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A CONCEPT AND PROTOTYPE FOR A NEW APP TO SUPPORT COLLABORATIVE AND MULTI- CRITERIA DECISION MAKING IN PRODUCT DEVELOPMENT

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Abstract

As products become increasingly complex, product developers have to make decisions effectively and efficiently. Therefore, the long term goal of the authors is the development of a new app to support collaborative and multi-criteria decision making in product development. For this, the basic requirements of such a new app are presented. Based on this, the methodological concept and procedure are briefly explained. Afterwards, a first prototype of the app with the core functionalities and the user interface is presented. Finally, this prototype is applied and evaluated by an example. In the future, the authors aim to improve the concept and to integrate further functionalities by implementing the presented concept as a real smartphone app.

Keywords: Decision making, Evaluation, Collaborative design, Decision-making app, Design management

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1 MOTIVATION AND OBJECTIVE

Human decision making is subject to several cognitive biases which often result in suboptimal choices (Kahneman, 2011). Therefore, companies need to follow methodical approaches to make good decisions. Today, various decision support systems are available, which enhance the use of decision-making methods. They can guide the user though the process, make calculations automatically and visualize the results of the evaluation. However, companies are developing their products increasingly with international teams, including multidisciplinary members located at different locations in time zones, with different expertise and perspective on a project. Thus, organizing conferences or online meetings to use collaboratively evaluating methods and decision support software in order to make decisions on a development project is challenging. Furthermore, observations relevant for a decision are often done in the field by one single member of the decision making team (e.g. at the assembly line). Hence, this member might not have a personal computer at hand to make documentations and share them with the team. Finally, team members usually work on several projects, so they do not have much time to spend on the evaluation for one decision.

These difficulties could be addressed with a decision-making app, with which the members of a decision-making team have the opportunity to be more flexible and independent of time and location while participating in the decision-making process (e.g. entering input). Despite the ongoing digitalization and the trend for using smartphones as everyday work equipment, no smartphone apps supporting decision making in product development are known to the authors.

Therefore, the long-term goal of the authors is the development of a new app to support collaborative decision making in product development. We expect that it can address the difficulties of co-located or global product development. This objective is divided into the following sub-objectives. First, it is important to identify, analyse and evaluate several decision-making methods, decision support systems and decision-making apps to gain an overview over the state of the art and to identify suitable methods and needs for a new app. Afterwards the conceptual design for the new app has to be developed. Finally, the implementation of a prototype and its testing is essential to deduce further improvements.

2 FUNDAMENTALS OF COMPUTER-AIDED DECISION MAKING

2.1 Multi-criteria and collaborative Decision Making in Product Development

The anatomy of a decision is characterized as a problem with a number of alternative solutions (Bazerman and Moore, 2013). By choosing an alternative, a high degree of rationality should be achieved (Brunson, 2007). A decision is rational when the decision maker prefers solutions which fulfil his or her consistent goals to the highest possible degree (Gächter, 2013; Haberfellner et al., 2012).

In order to make a rational choice, the decision should not be understood as the "final decision-making moment", but as a whole decision-making process leading to find the best solution (Simon, 1960). In literature, many decision-making processes are suggested, for example in (Bazerman and Moore, 2013; Haberfellner et al., 2012). They usually start with a definition of the problem and an identification of possible alternatives. Afterwards, the goals of the decision are defined and the alternatives are evaluated in order to ascertain how well they fulfil those goals. Based on this evaluation, a choice can be made. This paper is based on the specific decision-making process for product development according to (Luft et al., 2016b), which is based on the evaluation-process of technical systems from (Breiing and Knosala, 1997). It is complemented with further important aspects, such as negotiation, discussion or lessons learnt, identified by (Mekhilef and Le Cardinal, 2005).

The vast majority of decision-making problems depend on more than one single criterion – even if there is only one decision maker (Luft et al., 2015). In contrast to single decision making, in group decision making or collaborative decision making not only one but several persons (e.g. stakeholders, decision makers, interdisciplinary experts) are involved in the decision-making process (Yassine, 2004). Hence it is unlikely that one criterion would be acceptable for all decision makers (Roy 2005).

