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The Emoji Method: An Approach for Identifying and Formulating Problem Ideas

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***Abstract*—**For the analysis of already identified and existing problems, the pertinent literature provides a comprehensive collection of approaches as well as methods in order to analyze the problems in detail. But coming up with problems, which are assets worth pursuing further, is often challenging. However, the importance of well-formulated problem ideas and their influence of subsequent creative processes are incontestable and proven. In order to meet the covered challenges, the Institute for Engineering Design and Industrial Design (IKTD) developed the Emoji Method. This paper presents the Emoji Method, which support designers to generate problem ideas in a structured way. Considering research findings from knowledge management and innovation management, research into emojis and emoticons reveal insights by means of identifying and formulating problem ideas within the early design phase. The simple application and the huge supporting potential of the Emoji Method within the early design phase are only few of the many successful results of the conducted evaluation. The Emoji Method encourages designers to identify problem ideas and describe them in a structured way in order to start focused with generating solution ideas for the revealed problem ideas.

***Keywords*—**Emojis, problem ideas, innovation management, knowledge management.

I. Introduction

THE domain of design and, in particular, the domain of engineering design are very often considered to be very solution-oriented [3]. "The main task of engineers is to apply their scientific and engineering knowledge to the solution of technical problems […]. Problems become concrete tasks after the problems that engineers have to solve to create new technical products (artefacts) are clarified and defined" [1]. This quoted proposition is the introduction to a book published by [2], which provides the most established and important references on systematic engineering design in industry, research and education, primarily in German-speaking countries. In early design research, it was considered as a milestone in design education and still has an excellent reputation in many areas. Despite various valuable insights conducted based on the findings of Pahl and Beitz, the core statement of the introductory quote "…to apply their […] knowledge to the solution of technical problems…" still represents a current challenge in design research and industry, as well as education. Many of the design approaches differ distinctly in their structure, process or scope, but they all target the same objective: to provide solutions to technical problems.

Engineers are very well known for finding new solutions to problems. However, referring back to the quotation at the beginning of this paper, tasks seem to always be given to engineers and designers. In other words, the task of finding new problems or needs which might help humans in the future while problems are solved or the need is met does not seem like a typical designer's task. Real design problems are solution-oriented rather than problem-oriented, in a manner of speaking [3].

II. Problem Statement and Goals

A. Problem Statement

In general, this paper focuses on the problem-oriented perspective of the design process and deals with a new method which can be used by designers to analyze new problems and derive new problem ideas. These ideas serve as a task for the subsequent steps of the design process, thus the method addresses the very early phases of a design process, which can be defined as a dynamic, often disarranged phase, with few general methods and statements [4].

What we have learned from literature – and from several projects with industrial experts – is that the very early phases of the design process are not considered as important by designers and managers. This is underlined by [5], who claim that managers focus their management attention on the late, highly structured phase despite their knowledge that the factor decisive for project success lies in the early phases of the design process. In addition to this fact, [6] and [7] declare the beginning of the design process to be the most important stage for achieving development success.

B. Goal

In the course of our institute's internal research cooperation between the two research disciplines of Knowledge Management and Innovation Management, our goal is to develop an entire process and also individual methods which support the front-end phase of the design process. By doing so, the problem-orientation of the design activities in the early phases should firstly be emphasized, while secondly, designers should be able to define new problem ideas which result in new and innovative products. This paper's specific goal is to present a brief process model of the front-end phase, which usefully expands on existing early process models of the design process. In addition, a method called the Emoji Method

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is developed for identifying and formulating new problem ideas. This method supports the initial step of the aforementioned process and constitutes the main scientific contribution of this paper. In doing so, the primary goal is to structure the front-end phase of a design process in more detail. Our first focus was to structure this phase from a knowledge-management perspective. In addition, the process of using the Emoji Method for deriving new problem ideas is one step taken to support the process of developing more radical product ideas, which forms part of a research project in the field of Innovation Management at our institute.

III. Methodological Approach

The Design Research Methodology (DRM), according to [8], comprises the methodological foundation for structuring this paper. The methodology initially includes the Research Clarification, followed by Descriptive Study I, Prescriptive Study I and, finally, Descriptive Study II [8]. Within the first three chapters, the research aims are elucidated to represent the Research Clarification. In Chapter IV, insights into the pertinent literature regarding the state of the art are presented. This chapter comprises Descriptive Study I and develops a wider background for the problem in order to obtain a better understanding, in addition to including the four main topics related to this paper. The first part addresses the localization within the procedural landscape, where the Emoji Method is to be used. In the second part, different process models are presented with the focus on existing deficiencies regarding problem-oriented thinking. The third part represents a terminological clarification of the term "problem idea", which is necessary for the further understanding. The last part of Chapter IV deals with current research into emoticons and emojis, and provides relevant background information for a comprehensive vision of the Emoji Method. Based on the current situation shown, the description of the developed holistic idea process and the presentation of the Emoji Method form part of the third stage of the DRM, namely the Prescriptive Study (see Chapter V and Chapter VI.) This is an approach for bridging the gap analyzed in the pertinent literature.

At the end, within Descriptive Study 2, the presented approaches and the method are evaluated. This is presented in Chapter VII, while the results are critically discussed in Chapter VIII, which leads into a final conclusion and approaches for further enhancements (see Chapter IX).

IV. State of the Art

In the following Chapter IV, the four main topics related to this paper will be briefly presented in order to demonstrate the gap in the state of the art and provide a deeper understanding of the topic and its deficits. Firstly, the early phases of the design process are defined and briefly discussed (Section IV *A*). Existing theoretical approaches for process models for the early phases are subsequently presented (Section IV *B*). These two sections are intended to provide the necessary background knowledge to which the paper will refer. Thirdly, the term "problem idea" is discussed and defined in order to deliver a foundation for the paper (Section IV *C*). At the end of this section, the increasing role of emojis and the influence of emotions on the derivation of new product ideas are discussed (Section IV *D*). This discussion takes place because it is our main contention that emojis can be used to derive new problem ideas.

A. The Early Phases of the Design Process

The design process is often referred to using the term "product development process" if one considers it from the perspective of a product developer or mechanical engineer [1]. Nevertheless, the design process refers to the term "innovation process" if one takes the perspective of an innovation manager [9], [10]. All the same, the design process is – generally speaking – usually a formal, well-structured process characterized by a large amount of formalism with a prescribed set of activities, according to [11]. However, the front-end phase of this process is defined by those activities that come before the formal and well-structured phases [11]. The front-end phase or – as it is also called – the early phases of the design process, in particular of a "new product development" project (or of an "original design", as it is called by [1]), has been examined extensively [12]. The importance of these phases is emphasized by several scholars (inter alia [7], [13], [14]). However, the early phases are often considered to be "fuzzy" [6], [15], which is taken to mean that these phases are defined by a very dynamic, uncertain and only partly structured character whose arrangements are very individually influenced by the character of the current project [15]. The early phases therefore also present one of the greatest opportunities for making improvements within the process [16]. This is underlined by a study by [7], where managers of several companies indicate the fuzzy front end as the greatest weakness in the product innovation process. For [4], as well as [15], the front-end phases define all activities starting from the first stimulus for a new product opportunity or a service and ending with the decision as to whether a new project idea should be evaluated, ready for the following steps of the design process. So, activities like idea generation, assessment of the market and the definition of technology, competition and the product are often part of these phases [6]. However, there are several other similar, clear definitions of the early phases, for instance [7], [11], [17]. Additionally, [18] presents an overview of various different perspectives on the front-end phase. The aforementioned temporal definitions of the early phases of the design process by [4] and [15] is also used in this paper.

