highly structured and analytical approach might not always provide the most suitable foundation for creativity. It becomes clear that both approaches and sides are essential when it comes to being innovative on a highly competitive market while also managing the increasing complexity within the development process. The structured focus seems to be fairly established in the automotive industry (e.g. Systems Engineering), resulting in the need to integrate the unstructured sense mode and mitigating a solution to not only combine aspects of both approaches but furthermore try to find a suitable and feasible adaption for the automotive context. Therefore, the question arises how a 'sense mode' can be integrated into a 'focus mode' oriented automotive problem-solving cycle? To answer this research question, a two-part explorative expert study was set-up. Both study parts were executed in cooperation with a project leader of an automotive product development project in an interdisciplinary research project. The first part focussed on the status quo of a product development process in the automotive industry. Therefore, the use case of a new design of a cap from a power electronics developed in the project was used as a lead to visualize the process. Furthermore, current challenges and problems as well as well working elements were identified. The second part of the study then tried to explore possible elements of a more sense-oriented mode and on their possible application in the process. In conclusion it can be said that the possibility exists to integrate sense elements in a focus oriented automotive product development process. Still a fine tuning of those elements is needed. The study gave a first outlook on the feasibility for sense elements integration. In general, it seems to be it is essential to introduce the elements slowly and apieced as well as accompanied by instructors. Not only the accompanied

instructions seemed to be critical but also the project-cultural base is relevant for users to feel secure and at ease when integrating sense elements that might be untypical and uncomfortable at first.

Keywords: sense and focus mode; automotive product development; tangible business process modelling; Systems Engineering; Design Thinking.

1 Introduction

The rapid change in the environment of new mobility has a direct impact on the entire value chain in the automotive industry from idea generation to planning, development and production. The basis for the development of future products in the automotive industry is finding new creative and innovative solutions and ideas. Currently, problem solving cycles such as Systems Engineering play an important role when it comes to applied processes, approaches, and mindsets. These approaches are defined by structure and are analytical. They are applied to make highly complex environments manageable for product developers (Gausemeier et al., 2013; Haberfellner, Weck, Fricke, & Vössner, 2019). Still, the automotive environment is not only defined by its complexity, but, furthermore, by the need of developing creative ideas and innovative solutions in a highly competitive field. Here, the highly structured and analytical approach might not always provide the most suitable foundation for creativity.

To master this contradicting environment of - on the one hand being able to manage the complexity of the automotive product development - but on the other hand still being open and inspired to be creative, a closer look needs to be taken on these two approaches.

In literature the two opposite viewpoints are described by different researchers and disciplines. According to Arnold (1956) creative thinking can be categorized in an ‘organized approach’ and an ‘inspired approach’. Greene et al. (2017) analyzed the two different approaches and their associated attitudes. She tried to define the contradictory items when it comes to attitudes towards Systems Engineering and Design Thinking. In neuroscience these two sides are illustrated as the dual pathway model, with flexibility and persistence as the two dominant elements (Nijstad, Dreu, Rietzschel, & Baas, 2010). According to von Thienen and Meinel (2019), these two viewpoints can also be defined as ‘sense mode’ defined by means of feeling and ‘focus mode’ defined by means of reason. The sense mode is determined by feelings, referring to doing what feels right as well as acting spontaneously and in a playful way. This mode is unstructured and derives from intuition and impulses and is driven by curiosity. When working in this mode, creative leaps can be reached, opposed to the focus mode, where less novel but sophisticated and highly developed and perfected results are in focus. This mode is characterized by its rational planning and acting based on knowledge to analyse and synthesize material (von Thienen & Meinel, 2019). An overview of these contradicting approaches is visualized in figure 1.