In literature, different forms of group decision making are described. Yang (2010) differentiates in single leader decision making and consensus or collaborative decision making. Furthermore, it can be differentiated between group decision making with team members, who share the same objectives, and with members who have different objectives on the decision outcome (Jankovic et al., 2010). More information on group decision making can be found in (Kilgour and Eden, 2010; Jankovic, 2015).

Bazerman and Moore (2013) suggest the usage of decision-making methods to avoid mistakes or irrational choices in decision making. Today, plenty of such methods exist, which can be divided into rational methods and heuristics. Rational methods can further be differentiated into the so called American School (e.g. the Analytical Hierarchy Process (AHP) and the Scoring Method) (Wallenius et al., 2008; Figueira et al., 2005) and the French School (e.g. outranking methods like ELECTRE and PROMETHEE). Outranking methods are generally defined by binary relations on the set of potential actions. Those relations are to be created by pairwise comparisons about which the actor has already defined his or her preferences (Figueira et al., 2005). In contrast to rational methods, heuristics "rely on a minimum of time and information and computation to make effective decisions" (Katsikopoulos, 2012). One representative of heuristics is the Pugh Matrix or Method.

2.2 Decision-making support software

Decision-making support software, also called decision support systems (DSS), are computer based information systems which support decision-making activities (Mustajoki and Marttunen, 2013), for example by using data and knowledge bases as well as decision-making models and methods. Plenty of DSS are available. Some of these are web applications, while others have to be downloaded and installed. Most DSS have implemented some decision-making methods. In addition, not only the evaluation of different alternatives and the calculation of the result can be supported. Sometimes several ways for visualization of the process or the result can improve the transparency and usability. For instance, progress charts give an indication how many steps still have to be completed. Value profiles can visualize in which criteria a certain alternative is good. Moreover, it is easier for the user to recognize important aspects of the decision-making process. Furthermore, analyses of the results (e.g. through sensitivity analysis) and supporting the construction of a decision model are other common features (Mustajoki and Marttunen, 2013). Several DSS differ from each other with various functions. In the following Table 1, a selection of computer based DSS can be found (based on relevance for product development), including a short description of the tool and the information about the developer. Further information on software tools is referred to in Mustajoki and Marttunen (2013) and Weistroffer and Subhash (1997), and to the survey of OR/MS Today – Decision analysis software survey 2015, which is frequently updated (http://www.orms-today.org/surveys/das/das.html).

Table 1. Selection of computer based decision support systems (adapted list from OR/MS Today - Decision Analysis Software Survey 2015)

Product	Application	Short description	Source
1000Minds	Group and single decision making	1000Minds is suite of online tools for prioritization, group decision making, conjoint analysis and maximizing value for money.	Hansen, Ombler 2016
Decision Deck Project	Support complex decision aid processes	Project aims at collaboratively developing software tools implementing MCDA techniques which are meant to support complex decision aid processes. The software solutions are interoperable in order to create a coherent ecosystem.	Mousseau et al. 2009
@RISK 7	Prospecting, new product evaluation, portfolio optimization, reserves estimation, pricing	Since 1984, @RISK has been the leading add-in to Excel to analyze risks with Monte Carlo simulation	Palisade 2016a
Equity3	R&D investment prioritization, strategy planning, resource allocation, zero-based budgeting, business prioritization	MCDA portfolio modelling tool for helping you construct your most efficient portfolio of investments. Ideal for group workshops.	Catalyze et al. 2016
IDS (Intelligent Decision System)	New product development, performance assessment and management, risk and safety assessment and management	Evidential Reasoning extends Bayesian reasoning for handling imprecise probabilities and evidence which may not be fully reliable.	Yang 2011
The Decision Tools Suite 7	Prospecting, new product evaluation, portfolio optimization, reserves estimation, pricing	The DecisionTools Suite is suite of Excel add-ins: @RISK, PrecisionTree, TopRank, NeuralTools, StatTools, Evolver & RISKOptimizer	Palisade 2016b