B. Process Models for the Early Phases

Different scholars have tried to define the early phases by delivering an increasingly structured process model for the fuzzy front end (inter alia [16], [19], [20]). The most frequently mentioned approach is to present an "idea process model", which represents the step of idea creation and different evaluation steps until the idea is driven forward further as an idea-management approach. Several references

define the idea process as part of the planning step of the product development process [21], which must be traversed before a detailed design specification is developed, in particular within original design projects.

Nearly all approaches for idea processes have in common that they start from the initial step of idea creation (often by recommending the use of several creative techniques), pass through different evaluation steps and end with a selection of a solution idea for a new innovation project [21]-[31]. To give an example for such a process model, the generic approach of [30] is shown in Fig. 1. This approach demonstrates the most important steps or contents of an idea process: a step of idea creation, idea capture and different steps of idea detailing, as well as idea evaluation (here: three evaluation steps = rough, precise and detailed evaluation steps) and idea selection, plus the use of an idea storage pool in parallel.

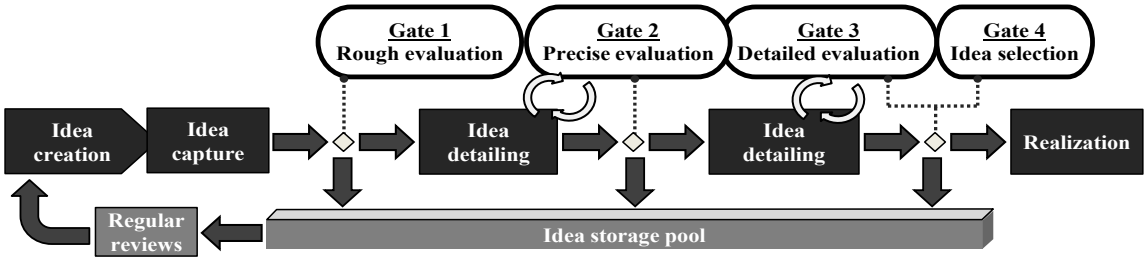


Fig. 1 Example of an idea process model according [30]

What can also be determined is that all approaches mostly refer to solution ideas, thus most of the approaches are very solution-oriented. Most of the existing approaches refer to the addressed problem only by recommending a more detailed definition of the underlying problem [21]. Detailed methods for how to do so are not distributed in a substantial way.

One reason for this fact might be that the steps before solution idea creation or problem analysis are not related to the tasks of the designers. By using typical tools such as trend analysis, strategic roadmaps, scenario planning, product portfolios or market research instruments [11], new future research and search fields are derived and preliminary opportunities are identified [7]. These tasks often refer to other disciplines within a company. Therefore, the problem or the task of developing new products is often born out of strategic management, or the Marketing or Sales Departments. They convey a customer's problem or need to the designer. The designers often merely receive the problem and are not involved in the creation or definition of the problem, which contradicts the user-centered method of designing.

Reference [32] discusses the interface between the so-called search field analysis and the actual idea process. They contend that the interface is of a very high interest and importance, although there is no approach for how the analysis of new opportunities might be integrated into a generic idea process. In addition, the communication within this interface is not significantly pronounced. Only a missing problem analysis and a missing analysis of the current situation in most of the approaches before creating new solution ideas were analyzed [32].

To summarize the first part of the analysis of the state of the art, one important conclusion can be drawn: None of the approaches for an idea process provide advice on defining new problems and thus new tasks for a new design challenge. Of course, there are some approaches, such as Design Thinking, which try to identify new products by centering on the customer's needs, although this problem-oriented perspective in the front-end phase of the design process should be expanded much further. Initial investigations show that by deploying the designer in the process of defining new opportunities, the designer's mindset can change positively, while a foundation for more radical product ideas can also be laid (see Chapter VII).

C. Discussion and Definition of the Term "Problem Idea"

As one of this paper's main objectives is to define new design opportunities, challenges or customer needs, a clear definition of these issues should be given in the following. To summarize these analyzing objects, different terms from pertinent references were analyzed, with the results being presented in the following paragraphs.

In order to use a general term for the aforementioned items, the term "problem idea" should be introduced. A short discussion on the basic term "problem" helps to generalize the different characteristics of this item, thus it must first be clarified exactly what a problem is in order to be able to describe the term "problem idea" and create a uniform understanding of this term.

A problem exists if "[…] an individual does not consider the present or predicted state of a material or ideal problem object to be desirable for whatever reason, but is unable to immediately transform the problem object into the desirable state" [33]. Reference [34] defined a problem as a "difficult task which arises when the available knowledge is not sufficient to be able to achieve the goal or to solve an upcoming task or it is not clear which steps have to be taken to solve a task or to answer a question" [34].

A very general definition of the term "problem" is given by [35]: "A 'problem' arises, for instance, when a living entity has a goal and does not 'know' how to reach that goal. Wherever the given state cannot be converted into the aspired state by mere action […], thinking is called into action" [35].

The core fact of all such definitions that have their origin in different scientific fields is the non-existent knowledge needed

in order to reach a goal. Reference [36] attempts to chart this connection (see Fig. 2). One problem is the relation between an unfortunate starting point and a desired condition, where the actions needed to get from the unfortunate starting position to the desired condition are unknown [36]. This is very similar to the model of a problem published by [37], whereby he differentiates between three components of a problem: the unfortunate starting point $s_{\alpha,}$ desired final state s_{ω} and the barrier, which prevents the transformation from s_{α} to s_{ω} at the moment [37].

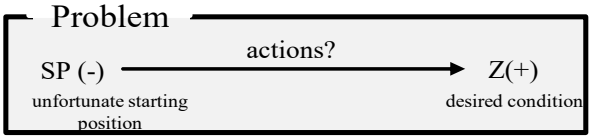


Fig. 2 Components of a problem according to [36]

In order to consider the term "problem" within the context of the early phases of the design process, the following theories should be discussed.

Firstly, [37]-[39] differentiate between well-defined and ill-defined problems. "Well-defined" means that solutions for that kind of problem already exist. It is possible that only one correct solution is present, for instance a rule, which can be determined with certainty or a guaranteed procedure for reaching the solution. "Ill-defined problems" ask for new solutions. They are based on conflicting assumptions, evidence and opinions which may lead to different solutions, thus the problem itself is also not sufficiently known or defined. None of the solutions, or a varying number of solutions, can lead to a solution. However, there is no guaranteed procedure or rule for reaching that solution [38], [40]. Ill-defined problems require inventive, imaginative and simultaneously ingenious achievements [41].

Reference [41] divides problems into latent and open problems. Open problems are those problems already consciously perceived as a problem by a selected circle of people. Open problems have the merit of confirming their problem-solving needs, so to speak. The result is a noticeable supply competition. Latent problems have not been recognized as problems or opportunities so far. They are often not perceived or accepted as being inadequate [41].

In order to link the definition and theories of the term "problem" with the design process and, in particular, with the idea process as part of the design process in the early phases, the term "problem idea" will be used, introduced and discussed in the following section.

VDI Guideline 2220 (VDI = Association of German Engineers) [21] defines a problem idea as being part of the product-finding step (see Fig. 3).

Here, the problem idea, along with the solution idea, is part of the idea-finding step. Table I shows several other definitions of a problem idea.