When it comes to actively applied approaches Systems Engineering and Design Thinking are a byword for the contradicting and opposing sides described above. Systems Engineering is an approach already established in automotive practice and is used in the field of complex system design (Greene et al., 2017). It is an integrative approach for the successful realization of technical systems using system principles and concepts as well as various methods (INCOSE, 2007). Design Thinking has so far encompassed the areas of product development and industrial design (Greene et al., 2017). It is a user-oriented approach that focuses on human-centered problem solving. Here, the focus is on the needs and requirements of the user instead of the technical solution to the problem (Schallmo, Williams, & Lang, 2018). To date, the approaches have largely been considered separately from one another (Greene et al., 2017).

A study conducted by the University College of Southeast Norway investigated which factors have a positive effect on the development of complex systems. The study found, that human factors need to be integrated into Systems Engineering in order to develop innovative systems (Sjøkvist & Kjørstad, 2019). Shafaat and Kentley (2015) also see the lack of human and cognitive aspects as a weakness of Systems Engineering (Shafaat & Kenley, 2015). In addition, the increasing complexity in Systems Engineering, especially in automotive product development, leads to so-called "ill-defined problems" in the early phases. These ill-defined problems are not covered in the Systems Engineering approach and thus represent another possible weak point (Tekaat, Kharatyan, Anacker, & Dumitrescu, 2019).
It becomes clear that both approaches and sides are essential when it comes to being innovative on a highly competitive market while also managing the increasing complexity whithin the development process. The structured focus seems to be fairly established in the automotive industry (e.g. Systems Engineering), resulting in the need to integrate the unstructured sense mode and mitigating a solution to not only combine aspects of both approaches but furthermore try to find a suitable and feasible adaption for the automotive context.
Therefore, the question arises how a ‘sense mode’ can be integrated into a ‘focus mode’ oriented automotive problem-solving cycle. To answer this question, it is important to analyse how sense elements can be construed to fit in the process and gain acceptance within the automotive product development environment. Furthermore, it is essential to take a closer look at the current development process and identify possible fields of applications together with the user.

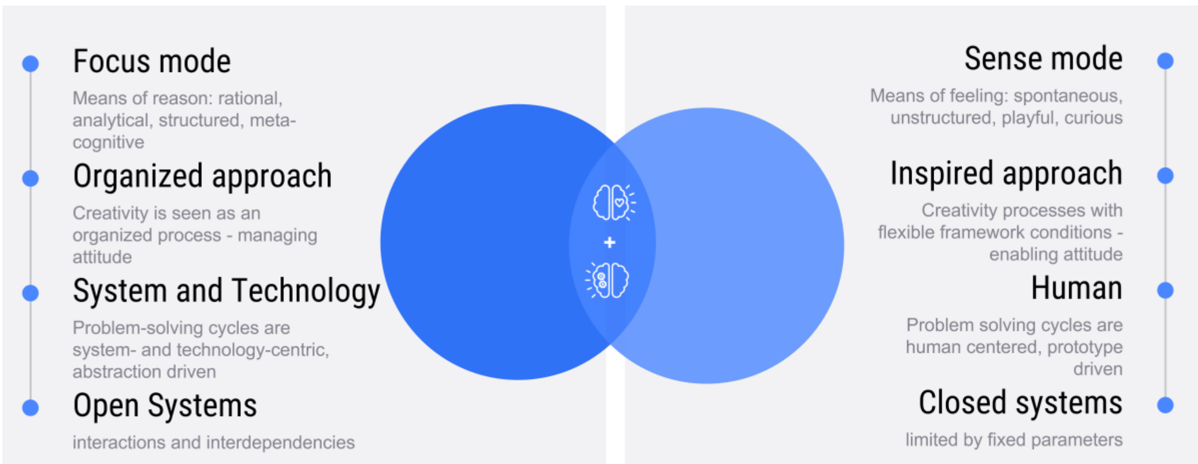

Figure 1. Two opposing approaches to creativity

2 Method

To answer this research question, a two-part explorative expert study was set-up. Both study parts were executed in cooperation with a project leader of an automotive product development project in an interdisciplinary research project. The first part focussed on the status quo of a product development process in the automotive industry. Therefore, the use case of a new design of a cap from a power electronics, which was developed in the project, was used as a lead to visualize the process. Furthermore, current challenges and problems as well as well working elements were identified. The second part of the study then tried to explore possible elements of a more sense-oriented mode and on their possible application in the process.