There are also some apps for decision-making support. These are easier to use, but have usually less functionality and are simpler than DSS. Smartphone apps are self-contained software applications and have become largely appealing for consumers in recent years and are used privately or professionally (Franko and Tirrell, 2012). In order to identify existing decision-making apps, research has been done in the app-stores of the leading smartphone operating systems Apple iOS and Android. Several decision-making apps were identified and classified into four categories:

- *Random choice apps* (e.g. Decision maker, Ultimate Decider, The Decider) randomly help to choose or eliminate options out of several and can help indecisive users to find a quick solution. The choice process is often adapted from the gambling world (e.g. spinning wheels, coin flip).
- *Question and Answer Forum apps* (e.g. Quora) connect users through a platform, where they can search for existing or post their own questions. This type of app is very useful to get qualitative information on one problem and share knowledge e.g. within a company.
- *Voting apps* (e.g. Easymind, Decision Buddy) support both single leader and consensus decision making and enable to vote among several options. These apps are especially suitable if teams cannot come to a consensus through discussion or if it is important to find a compromise.
- *Methodical evaluation apps* (e.g. MyDeci, Ethical Decision Maker, FYI Decision) enable users to make a methodical evaluation due to a decision-making method. After adding options and criteria, the users are asked to state their preferences in a way, which fits to the implemented decision-making method (e.g. according to AHP or the Scoring Method).

3 REQUIREMENTS FOR A NEW WEDECICE APP

To choose appropriate decision-making methods for a new decision-making app, existing methods were analysed (Luft et al., 2016a). It is most important, that they lead to successful designs and fit to the characteristics of a smartphone app, such as small screen, intuitive to use, easy to understand.

Based on evaluating the relevance of the categorized decision-making apps (see Chapter 2.2) for product development, the authors see methodical apps as the most relevant ones for decision making in engineering design. They can calculate utilities, help to make rational choices and focus on choosing options with the highest value for the company. Furthermore, the application of a method helps to justify decisions in front of the management. The existing apps of this category are not very advanced yet. All of these apps either use variations of AHP or the Scoring Method. They only take the user input and calculate a final result. So, there is no opportunity for explaining and negotiation or opportunities which enable team discussions. Generally, there is a lack of further functionality to support the decision. Most of those apps have no group functionality or the implementation of this functionality is poorly elaborated. It can be concluded, that none of those apps is elaborated enough to be used in real engineering projects. Therefore, it is recommended to develop a more sophisticated methodical decision-making app for product development. For the development of a new app, the authors first deduced the following general requirements from the goal of this paper: Support decision making in the context of product development; support decision making by considering multiple criteria; support decision making with several participants. Based on these general requirements, more specific requirements can be deducted:

- *High intuitiveness*: It must be ensured, that the app is easy to use during the whole process as not every user is an expert in multi criteria decision making and not much time is available to give instructions on using the app. Showing the user´s current step as well as the following steps is as important as recognizing missing or wrong information, to warn the user and highlight, where and how to interact.
- *Independency of time and place*: At least for parts of the evaluation steps, it should be possible that the participants can do them independently from each other. This makes the app more flexible and mobile than computer based solutions and might be one of the main advantages of a decision-making app. The app should consolidate the input of the users and highlight the discrepancies (e.g. regarding the evaluation of criteria) to facilitate a discussion.
- *Require few information and input from participants*: The effort for information delivery in a smartphone screen should be reduced significantly. As the display of a smartphone is small, it has to be taken into account that not much information can be displayed at the same time.