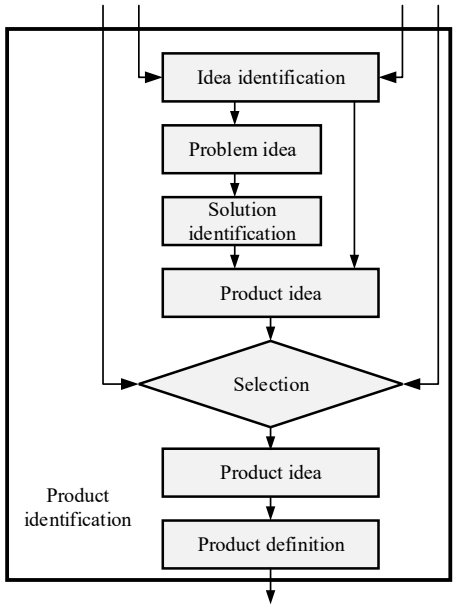


Fig. 3 VDI Guideline 2220 [42]

TABLE I
DIFFERENT DEFINITIONS OF THE TERM "PROBLEM IDEA"

Definition	Reference
"A problem idea defines a (lateral) need, a requirement, a task, etc., in short, a problem which (also) has meaning in the future and to which no or only an inadequate solution exists."	[26]
"A problem idea defines a future problem or customer need, which occurs as a result of a future projection and to which no or only an inadequate solution exists."	[43]
"Problem ideas build upon 'new' problems or requirements on the part of the market and customers, which can be realized by already known solutions."	[44]
"A problem idea is a functional problem or requirement of the analyzed object which requires a need for a technical solution. It represents a need for an application and is described by one or more purpose functions, application requirements and desired functional changes."	[45]
"A problem idea is a new problem for a known solution."	[1]

Besides the term "product idea", the very similar terms "product profile" or "product profile idea" exist in the pertinent literature. A product profile defines the situation of a need on the market. It consists of a first claim ("We need a product that…") [46], determines a solution-neutral characterization of the qualities of a future product and defines the innovation task [47]. First, potentials and needs are described, thus the profile defines the boundary conditions and delivers an initial framework for the design task [48].

With the exception of [2], all definitions have one fact in common: the need for a solution to a problem, thus a problem exists for which it is claimed that a solution is needed. This solution can be generated differently. The description of the problem, which is not yet solved, is thus defined by a problem idea.

The counterpart of a problem idea comprises a solution idea. This is a "new solution for a known problem" [49].

Reference [26] defines a product idea (see also Fig. 3) as a combination of at least one problem idea and at least one

solution idea.

According to [48], the combination of a problem idea, an invention and the successful diffusion of the invention on the market is defined as an innovation, while an invention is a technical realization of the idea [48]. From our perspective, a problem idea defines the task for the early phases of the design process. In other words, it is a short description of a problem. Furthermore, a solution is demanded by somebody for this problem, thus a problem idea consequently defines an initial framework and gives information about the solution space for solution ideas. Fig. 4 shows that a problem idea is needed at the beginning of the innovation process, which is the beginning of the idea process as part of the early phases of the design process. Based on this, a solution idea has to be found. Together, these two ideas form a product idea. After assessing all product ideas and the downstream selection process (see Sections IV.A and IV.B), the most promising product idea is developed with the goal of creating an invention during the various phases of the design process. After launching the invention onto the market, and after the successful diffusion on the market, the invention becomes an innovation. In order to refer to the theory by [41] of latent and open problems, the stringent process shown in Fig. 4 deals more with latent problems, although open problems can also be addressed and result in a successful innovation. We will come back to this point once more in Chapter V.

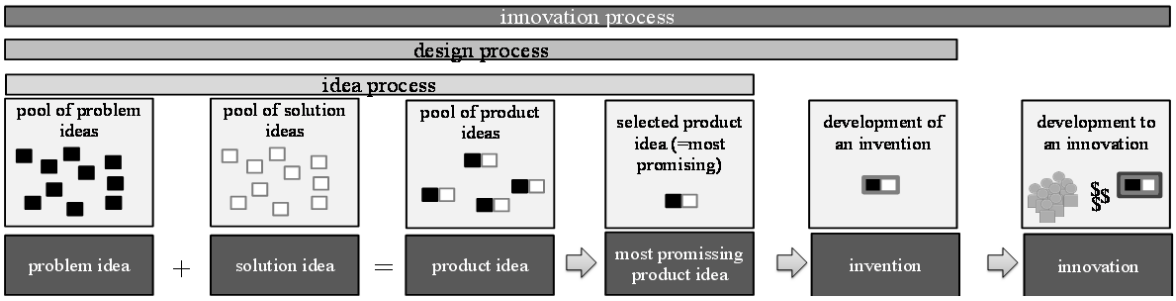


Fig. 4 Origin and development of a product idea

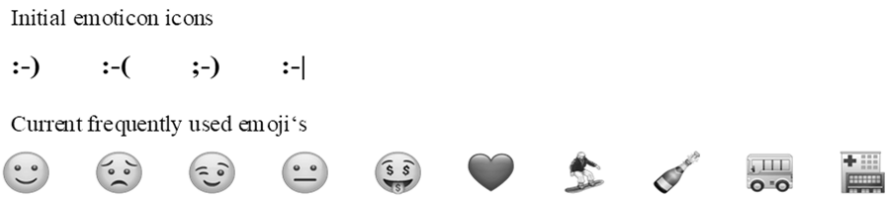


Fig. 5 Comparison between initial and current emojis

Reference [50] supports a similar model. This model consists of a problem model, which serves as an abstract description of the problem and enables a better problem and system insight to be generated. Based on that, new solution ideas can be created. These ideas have to be substantiated and can lead to a new technical solution [50].

To complete the insights into the state of the art, initial research results on emojis and emoticons are presented in the following section to establish a foundation for the presented idea of using emojis for deriving new problem ideas (see Chapter VI).

D.Research into Emojis and Emoticons

Since computer scientist Scott Fahlmann [51] suggested in 1982 that the punctuation marks :-) and :-(could be used to distinguish jokes from serious statements online, one cannot begin to estimate the overall extent of the impact of the so-called "emoticon icons" on our daily lives in the world today. Shortly afterwards, in the late 1990s, the Japanese communication firm NTTDoCoMo presented different pictograms with the words "e" and "moji" [52]. In contrast to emoticons, emojis are simple pictures and do not exclusively portray emotions (there are categories such as nature, food, activity, symbols, etc.) in the context of textual language usage (see Fig. 5).

Current research into emojis and emoticons confirms the influence of these special ideograms, especially in the research field of Computer-Mediated Communication [51]-[54]. Along with differences regarding the necessity and usage of emojis and emoticons, there is a broad consensus in the scientific community on the definition of emojis and emoticons, in addition to the fields of activity in which they occur [51].

Due to the lack of nonverbal communication cues within computer-mediated communication, the most frequent usage of emojis is as part of mobile messaging, chats and online discussion boards to convey emotions between the sender and recipient in text-based conversation [55], [51], [56]. Similar to words, emojis take on different meanings based on the context of the message to be sent as well as the individual understanding of the recipient [53], [51]. However, emojis express informality and social closeness by providing an indication of communication context. The use of emojis therefore contextualizes the utterance of a nonverbal, text-based message. This property and the simple application of

emojis in particular (by pushing the emoji icon or entering the referenced Unicode) are reasons for the undeniable importance of the world's electronic communication vernacular [53], [55].