2.1 Phase 1: Use Case

The first part of the study took approximately one hour. Together with the project leader the different steps to derive from the inital problem of the development process to the solution were illustrated. To be able to incorporate the project leader directly into the modelling of their development process it was decided to apply an adapted version of tangible business process modelling (tbpm). When adopting this approach during the study the expert had the option to co-design the process together with researchers rather than just being interviewed. Furthermore, this approach enabled a hands-on development process from both sites with a shared working space. The expert had the opportunity to 'jump around' within the process and go back in the storyline to reach a higher consensus between researchers and expert (Edelman, Grosskopf, Weske, & Leifer, 2009; Lübbe, 2011).

To prepare the tbpm and structure the study, a template was constructed. Therefore, process steps cards were prepared that stated who was involved in the process, what the goal was, what methods were used and what the resulting end-product of the process phase entailed. In combination with a problem statement, a picture of the resulting solution (power electronic) and a whiteboard canvas, the first part of the study started.

After a short introduction into the study format and signage of the data protection the expert was asked to recall and explain the development process step by step. Together the template process phase cards were filled in and allocated to their position within the process. Inbetween some cards were revised. After all process phases were positioned and filled out, the corresponding arrows were drawn on the whiteboard canvas to connect related phases and visualize the process flow. Moreover, the time frame of the process was noted.

Afterwards, the expert was asked to evaluate the process and pin down challenges and problems as well as elements that should not be changed because they are already working as wished. These elements were noted down on green and red sticky notes and allocated to the phase they occured the most. On transparent sticky notes, ideas were collected that indicated how problems and challenges could be changed. These sticky notes were put down above the challenge/problem to connect them visually.

2.2 Phase 2: Sense Elements

The second phase of the workshop then focussed on a possible future of the process and studied how sense elements could be integrated and change current problems. Therefore, the first part of the study was analysed and based on literature, fitting sense elements were established. To provide a short overview on what these elements entailed sense elements cards were designed (see figure 2). Here, the characteristics of the elements were presented, such as how and what the element is intended for, why this element could be important and when the element should be used. Furthermore, extras such as videos or templates were used for easier understanding of the elements. In total, four elements were presented and discussed with the expert (mind wandering, creativity methods, warm-ups, ProTable/interactive tabletop). During the second study session these cards were presented to the expert. After each short introduction, the card was turned to note down points for evaluation. The evaluation was structured on the backside on the card to guide the discussion between the expert and the researchers. Main points of the evaluation dealt with what aspects of the elements seemed feasible and what aspects pose a challenge. Furthermore, it was discussed how to change these elements and what would be essential to integrate them to the process. In the end, after all elements and cards were reviewed, the elements were ranked on a scale by the expert according to the likelihood they could be integrated and accepted. The second part of the study took approximately one hour.