In addition, the app should be a methodical decision-making app. After discussions during several workshops the authors decided to implement both a heuristic and a rational method. As common heuristic, the Pugh matrix turned out to be most appropriate. However, it does not lead to a ranking of alternatives and the authors see the ranking as a mayor benefit in the decision-making process. Thus, combining this method with a rational decision making method ranking alternatives is necessary. In the context of analysing possible methods, the scoring method turned out to meet necessary requirements, as e.g. simplicity, easy to understand etc., best and thus was chosen as second method. . Furthermore, collaborative decision making and the automatic consideration of the input of different users should be possible. For the first version of the app, product development decisions with the following characteristics are seen as promising:

- Decisions with a *middle complexity*. Decisions with low complexity do not necessary require decision support, and decisions with a high complexity deal with a lot of information which would not be suitable to add into an app.
- Decisions in the *early phase of product development*, when there is only a little detailed information, but more rough and general criteria. In case that there would be excess detailed information, it is recommended to do calculations and evaluations with a computer based DSS.
- Decisions with a *lack of information and uncertainty*, where different team member can contribute with their specific knowledge to achieve a common sense about the decision and potential alternatives.

According to the authors, it would be best to implement both – a heuristic and a rational decision-making method. As heuristic and for the qualitative evaluation, the Pugh Matrix is chosen. One great benefit of this method is that subjective opinions about one options in comparison to another can be made more objective and transparency about the decision is created among the participants. As the criteria are not weighted and the qualitative assessment can be made intuitively and easily, the Pugh Matrix allows a quick selection process.
This qualitative method should be combined with a more quantitative and rational decision-making method, which ranks the different options according to the objectives of the team. This helps especially to make the final choice out of the suggested alternatives. In the context of analysing possible methods, the Scoring Method turned out to meet the previously defined requirements best and thus is chosen as rational method for the decision-making app.

4 THE CONCEPT FOR THE WEDECIDE APP

The developed app follows three main phases, which can be divided into several steps (see Figure 1).

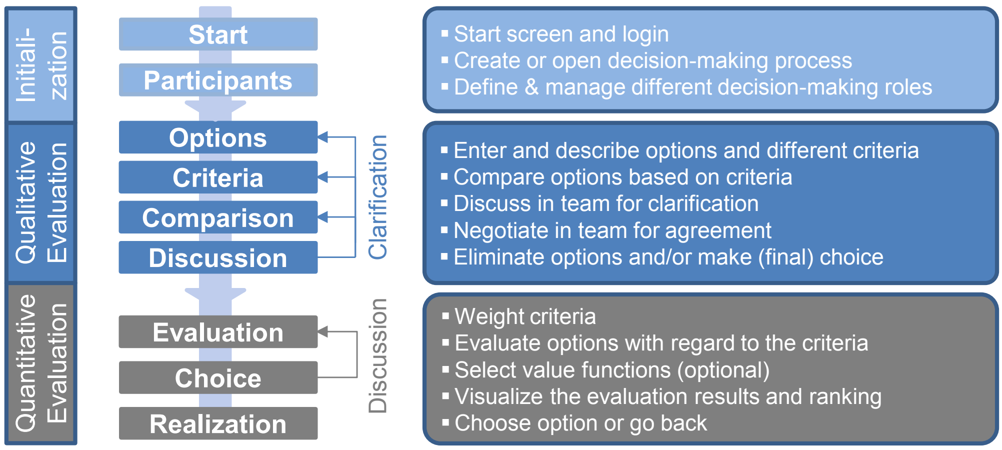

Figure 1. The three phases with the main steps of the decision-making app

The first phase – the initialization phase – is important to prepare the decision-making app for the following evaluation phases and to guarantee a good collaboration of different participants. Therefore, basic steps – like log in, create a new or open an existing decision, as well as determine or change roles (administrator, evaluator and viewer) of participants – can be performed during this initial phase.
In the second phase, the qualitative evaluation takes place. The user adds and (if required) describes options and criteria and separately evaluates those options with a Pugh Matrix. During this so-called Pugh`s convergence process, several experts qualitatively compare several alternatives (e.g. concepts for a design) with a selected reference option and enter their evaluations into this matrix. As one (well understood, generally strong) alternative has to be chosen as a reference, a qualitative evaluation referred to the reference option can be inserted in the respective matrix cells. Thereby, the rows of the matrix are labelled with relevant criteria to compare the alternatives represented through the columns (cf. Figure 2). Therefore, the possible evaluation symbols are "+" ("-"), if the considered alternative fulfils the

referring criteria better (worse) than the reference, or "*s*", if it is roughly similar (Frey et al., 2007). For a qualitative differentiation, the cells of the matrix used for the decision-making app, can be filled with more "+" or "-".