A great deal of research into emojis is undertaken in the area of cognitive sciences with different focuses. For instance, [57] analyzed a person's brain activity when he or she sees an emoticon at the end of a sentence [57]. The results of this study confirm the relevance of emojis as part of nonverbal information, and that emojis enhance computer-mediated communication. A detailed psychological analysis was conducted by [58], who analyzed psychological factors involved in emoticon usage and implications for judgment accuracy [58]. In their studies, they revealed links between the "big 5" personality traits (openness, conscientiousness, extraversion, agreeableness, neuroticism) and the usage of emojis. Furthermore, new insights have been generated concerning online behavior and the way in which this behavior influences personal judgments. Online interaction plays a prevalent part in our daily lives. For that reason, it is important to understand the causal relations by using emojis. In the near future, entirely new possibilities in nonverbal and computer-mediated communication can be used as instruments (i.e. an emoji Likert scale to evaluate questionnaires, see Fig. 6) [54]. These new opportunities are much more than simply visualized icons deployed to add an emotional component. Unlike cognitive science researchers, the researchers working with Wijeratne [53] explore emojis in an analytical way. Even natural language with a predefined syntax takes on different meanings for words or whole sentences when rigid semantics are lacking. For this reason, a machine-readable sense inventory for emojis (EmojiNet) has been established to conduct further research into emoji analytics [53]. Entirely in line with the OpenSource community, EmojiNet constitutes a resource that enables systems to associate emojis with their context-specific meanings [59]. The frame of EmojiNet consists of three specific parts (see Fig. 7). The first part is represented by the databases BabelNet, Unicode emoji list, Emojipedia and Emoji Dictionary. The second part is a step-by-step procedure that describes how to link and connect the different resources. Finally, the results are grouped together and prepared in the form of fact sheets for an emoji. This fact sheet provides nine specific characteristics of the emoji to be analyzed ("nonuple" of an emoji).

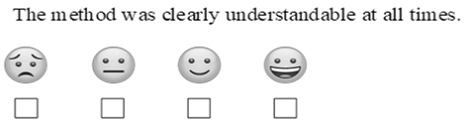
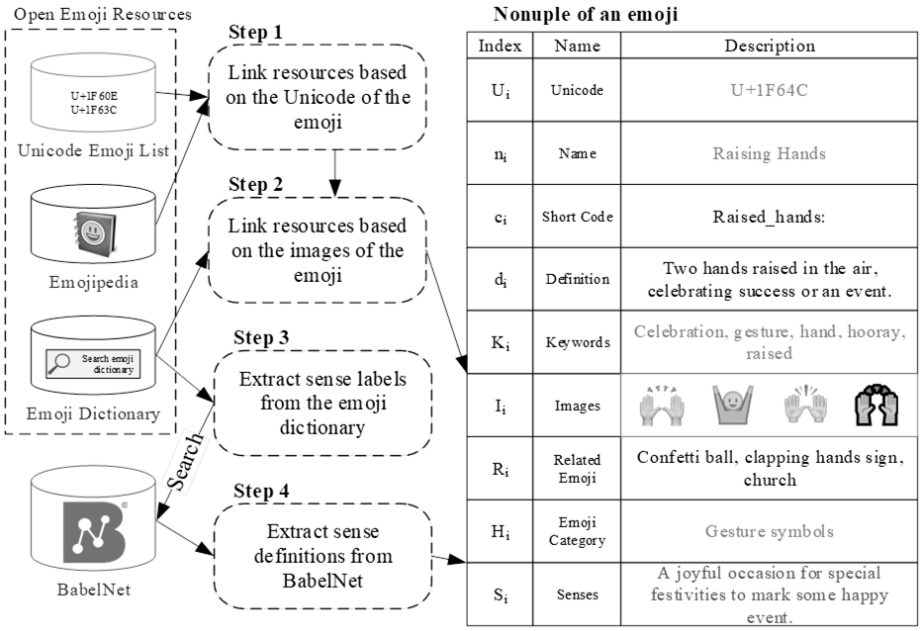


Fig. 6 Emoji Likert scale adapted from [54]



Nonuple of an emoji

Index	Name	Description
U_i	Unicode	U+1F64C
n_i	Name	Raising Hands
c_i	Short Code	Raised_hands:
d_i	Definition	Two hands raised in the air, celebrating success or an event.
K_i	Keywords	Celebration, gesture, hand, hooray, raised
I_i	Images	
R_i	Related Emoji	Confetti ball, clapping hands sign, church
H_i	Emoji Category	Gesture symbols
S_i	Senses	A joyful occasion for special festivities to mark some happy event.

Fig. 7 Structure of EmojiNet

EmojiNet provides a holistic dataset of emojis and their associated metadata (nonuple of an emoji). Furthermore, [59] developed a REST API (REpresentational State Transfer Application Programming Interface) to encourage other researchers to use the functionality of EmojiNet in their own efforts.

In summary, it can be concluded that a great deal of research is performed into this scientific field due to the continuing trend of using emojis for mobile messaging, chats and online discussion boards. The cognitive science research reveals insights ranging from new brain activities to causal personality effects. The promising project EmojiNet constitutes an analytical approach for understanding and applying emojis in a different way. The preliminary work of

[53] and [59] plays a particularly significant role in further developing the emoji method in this paper.

V. Holistic Idea Process

In order to explain the process behind the current research work at our institute and to demonstrate open research fields, a holistic idea process is presented to which the developed Emoji Method can be assigned.

As shown in the previous sections of Chapter IV, process models, methods and, generally speaking, the way of thinking of designers is very solution-oriented. On the other hand, a problem-oriented way of thinking is often necessary or appropriate. According to [60], two types of information are required in order to generate new ideas: firstly, knowledge concerning a relevant need, problem or opportunity. Secondly, knowledge concerning a method or technique for satisfying the need or problem, as well as how to benefit from the opportunity [60]. This shows the importance of both a problem-oriented and solution-oriented perspective of the idea process. To underline this, [61] used to claim:

> "Successful problem-solving requires finding the right solution to the right problem. We fail more often because we solve the wrong problem than because we get the wrong solution to the right problem" [61].

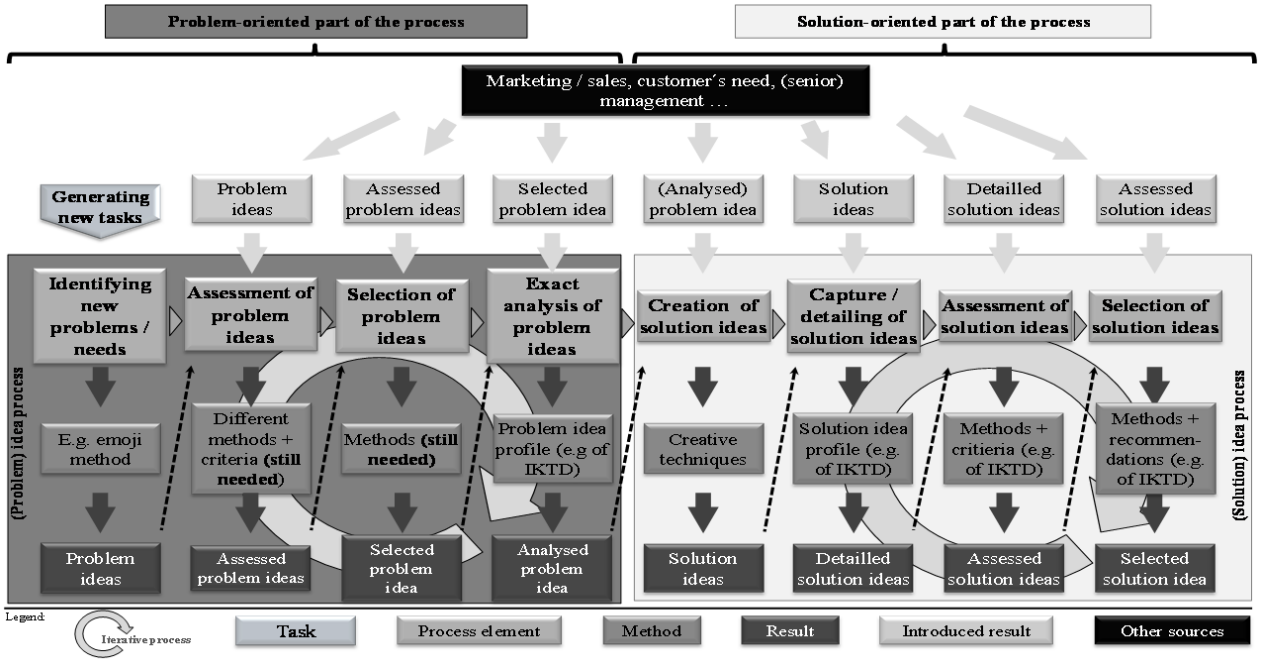


Fig. 8 The holistic idea process model

Our model of the holistic idea process, shown in Fig. 8, is therefore split into a problem-oriented part and a solution-oriented part. Besides the main starting point, which we call "generating new tasks", the process model offers different secondary results, which can be used as an individual starting point depending of the nature of the project. We will refer to those secondary starting points while explaining the main stream of the process.