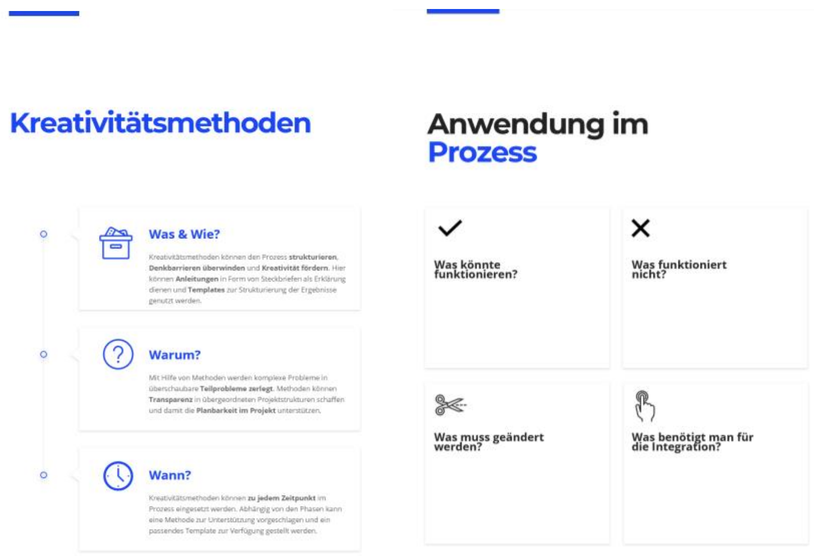

Figure 2. Sense elements cards – explanation and template for evaluation

3 Results

The two-stage study resulted in four main results: the visualized use case, the challenges and well running elements within the use case, the evaluation of suitable sense elements within this use case and the ranking of those elements. An overview on these different results is given below.

3.1 Use Case

The studied use case/project entailed the development of a cyberphysical lid/cap for a power electronics. The use case tries to depict the current status quo of a product development process with its problem-solving cycles. The whole development process as well as the problem definition of this use case was based on a sample component of a power electronics. The goal was to equip the lid of the power electronics with sensors as well as basing the applied material of the lid predominantly on fiber-reinforced composites. Resulting challenges included the use of fiber-reinforced composites since no sharp edges are possible as well as the integration of the sensor technology into the lid. The project manager/expert then presented the current solution to the problem. The aim of the project is to collect live data of the sensors, such as forces or acceleration which act upon the component. Moreover, the focus of the development was laid on "predictive maintenance" to provide preventive maintenance of the component based on collected data if necessary. In addition to reading out the data by the sensors, the replacement of aluminium by fiber composites was also intended to save weight of the component itself. The implementation of these goals was then realized in a first prototype, a ‚MVP‘. MVP stands for Minimum Viable Product and in the context of the project regards to a first prototype that should be produced as early as possible within the problem-solving cycle. This procedure was continued throughout the rest of the process, so that new prototypes could always be created, or improvements and updates were integrated to the current MVP.
After the boundary conditions of the project had been presented, the project manager described the step-by-step procedure of the development process. Therefore, the prepared cards were filled regarding the questions what was done, who was involved, how it was implemented and the result of the step. Figure 3 shows the tangible use case model with its different steps, which are briefly described below.

The first step of the process dealt with the requirements analysis. For this step, the requirements specification of the original power electronics was analyzed together with all project partners. The original specifications were shortened to the information necessary to the project and then expanded with new requirements. In addition, a first analogue drawing of the product was made. The boundary conditions and information were taken up in the next step to create a CAD model. Since 3D printing was used as a manufacturing process for the production with fiber composites, the project team also created a CAD negative model in addition to the CAD model. The next step during the process was to create the first 3D print, which also served as a feasibility study. The resulting prototype was then presented and discussed with the other project members. The first three steps took about six months. Subsequently, the further development was splatted up to different smaller teams defined by their disciplines and knowledge. The areas included toolmaking, simulation, 3D printing, materials research and sensor connection. Here a so called ‘cooperation week’ was used for exchange between the areas and teams. The set-up of the individual meetings was dependent on the problem. Therefore, the meetings were planned and carried out without a predefined structure. In addition to the cooperation week, meetings and exchanges also took place between the individual teams.