Criteria	Reference Concept 1	Concept 2	Concept 3	Concept 4
Performance	s	s	-	-
Robustness	s	-	-	- -
Mass	s	s	+	+
Market Risk	s	+	+	+ +
Availability	s	-	-	-
Flexibility	s	-	- -	s

Legend
++ better than +
+ better than reference
s roughly similar
- worse than reference
- - worse than -

Figure 2. Qualitative evaluation with a Pugh Matrix

As disagreements (i.e. different evaluations regarding one matrix cell) between the experts might occur during this evaluation process, it is useful to communicate the reasons for their opinion. The aim of this phase is to convey a common understanding of the decision, options and criteria, and to create transparency about the advantages and disadvantages of each option among the whole group.

To make a final choice, the app combines the Pugh Matrix of the qualitative evaluation phase with the Scoring Method, which ranks alternatives based on the preferences of the decision makers (e.g. Zangemeister, 1976). This method is part of the third phase, the quantitative evaluation phase, and consists of the two main steps weighting (of criteria) and rating (of options). Within the first step, all defined criteria have to be assigned to *criteria weights* w ($\Sigma w = 1$ or 100%), which reflect the importance of each criterion. In the second step, it has to be evaluated how "good" the options fulfil the criteria. Therefore, *value measures* m will be assigned to each option and for each criterion.

The determination of criteria weights and value measures can be done both by direct assessment through estimation and through calculation. The approaches used within the decision-making app are the well-known *preference matrix* for weighting the criteria and different *value functions* for rating options. The preference matrix is based on pairwise comparisons among all criteria and is a simple method to determine criteria weights. The more often one criterion "wins" against another (i.e. is more important), the higher is its weight. Thus, the user has to compare all pairs. Once the comparisons are completed, the app uses this information to fill a preference matrix and to calculate the criteria weights. Value functions (e.g. non-monotonic/monotonic increasing, decreasing) can be defined as mathematical functions which transform characteristics towards a goal into numerical utility values. In the app, those numerical utility values are used as (normalized) scores in the Scoring Method.

As the decision-making app should be easy to use and enable a rapid application, the Scoring Method uses the information already inputted in the Pugh matrix. However, the Pugh matrix only includes qualitative evaluations in forms of several plus and minuses which have to be transformed into numerical characteristics (e.g. by an association table) before the normalization can be done.

The assignment of the judgements of an option starts with assigning the neutral or similar (*s*) to the reference option. A plus (+) is then assigned to the next better option and the number of pluses rises by one with each option better than a previous one. This helps to qualitative differentiate between the options. For options worse than the reference option, the same logic is followed by assigning minuses (-). Consequently, an option with more pluses on one criterion is always better than one with less plusses or even some minuses. Therefore, the assigned value measure of options with more pluses has to be higher than for other options. Consequently, only strictly monotonic increasing value functions are relevant for the app. For simplification, the user can choose only among the most basic curves during the quantitative evaluation phase: linear, progressive, declining and s-shape.

Figure 3 exemplarily illustrates the transformation of normalized characteristics (e.g. 2,0 kW, 2,5 kW, 3,0 kW, 4,0 kW) into value measures using a linear (left) and a declining value function. The linear value function proportionally assigns value measures m to the normalized characteristic x. In case of a declining (progressive) value function, the assigned utility measures between the best and the worst characteristic would be over-proportional (under-proportional). The s-shaped value function assigns under-proportional value measures for $x<0,5$ and over-proportional value measures for $x>0,5$.

After the weighting of criteria and the rating of options is completed, the score of each option can be calculated by the app. First, the app is multiplying the weights w with the corresponding value measures m and then it is summing up among the results for all the criteria. Hence, the options can be ranked according to the scores and the emulations results can be clearly visualized. Finally, a recommendation for the best option can be derived.