As mentioned previously, the designer's task at the beginning of the process is to generate new tasks (left arrow, Fig. 8). The first process step (left grey box, Fig. 8) is called "identifying new problem needs". For this, we suggest using the Emoji Method (left dark-grey box, Fig. 8) developed at our institute, which will be introduced in detail in Chapter VI. The result (left black box, Fig. 8) is represented by a problem idea and forms the basis for the next process step "assessment of problem ideas". Obviously, problem ideas can also be found and inserted by other disciplines (Marketing, Sales, etc.), can be derived from a customer's need or may simply be an input from the (senior) management or another company's units. However, the Emoji Method can help to derive new problem ideas that may be a special input for a company's success, while new problem ideas might expand the company's portfolio. As different problem ideas may have been derived, there should be a process step which assesses problem ideas and supports a decision as to which of the derived problem ideas should be advanced further. As we learned from literature, only a few recommendations exist on how to perform these process steps (see Sections IV.A and IV.B). Special research work on that topic is thus necessary (see dark-grey boxes, Fig. 8). After assessing different initial problem ideas, selection methods also have to be offered which form another white space for specific research work.

Since the next process step marks the end of the problem-oriented part of the idea process and the start of the solution-oriented part of the process, a precise analysis and dispute with the problem idea is necessary before starting with the creation of solution ideas. The problem idea being selected for

further steps should therefore be analyzed, and more information on the problem should be gathered. Obviously, all process steps introduced so far can be fed by "introduced results" from other sources at the company and deal as a project-dependent starting point for the process (light-grey boxes at the top with light-gray arrows, Fig. 8).

The ideal result to start the "solution idea process" as we call it, and as it is mostly introduced in literature (see Section IV.B), is an analyzed problem idea. Based on this, creative techniques can be used to develop new solution ideas, which have to be captured and detailed in the next process step. This is followed by the process steps for assessing and selecting solution ideas. Different methods or criteria are provided from different research work (see Section IV.A, inter alia 62). Here, too, lateral entry is naturally always possible (see light-grey boxes at the top, Fig. 8). At the end of the process, a selected solution idea or ideas form the starting point for the downstream activities in the design process. Both parts of the holistic process have to be seen as iterative. Setbacks are thus possible whenever necessary or appropriate.

For the most part, this idea process forms part of the planning phase of a design process, according to [1]. Some steps may, however, be part of the conceptual design phase. The holistic process can be used for new design tasks, although it can also be part of adaptive or variant design tasks.

A parallel can be drawn to the process description of a student development project published in the new version of the VDI Guideline 2221 [63].

Furthermore, the model of the problem-solving process by [64] is very similar to this holistic idea process. He differentiates between four phases: problem statement, solution finding, optimization and implementation. The first phase is based on a problem recognition, which is followed by a problem analysis and a problem formulation. The solution-finding phase is characterized by the recognition, analysis and formulation of alternatives to solve the problem. After that, during the optimization phase, the assessment and selection of the optimum solution is performed. The last step comprises the implementation and the controlling of the plan [64].

The reason for presenting the model by [64] in this paper is the activity of problem recognition. This activity forms the focus of the Emoji Method, which will be presented in Chapter VI.

VI. Presentation of the Emoji Method

The goal of the Emoji Method is to offer a method which assists in recognizing new problems and deriving new problem ideas. Within the initial description of the method and the used form, we will pare specifications down to the original idea of the Emoji Method (Section VI.A). Later on, we will describe different concepts for using the method and its form in an alternative manner (Section VI.B).

A. Original Format and Usage of the Emoji Method

In Fig. 9, the form used within the Emoji Method is shown. To show the usage of the form, a concrete example is implemented. The test subject is called Alex, while the usage of the form is described in the following section according to the example of the test subject.

The form is separated into five main parts. The first part forms the AIS diagram (Areas of Interest and Skills), which asks for the user's interests and skills. The AIS diagram functions as an entry into the method. It assists in subsequently finding a proper stimulus word for applying the emojis. The Emoji Method specifies problems, needs and open solution fields for the collated interests and skills of the user. The advantage of this method is that the user analyzes the problems of his/her own skills and interests. Within these fields, the user is supposed to have background information and knowledge, thus obvious problems, challenges and deficits should be easily identified by the user.

As shown in Fig. 9, test subject Alex has different areas of interest and skill, e.g. cars, bikes, travelling, computers and music. These skills and interests have to be specified through different acts. In simple terms, the user of the method has to add a verb to the previously defined skills and interests. In our example, the field "bikes" was specified by the acts of riding bikes, transporting bikes or maintaining bikes. For this step, a catalog of action verbs was developed through the brainstorming method which contains different actions that, in turn, may refer to skills and interests. This catalog can stimulate the user of the Emoji Method (see Fig. 10). Actions falling within the field of interest or skill which are not very obvious should be identified. The pairs of nouns and verbs can be further detailed by adding adverbs using the catalog of Fig. 10. The user is now able to proceed to the next step immediately.

In addition to the aforementioned verb list, we derived a list of adjectives which is useful for specifying the action: These can be used as adverbs in the context of the AIS diagram (see Fig. 10). In the example of Fig. 9, the user Alex could have qualified his action of "riding bikes" by using the adverbs quickly, safely or ergonomically. Every further detailing step helps to further qualify the skill or interest. No matter which detailing step is used (with/without verbs & adverbs), the user can choose one of his/her produced stimulus words before writing it in the text box. In the example, Alex has chosen the stimulus word "Maintain bikes".

The user can detail the stimulus word further, although a sufficient level of abstraction should be targeted. There is no right or wrong in terms of which stimulus word is chosen for the further steps. The user will potentially choose the one where he/she has the most skill or the highest interest, or the one with the most potential for improvement in any actions. However, the next steps of the method can be repeated several times with a new stimulus word.