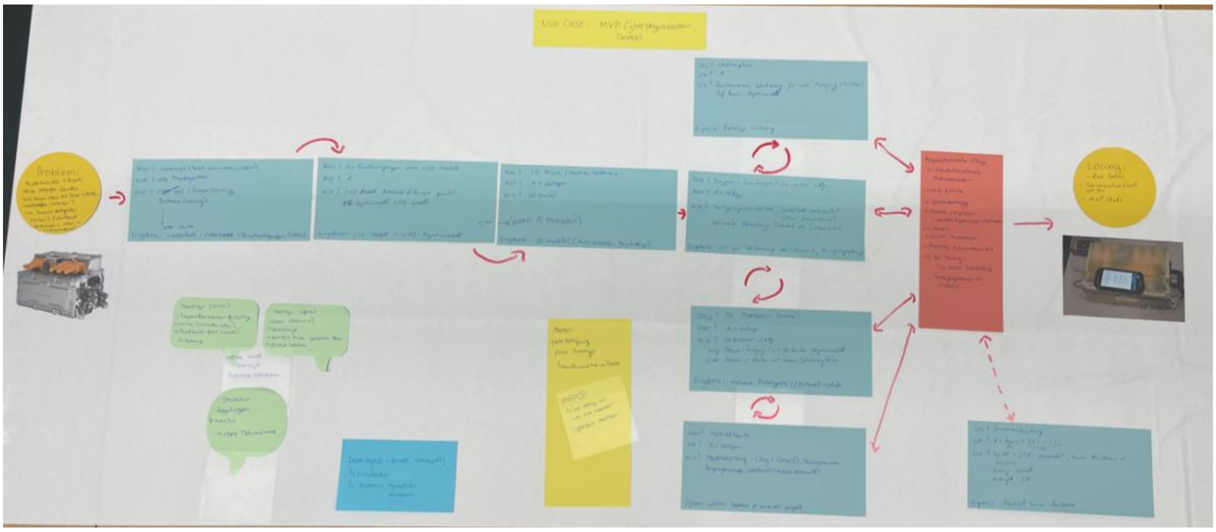

Figure 3. Tangible use case model

3.2 Evaluation of the Use Case

The use case provided a base for suitable connecting points for sense elements as well as interchangeable elements that might be convertible to sense elements. Therefore, the evaluation of the process/use case was essential to reach insight into thoughts behind the different steps as well as to grasp the intention of the product developers and their decisions and actions. One main point during the discussion with the expert was the MVP. The focus on an early MVP was seen as essential to the development process and should be part of every future process. It was an element that was newly introduced and not yet emerged in other processes. The purpose of an MVP was to make the product tangible and to identify initial errors. In comparison to the rest of the process this element can be allocated to the ‘sense-mode’ with a focus on the early phases with an early materialization of ideas that are graspable for developers. Other elements that depict a focus on early phases of a problem solving cycle or putting the problem in centre rather than the solution, could not be detected in the use case. In general, the process was focus oriented with a main focus on finding a solution in an analytical manner. This can also be detected when it comes to the use of creativity methods and the time spent on the problem itself.

The first phase was the only phase that dealt with understanding and getting a grasp of the problem and not finding a solution. Furthermore, it was the only phase where a creativity method was applied (brainstorming). The micro level of the process reflects the focus mode. Although, some aspects and decision were drawn based on intuition, this intuition evolved from an analytical and highly structured experience and knowledge of solving problems. The macro level with its cooperation weeks was highly structured and process oriented. The cooperation week format allowed for fast communication tracks and easy interaction and communication which was seen as positive. Still the process stayed on a highly (meta-) cognitive level. The challenge and/or problem that was described was the slow starting communication – with only ‘monologues’ and focus on one person and missing feedback and interaction. Although the interaction format provided easy ways of communication, the communication/interaction sometimes started of slowly.

3.3 Construction sense elements

Based on these results it was decided to introduce four elements that might fit the use case and automotive product development process as well as putting more focus on a sense-oriented-mode. The first element ‚**warm-ups**‘, was chosen due to the problematic of the only slow starting communication and interaction. Here, warm-ups could start of an interaction more easyly an serve as an ‚ice-breaker‘. Furthermore, warm-ups provide the opportunity to optimize the ideation process (So, Jun, & Nah, 2016).
As a second element **creativity methods** were chosen. Here, the methods presented by Lewrick, Link and Leifer (2020) were used as a base for explanation. These creativity methods are a part of Design Thinking and try to support users during a creativity process while also laying the focus on playful and curious way of acting. Creativity methods encompass a variety of advantages. With the help of methods, complex problems are broken down into manageable sub-problems. Methods can create transparency in higher-level project structures and thus support plannability and promote comprehensible documentation, which in turn supports decision-making processes and offers the possibility of cross-project knowledge transfer. Furthermore, methods can help overcome barriers and promote creativity that is necessary for the development process (Becerril, Guertler, & Longa, 2019; Ehrlenspiel & Meerkamm, 2017).
Another element that was set-up based on the analysis was ‚**mind wandering**‘. Due to the process being highly analytical and focussed on cognitive control and meta cognitive abilities it seemed to be essential to detach and uncouple the user partly from the process. Low cognitive control and switching neurologically to the default mode network can lead to creative insights as well as empower the playful sight (Brandmeyer & Delorme, 2020).
The last element that was decided on was an **interactive tabletop**. This tool could function as an interactive base to manage the process while also providing the users with all their familiar tools (e.g. CAD tools, project management tools). The features of this element were based on IDEA (interactive development environment assistant). Here users have the opportunity to share ideas on an interactive surface (ProTable - Bues, Wingert, & Riedel, 2018) whiteboard while also being able to jointly interact and share their tools on a common space (Kaschub, Wechner, Lossack, & Bues, 2021a; Kaschub, Wechner, Lossack, & Bues, 2021b) (see figure 4).
This interactive tabletop could provide support on managing the process (giving structure, collecting developed material) as well as provide distributed cognition for product developers to transfer their current ideas and thoughts to a tool (e.g. whiteboard). This could then lead to product developers needing lower level of cognitive control and being more spontaneous and unstructured (Davis, Winnemöller, Dontcheva, & Yi-Luen Do, 2013).

Figure 4. Interactive Tabletop – IDEA Tool on the ProTable

3.4 Evaluation and ranking of suitable sense elements

The second part of the study tried to analyse the sense elements described above and rank them together with the expert. In general, the elements were perceived well. Only when it came to the specific context and their possible integration to the actual process challenges and implementation barriers emerged. In general, the use of warm-ups is conceivable. Particularly at the start of the project or when new team members start in the team. Furthermore, adjustments should be made to the warm-ups to adapt them to the team. For integration a facilitator should be available, and a non-judgmental atmosphere should prevail. Still not every meeting should start with a warm-up session. It seems that during special occasions these warm-up sessions are tolerated but if applied in an frequent manner they seem to impede the process itself.
Also, the implementation and use of (more) creativity methods was considered in a positive to neutral manner. The presented methods (see Lewrick, Link and Leifer, 2020) were predominantly preferred to take place during the early phases to support the formulation and understanding of the problem. Other phases could also be supported by creativity methods. Still, creativity methods would have to be adapted to fit the context. A method-expert should be available for integration, who can make suitable method suggestions depending on the situation and according to the experience level of the product developers and maturity of the product itself.
The element ‚mind wandering‘ was perceived in a neutral manner. Here, the ‘level’ of implementation defined the perceived usefulness and acceptance. On a non-intrusive level (e.g. take coffee breaks, go for a walk to break out of the task) an implementation was agreed with but with more intrusive ways to reach a break out of the task and get into the default mode network (e.g. short meditation, mindfulness task) there was insecurity. This element required the need for users to feel at ease and not be judged even more than compared to warm-up sessions. A slow integration and increase might be feasible. Still, also here the general project-culture of the team seems to be essential to provide a fruitful base for acceptance.
The last element ‘interactive tabletop‘ was introduced with a short video for easier understanding. This element seemed to be difficult to grasp due to the missing option for directly experiencing it. The advantage compared to a normal projection was therefore difficult to determine. Here, only direct experience and testing can provide a suitable ground for further analysis on implementation.
At the end of the second study, the elements were sorted and ranked according to their applicability in future development projects. Almost all elements were given the same neutral

to positive rank. Only the element of ‚creativity methods‘ was classified as more suitable. In the discussion the most important requirement to further evaluate the elements was to experience them in an actual process.