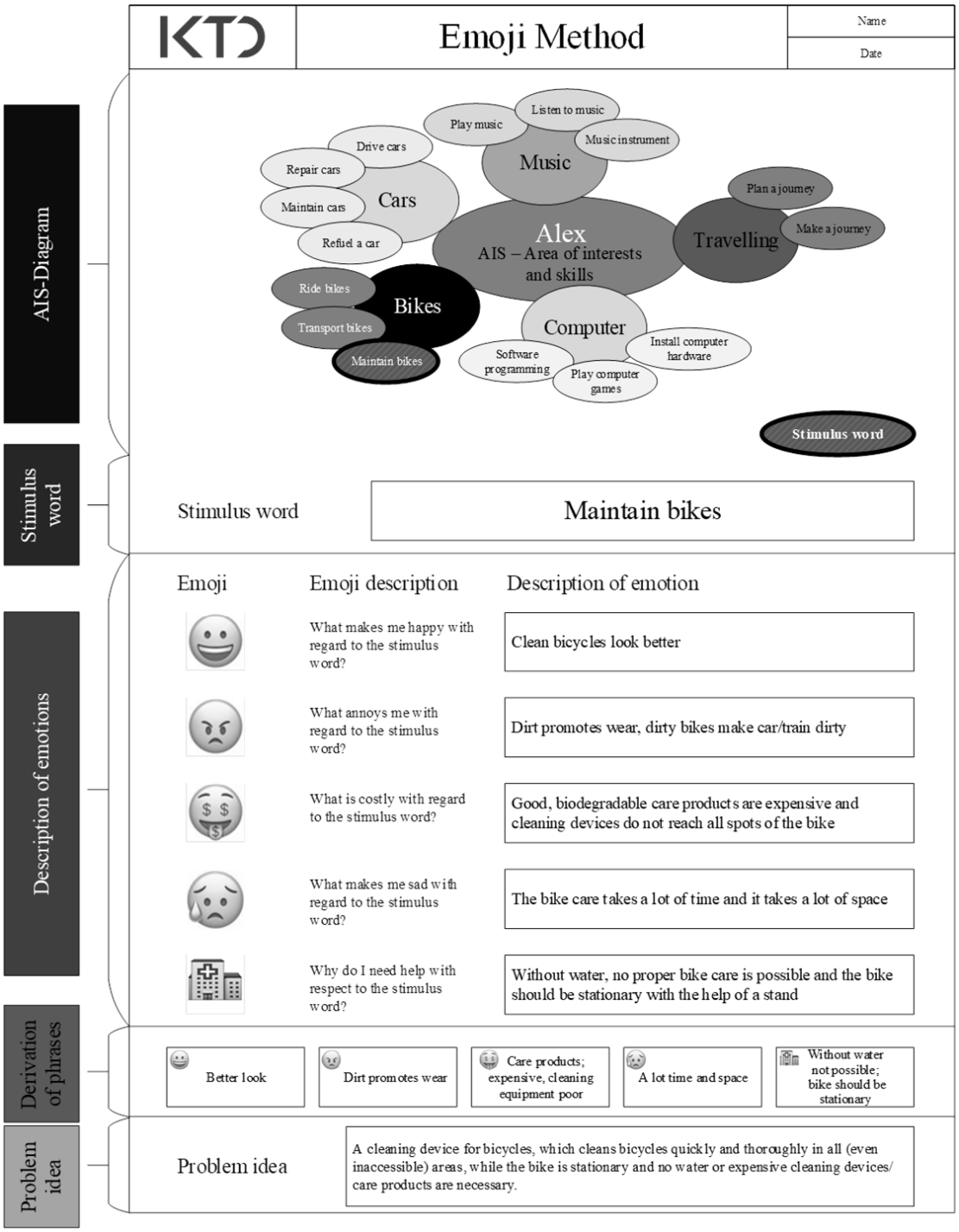


Fig. 9 Form for using the Emoji Method, filled out with an example

KTD	Catalogue of verbs and adjectives / adverbs for AIS-diagram	User name / Date
Category	**Actions (verbs)**	
Transport / storage	transport, store, move, park, deliver, position, collect, store, …	
Assembly / disassembly / equipping	assemble, dismantle, adjust, calibrate, configure, add, equip, screw, …	
Control	control, check, tag, test, certify, label, …	
Maintenance / servicing	debug, adjust, paint, update, screw, repair, maintain, change, clean, formalize, …	
Standardization	visualize, describe, certify, formalize, …	
Production	manufacture, dye, varnish, produce, paste, …	
Optimization	optimize, slow down, accelerate, save costs, increase robustness, make it easier, modify, simplify, cool, …	
Ergonomics	adapt, flexibilize, simplify / simplify, standardize, feel, …	
Safety	rob / steal, endanger, protect, limit risks, cool, label, …	
Construction / design	configure, electrify, design, construct, shape, integrate, design, couple, modify, position, prepare, realize, combine, mechanize, miniaturize, personalize, type, …	
…		
possible adjectices / adverbs for detailing the action		
accessible, accurate, advantageous, age-appropriate, agile, agressive, ambidextrous, anxious, appropriate, assistant, bio, (logical), brave, careless, chaotic, cheap, chronic, classy, clever, cold, competitive, completely, complex, comprehensively, cyclical, transparent, decrepit, detailed, digital, direct, disability, double, dull, dynamic, easy, …		

Fig. 10 Extract from the catalogue of verbs and adjectives/ adverbs for the AIS diagram

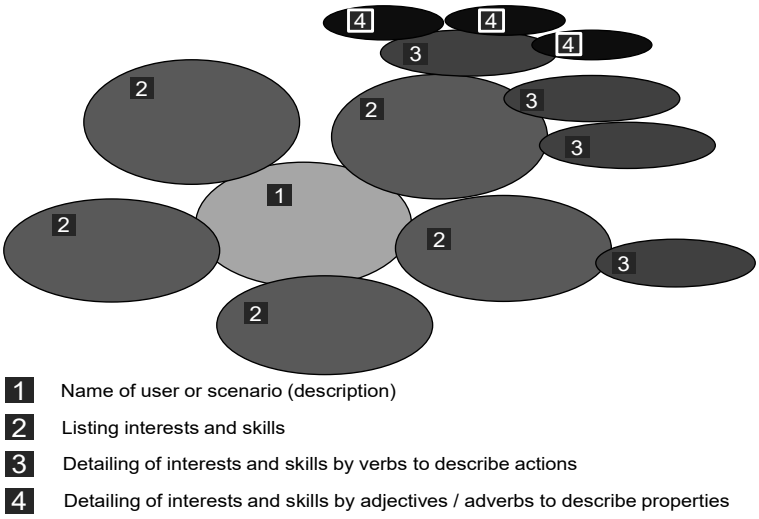


Fig. 11 Basic structure of an AIS diagram

In Fig. 11, the structure of the AIS diagram is shown to explain and summarize its purpose and use. Consequently, after the second step, which comprises the specification of the stimulus word, the third step involves the description of emotions regarding the stimulus word (see Fig. 9). Within the form, several emojis are used to stimulate the user's emotions towards the stimulus word. The emojis can be exchanged, although we started with the five emojis provided on the form in our first test (see Fig. 9). There was no deeper investigation as to which emojis might be chosen from the wide variety of available options. We simply wanted to have a manageable number and therefore chose those with the most significance to us. A description for the emojis is also provided on the form, although this is not mandatory. The five used emojis are intended to express what makes the user happy, sad and angry with regard to the stimulus word. Additionally, the cost driver and possibly required auxiliary tools or equipment are to be analyzed. After this, another analysis step is necessary. From the description of the emotion, short phrases should be derived to summarize the important points of the emotion. As a final step, the synthesis of the derived phrases should result in a clearly formulated problem idea. As shown in the example, our test subject described different emotions in the middle part (see Fig. 9). He claimed that clean bikes look better and that dirt encourages wear. He always needs water for maintaining bikes. Furthermore, good, biodegradable care products are a big cost driver in his opinion, and a great deal of time, money and space is needed.

As a result, the test subject derived the following problem idea:

A cleaning device for bicycles which cleans bicycles quickly and thoroughly in all (even inaccessible) areas while the bike

is stationary, and no water or expensive cleaning devices/care products are necessary.

This sentence provides an objective for a new design project. One helpful recommendation for formulating a problem idea using the previously described emotion might be the negation of the short phrases. This is not always relevant, although it can sometimes help to bridge the gap between the individual emotions and the problem ideas.

Fig. 12 once again summarizes the usage and restrictions for using the Emoji Method form. As far as our experience goes, the Emoji Method can be applied in approximately 20 minutes. Within that time period, each of our test subjects was able to work through the form, subsequently formulating at least one problem idea by the end. A possible second round initiated by choosing another stimulus word can be conducted much faster because the step of filling out the AIS diagram can be skipped, or rather because the results of the AIS diagram can be reused by choosing a different stimulus word.