4 Conclusion and Discussion

In conclusion it can be said that the possibility exists to integrate sense elements in a focus oriented automotive product development process. Still a fine tuning of these elements is needed. The study gave a first outlook on the feasibility of general integration for sense elements. A fine-tuning of the element ‚warm up‘ could study how a given scientific explanation on the advantages of its use can have for an impact. Furthermore, a closer look can be taken at how the habit forming of applying a warm up in the beginning of each session could have and how it is accepted when being a 'regular' procedure in the beginning of each session. Also, the element of creativity methods could benefit from further fine-tuning. Here, a possible digital method selection based on situational context data can be tested out in the process. An example of this method selection is provided by Reiß and the InnoFox project (Albers, Reiss, Bursac, Walter, & Gladysz, 2015; Reiß, 2018). With all elements the study showed, it is essential to not be too intrusive and it might be suitable to integrate the option to offer sense elements and product developers can decide for themselves if they want to apply these elements in this particular situation. If experienced, the elements might uncover their benefits directly to users and therefore might be used more frequently in the future. Therefore, it seems to be essential to integrate these elements in a use case and test them out directly in an actual development context.

In general, it seems to be essential to introduce the elements slowly and apieced as well as accompanied by instructors. Here, it might be interesting to take a closer look on how the accompany of instruction could look like. For example, a user interface of a supportive tool that accompanies the development process might also be feasible. Not only the accompanied instructions seemed to be critical but also the project-cultural base is relevant for users to feel secure and at ease when integrating sense elements that might be untypical and uncomfortable at first. Here the critical success factors of De Paula, Dobrigkeit and Cormican (2019) developed for integrating Design Thinking could also assist the implementation of these particular sense elements.

It needs to be taken into consideration that the explorative study only analysed one use case and development project. Other projects should be taken into account to detect other suitable sense elements as well as evaluate and validate the sense elements in this study. The current study provided a first outlook on suitable integration points and gave first hints and guidance for real implementation.

References

Albers, A., Reiss, N., Bursac, N., Walter, B., & Gladysz, B. (2015). *InnoFox – Situationsspezifische Methodenempfehlung im Produktentstehungsprozess*.

Arnold, J. E. (1956). Creativity in engineering. *SAE Transactions*, 17–23.

Becerril, L., Guertler, M., & Longa, E. (2019). Developing Design Methods - a Conceptual Requirement Framework. *Proceedings of the Design Society: International Conference on Engineering Design*, *1*(1), 1463–1472. https://doi.org/DOI: 10.1017/dsi.2019.152

Brandmeyer, T., & Delorme, A. (2020). Meditation and the Wandering Mind: A Theoretical Framework of Underlying Neurocognitive Mechanisms. *Perspectives on Psychological Science*. https://doi.org/10.1177/1745691620917340

Bues, M., Wingert, B., & Riedel, O. (2018). VD1: A technical approach to a hybrid 2D and 3D desktop environment. *2018 IEEE 11th Workshop on Software Engineering and Architectures for Real-Time Interactive Systems, SEARIS 2018*. https://doi.org/10.1109/SEARIS44442.2018.9180231

Davis, N., Winnemöller, H., Dontcheva, M., & Yi-Luen Do, E. (2013). *Toward a Cognitive Theory of Creativity Support*.

De Paula, D., Dobrigkeit, F., & Cormican, K. (2019). Doing it Right - Critical Success Factors for Design Thinking Implementation. *Proceedings of the Design Society: International Conference on Engineering Design*, *1*(1), 3851–3860. https://doi.org/DOI: 10.1017/dsi.2019.392

Edelman, J., Grosskopf, A., Weske, M., & Leifer, L. (2009). Tangible business process modeling: a new approach. *Proceedings of the 17th International Conference on Engineering Design, ICED*, *9*, 153–168.

Ehrlenspiel, K., & Meerkamm, H. (2017). *Integrierte Produktentwicklung: Denkabläufe, Methodeneinsatz, Zusammenarbeit*. Carl Hanser Verlag GmbH Co KG.

Gausemeier, J., Czaja, A., Wiederkehr, O., Dumitrescu, R., Tschirner, C., & Steffen, D. (2013). Studie: Systems Engineering in der industriellen Praxis. In *Tag des Systems Engineering* (pp. 113–122). https://doi.org/10.3139/9783446439467.012

Greene, M., Gonzalez, R., Papalambros, P., & McGowan, A. M. (2017). Design thinking vs. systems thinking for engineering design: What's the difference? *Proceedings of the International Conference on Engineering Design, ICED*.

Haberfellner, R., Weck, O. de, Fricke, E., & Vössner, S. (2019). *Systems Engineering: Fundamentals and Applications*.

INCOSE. (2007). *Systems Engineering Vision 2020. Hrsg. von INCOSE Technical Operations.*

Kaschub, Verena Lisa, Wechner, R., Lossack, R., & Bues, M. (2021). A collaborative and interactive surface concept for early stages of new product development – a multi-stage expert study. *ICPR26 - International Conference on Production Research*. Taichung, Taiwan: ICPR.

Kaschub, Verene Lisa, Wechner, R., Lossack, R., & Bues, M. (2021). IDEA - Towards an interactive intelligent supportive tool that facilitates collaborative creativity sessions. *The Disruptive Role of Data, AI and Ecosystems in Services : Proceedings of the 31th RESER Conference; Heilbronn, Germany, 14th - 15th October 2021*, S.383-392.

Lewrick, M., Link, P., & Leifer, L. (2020). *The design thinking toolbox: A guide to mastering the most popular and valuable innovation methods*. John Wiley & Sons.

Lübbe, A. (2011). Tangible business process modeling–design and evaluation of a process model elicitation technique. *Diss., Universität Potsdam*.

Nijstad, B. A., Dreu, C. K. W. De, Rietzschel, E. F., & Baas, M. (2010). The dual pathway to creativity model: Creative ideation as a function of flexibility and persistence. *Http://Dx.Doi.Org/10.1080/10463281003765323*, *21*(1), 34–77. https://doi.org/10.1080/10463281003765323

Reiß, N. (2018). *Ansätze zur Steigerung der Methodenakzeptanz in agilen Prozessen der PGE -Produktgenerationsentwicklung* (Karlsruher Institut für Technologie (KIT)). https://doi.org/10.5445/IR/1000084762

Schallmo, D., Williams, C. A., & Lang, K. (2018). An integrated design thinking approach-literature review, basic principles and roadmap for design thinking. *ISPIM Innovation Symposium*, 1–18. The International Society for Professional Innovation Management (ISPIM).

Shafaat, A., & Kenley, C. R. (2015). Exploring the role of design in systems engineering. *INCOSE International Symposium*, *25*(1), 357–370. Wiley Online Library.

Sjøkvist, N. M., & Kjørstad, M. (2019). Eliciting Human Values by Applying Design Thinking Techniques in Systems Engineering. *INCOSE International Symposium*, *29*(1), 478–499. https://doi.org/10.1002/j.2334-5837.2019.00615.x

So, C., Jun, S., & Nah, K. (2016). Configuring time for creativity: How to optimize the ideation process in design thinking workshops. *International Journal of Design Management and Professional Practice*, *10*(4), 25–33. https://doi.org/10.18848/2325-162X/CGP/V10I04/25-33

Tekaat, J., Kharatyan, A., Anacker, H., & Dumitrescu, R. (2019). Potentials for the integration of design thinking along automotive systems engineering focusing security and safety. *Proceedings of the International Conference on Engineering Design, ICED*, *2019-August*, 2883–2892. https://doi.org/10.1017/dsi.2019.295

von Thienen, J. P., & Meinel, C. (2019). Balancing Child-Like and Adult Approaches in Creative Pursuits: The Sense-Focus Model of Creative Mastery. *EC3 – 3rd MIC Conference*, 36–39. Bologna.