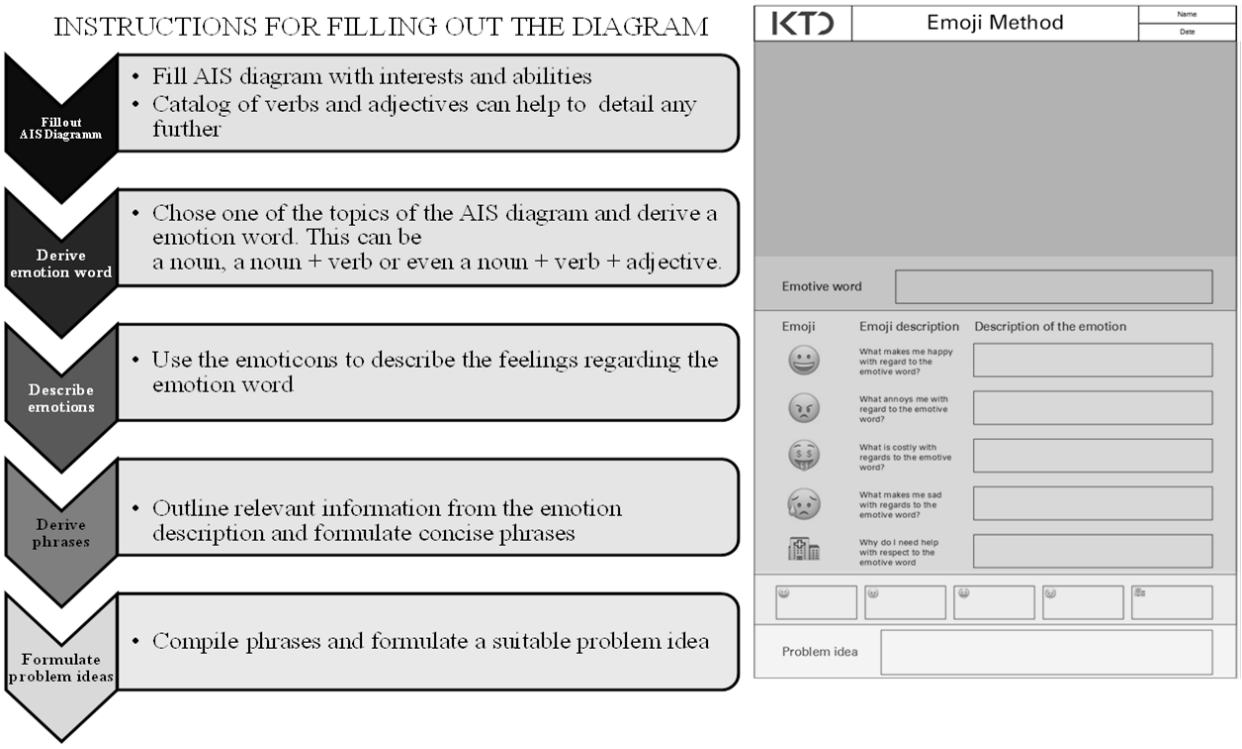


Fig. 12 Instructions for filling out the Emoji Method form

B. Alternative Usage of the Emoji Method

During our first tests of the Emoji Method, different alternative fields of application and use cases were found: These will be presented in the following section.

Applying the Emoji Method, as presented in Section VI.A, results in problem ideas which are closely connected to the interests and skills of the user. To gain an effect for a company or a team of designers, the derived problem ideas have to be assessed. The questions of whether the problem idea can be linked to the current portfolio of the company or whether it can expand the current portfolio appropriately have to be examined. As we have shown in Chapter V (see Fig. 8), the assessment of the problem ideas comprises the downstream step of the Emoji Method. However, we will not refer to that point in any greater depth in this paper. Of course, if a designer is asked for his or her skills and interests, it is quite unlikely that the derived problem idea will match the company's portfolio. What can be done, however, is to collect a wide variety of problem ideas from different characteristics. A large pool of problem ideas is thus collected and needs to be assessed. This can be performed within the company or outside of it.

Another possibility is to adapt the Emoji Method. One scenario is to use the customer and write their name in the first oval of the AIS diagram (No. 1 in Fig. 11). The new task is to find skills and interests of the customer and to derive new problem ideas from that. Another possibility is to enter a company's significant workplace, e.g. an assembly workplace or CAD workstation. Another top-down process can be started by using this as a new scenario in the center of the AIS diagram. By doing so, problem ideas referring to these workplaces and connected with the special interests and skills of the worker can be identified.

There is also no restriction as to whether the Emoji Method must be applied individually or in a group. If the considered scenario refers to a foreign aspect (e.g. customer, workplace, etc.) group work can stimulate the result of the method.

In addition, the method can be split into group work for the AIS diagram and individual work for the emotional part, or vice versa.

As we mentioned previously, the AIS diagram is not at all mandatory. Therefore, the emojis and the emotional part of the method can be applied immediately with a suitable stimulus word.

The emotional part of the method can also be used as an interview tactic, meaning that a person (for example, a customer) can be asked questions according to his or her emotion towards the stimulus word. This can be performed with index cards showing different emojis, whereby the customer or respondent should describe his or her emotions. By doing so, the Emoji Method increasingly addresses the empathic design and the field of "Application Research" [65]. In turn, this increases customer retention and contributes to a user-centered design.

VII. Evaluation of the Emoji Method

In order to test the Emoji Method, its applicability and its output, we asked 95 people to apply the method and evaluate it afterwards. At first, we tested the Emoji Method with 63 students. All students were undertaking their Bachelor's or Master's Degree in Mechanical Engineering or similar disciplines, and they were all approaching the end of their studies.

After achieving a convincing result with the students, we evaluated the method with two expert groups comprising 32 people in total.

Our first expert group consisted of 15 academic researchers, most of whom were research assistants; however, a few chief engineers and one professor also took part. All participants work for the IKTD at the University of Stuttgart.

The second expert group was a group of 17 designers working in the Research & Development Department of different German companies in the consumer industry (13) and capital goods industry (4).

With the second expert group, we tested different scenarios of the method (see Section VI.B), e.g. different workstations within their company (e.g. assembly workstation), their own workstation, a typical customer of their company or, alternatively, other different stereotypes were analyzed. However, at the beginning of the tests, every test subject had to apply the method to their own skills and interests to familiarize themselves with the method.

We also applied the method within a student's project. Three different teams of five people were asked to develop a product to support the daily life of city-dwellers. The only restriction they were given was to make use of a small 10-volt battery. The three groups applied the method successfully at the very beginning of the project to derive new problem ideas. After assessing the problem ideas, they successfully continued with the project. These 15 students were part of the aforementioned student group of 63 students.

After applying the method, all 95 test subjects were asked to fill out an evaluation sheet. The result of the evaluation of all 95 test subjects is shown in Fig. 13. Some questions were not answered by every test subject. We used a four-tiered Likert scale for the evaluation (4 = strongly agree | 3 = agree | 2 = disagree | 1 = strongly disagree).

For nearly everybody concerned, the method was clearly understandable at all times (average 3.18).

We did not provide the catalog of helpful verbs and adjectives/adverbs to every test subject (only 54 of 95), with the aim of ascertaining just how effective this catalog is. However, the test subjects who did not use the catalog clearly did not miss out, with the AIS diagram filled out to a satisfactory standard in their case. However, the feedback from the individuals who did use it was quite varied (see the second line of Fig. 13, average 2.59). Some users viewed it as very helpful, while some did not. Whether or not the catalogue is considered helpful consequently depends on the character of the person in question.

For formulating the stimulus word, most of the test subjects agreed that the AIS diagram could be a useful help or entry point (average 3.15). The five emojis used (see Fig. 9) more or less matched the stimulus words for all test subjects (average 3.04). However, many test subjects had problems differentiating between the sad and angry emojis. They recommended leaving one of these two emojis out or choosing others.

The textual description of the respective emoji or the meaning behind it helped most of the test subjects (average 3.38). However, we also first tested the method with and without the description of the emoji (see Fig. 9), which did not cause any significant change in the result. Nevertheless, we have to admit that emojis can be understood differently. For example, the last emoji we used, which symbolizes a hospital, might suggest that somebody just needs support in doing something. It can also be understand that somebody needs medical help or that something is dangerous or has noxious effects. No matter how it is intended, the problem idea will have a different meaning, which does not necessarily have to be viewed as a disadvantage.

With an average of 3.04, the test subjects did not have many problems expressing their feelings, nor were they overstrained. Several of the test subjects had problems formulating the problem idea with or without the help of inverse feelings. However, the average of 3.03 indicates that they were not overstrained. The majority (average 3.18) claims that the development of a problem idea is carried out in a structured manner, and that the problem idea does not simply fall from the sky. Furthermore, the main effect of the method is expressed in the fact that the majority agreed that the downstream idea process could be supported and started in a target-oriented manner with their formulated problem idea (average 3.28).

We tried to analyze any significant issues between the different groups of test subjects. The average values for each group are shown in Fig. 14. No conclusions on the differences in the values of each group can be drawn. The students' group was frequently even more critical than the experts, while the opposite was true in other cases. In comparison with the student group, the experts did not feel confident with the verb catalog. The formulation of the problem idea proved easier for the students than for the experts.

	Strongly disagree Level 1		Disagree Level 2		Aree Level 3		Strongly agree Level 4		∅	Total answers per question
	Answers/percentage of answers given									
The method was clearly understandable at all time.	0	0,0%	8	8,4%	62	65,3%	25	26,3%	**3,18**	95
The catalog of verbs and adjectives/ adverbs helped me to describe the AIS diagram in more detail.	2	3,3%	25	41,0%	20	32,8%	7	11,5%	**2,59**	54
The AIS diagram helped me to formulate the stimulus word.	3	3,3%	17	18,7%	34	37,4%	37	40,7%	**3,15**	91
The emojis matched the stimulus word. I was able to describe an emotion to each emoji.	3	3,2%	16	17,0%	49	52,1%	26	27,7%	**3,04**	94
The description of the emoji helped me to better understand the emoji.	1	1,1%	6	6,3%	43	45,3%	44	46,3%	**3,38**	94
Expressing the emotions consistently did not overstrain me.	3	3,2%	10	10,5%	61	64,2%	20	21,1%	**3,04**	94
Expressing the problem idea with the help of inverse feelings did not overstrain me.	1	1,1%	16	17,0%	51	54,3%	21	22,3%	**3,03**	89
A problem idea is formulated in a structured manner and does not simply fall from the sky.	1	1,0%	16	16,7%	43	44,8%	35	36,5%	**3,18**	95
With my fomulated problem idea, a downstream idea process can be started in a target-oriented manner.	1	1,1%	12	12,6%	41	43,2%	41	43,2%	**3,28**	95

Fig. 13 Evaluation of the Emoji Method (overall result)

VIII. Results and Discussion

To summarize the evaluation results, all test subjects were satisfied with the method, while the purpose of the method was clear to nearly everybody. Many of the test subjects agreed that problem ideas could be found with the use of the Emoji Method that would otherwise not be on their daily radar. It was underlined by the experts that it proved easier to formulate a problem idea containing all important information when using the method. Some experts underlined that the Emoji Method is a helpful method for thinking "outside the box", while many experts encourage us to continue with this research field and follow up on this method. Some test subjects thought that this approach could help in departing from entrenched thought processes. Moreover, a large majority of the test subjects specifically mentioned that one of the main advantages of the Emoji Method is its simple and intuitive use. Reasons for this are, inter alia, the aforementioned (compare Chapter IV) daily confrontation with emojis within nonverbal communications. So, the test subjects were familiar with handling the emojis and their context-specific meaning related to the stimulus word without needing a time-consuming workshop in advance. However, some critical statements on the method indicate improvements which will be required in the future. We have already mentioned the difficult differentiation between the sad and angry emoji. In addition, certain test subjects stated that the five given emojis were not suitable for every stimulus word.

We also had interesting and beneficial discussions on alternative usage scenarios for the Emoji Method (compare Section VI *B*). While some experts found it difficult to get into

a different character when putting a stereotype in the center of the AIS diagram, others considered this a good opportunity to think about customers' actions, skills and interests.

As the main emotion regarding the method was positive, we are convinced that the Emoji Method can serve as a supporting method for finding new niches in a company's portfolio. The Emoji Method can assist in thinking in a more problem-oriented way and change the perspectives of designers.

	Average all participants	Average students	Average all experts	Average expert group 1	Average expert group 2
The method was at anytime clearly understandable.	3.18	3.24	3.06	3.18	2.93
The catalog of verbs and adjectives / adverbs helped me to describe the AIS diagram more detailed.	2.59	2.73	2.29	2.29	
The AIS diagram helped me to formulate the emotive word.	3.15	3.07	3.31	3.18	3.47
The emoticons matched the emotive word. I was able to describe a feeling to each emoticon.	3.04	2.92	3.28	3.35	3.20
The description of the feeling helped me to better understand the emoticon.	3.38	3.24	3.66	3.76	3.53
Expressing the feelings consistently did not overstrain me.	3.04	3.02	3.09	3.18	3.00
To express the problem idea with the help of inverse feelings did not overstrain me.	3.03	3.10	2.90	2.82	3.00
Formulating a problem idea is carried out structured and does not fall from the sky.	3.18	3.10	3.34	3.41	3.27
With my fomulated problem idea a downstream idea process can be started target-oriented.	3.28	3.21	3.44	3.35	3.53

Fig. 14 Evaluation of the Emoji Method (average of every group)

IX. Conclusion and Outlook

Several conclusions can be drawn based on the presented results and the discussion. We demonstrated the need for and relevance of a new method for assisting the problem-oriented thinking of designers. In addition, we linked the method and its application with existing process models of the idea process. By demonstrating the Emoji Method, its use cases, its forms and its sequence, the advantages and the effect of the method can be understood or tested within the reader's own use scenario. Furthermore, we demonstrated the function and the positive response to the performed evaluation. However, the evaluation was only performed initially, meaning that further tests in a realistic atmosphere should be implemented, i.e. in a product development process, where the Emoji Method is involved in a company's daily operations.

We only showed a paper-based version of the Emoji Method. However, we are currently working on a digital version of the method, where the user will receive much more support. The AIS diagram should thus be set up on a digital platform (e.g. web-based application), where the stimulus word can be chosen automatically, e.g. based on the relevance to the company or other restrictions. Another step is to separate the AIS diagram from the second part where emojis are used. As a result, the AIS diagram will be able to be filled out, while several stimulus words will be able to be chosen and analyzed further. This can be an approach for the paper-based and digital versions alike. The form used for the Emoji Method should thus be changed, particularly the structure of the two main parts, namely the AIS diagram and the emotion description.

As several test subjects suggested varying the used emoji, we are working on a situation-based use of different emojis or the possibility for users to choose the emojis on their own. For this purpose, we are trying to apply the REST API of the EmojiNet (see Chapter IV.D) to our web-based application. Through this combination, we expect an automatic and appropriate proposal for an emoji set that is most suited to the derived stimulus word.

Another research topic involves finding methods for supporting the formulation of the problem idea by an algorithm which analyzes the syntax components of the emotion description and filters relevant aspects. This will also form part of the digital, web-based application.

The future target is to implement the digital version of the Emoji Method in a holistic idea process. We have already developed a digital, web-based application for the solution-oriented part of an idea process according to the research work of [62] (see [66]). Furthermore, the systematic assessment of problem ideas is another open research field.

Referring to the comments of the test subjects, we also

gained some suggestions for improving the Emoji Method which will be implemented in future work.

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