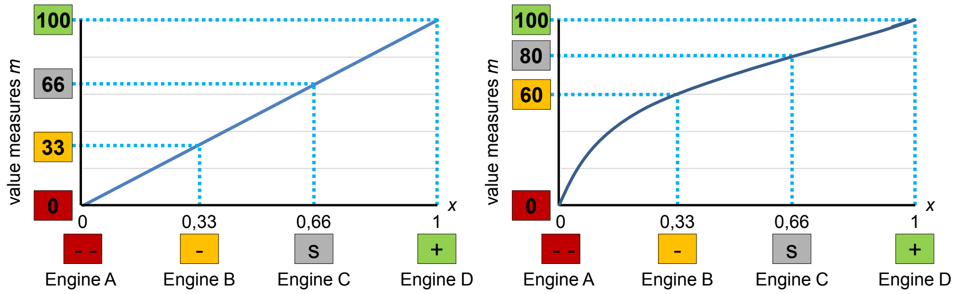

Figure 3. Value measure assessment with value function

5 THE PROTOTYPE OF THE WEDECIDE APP

5.1 Key Functionalities

In order to test and demonstrate the concept of the app, a prototype has been developed by using MS Excel. Through this prototype, the concept can be understood easier and it also can be applied to gain feedback. This can be taken into account for further improvements. Generally, the prototype allows a single user to go through the whole qualitative and quantitative evaluation phases and thus simulates a decision from the beginning to the end. Thereby, the authors concentrated on the main functionalities of the concept and consequently made some simplifications.

The initialization phase, for example, mainly consists of a graphical user interface, which indicates the implementations planned in the final app. Furthermore, the group functionality is missing in the prototype, so each user of the prototype has the same rights to enter or manipulate data.

The qualitative evaluation phase is almost completely implemented, but allows only the input from one single user due to the missing group functionality. As consequence, the disagreements between expert judgements cannot be highlighted by the app. If a whole team wants to test the prototype, it is recommended to follow all the steps together and discuss critical points before entering them into the prototype of the app.

As well as the other phases, the quantitative evaluation phase only enables input from one user. Nevertheless, all conceptual steps of this phase can be followed. After the user is asked to make pairwise comparisons of all criteria, the value functions can be chosen. The prototype calculates the results, shows the ranking and offers basic visualization functionalities for the evaluations results.

5.2 Graphical User Interface

One of the requirements for a new decision-making app is a high intuitiveness which implies a well-designed graphical user interface (GUI). Thus, for testing the concept realistically, the prototype also needs an appropriate GUI. The GUI used for the prototype consists of several screens – one for each step in the process.

To improve the guidance through the process and indicate the user´s current step, a process flowchart with the main phases and the single steps is located at the top of each screen. On this flowchart, the current step is highlighted in light blue (see Figures 4 and 5). To navigate between the screens of each step, the user has to click on the tab of the step he wants to go next. In case a user wants to proceed to a step where previous input is crucial, error messages appear to inform the user what to do.

To further support the user, explanation boxes are located on the right side of each screen. Those boxes give instructions what to do on the respective screen. Furthermore, background information is given to help understand the logic of the process. In a smartphone app, this information could be opened for example with a help button.

A possible scenario for the application of the WeDecide App prototype is a company which has to make a decision about different engine concepts for a new rotary hammer for do-it-yourself customers. For

instance, there could be the following three possible concepts: Inhouse Professional (IH Prof.), Inhouse Simple (IH Simple), Purchase Professional (Purch. Prof.). Based on this example, the steps of the app are explained and the most relevant screens are shown in Figure 4 and Figure 5.
At the beginning a start screen with some basic information on the app and the possible navigation appears during the initialization phase. Afterwards, the user has to open or create a new decision and define the roles of the participants. The first screen of the qualitative evaluation phase is about adding options (with descriptions) and selecting one of them as reference. Before the alternatives can be compared in the Pugh Matrix ("*s*" for similar, "+/-" for better/worse than reference), relevant criteria (e.g. market risk, flexibility, performance) have to be entered and added to the decision model (Figure 4). Then, the overview of the filled Pugh Matrix can be discussed in the team in order to gain a common understanding and transparency about the decision and to solve controversial judgements.

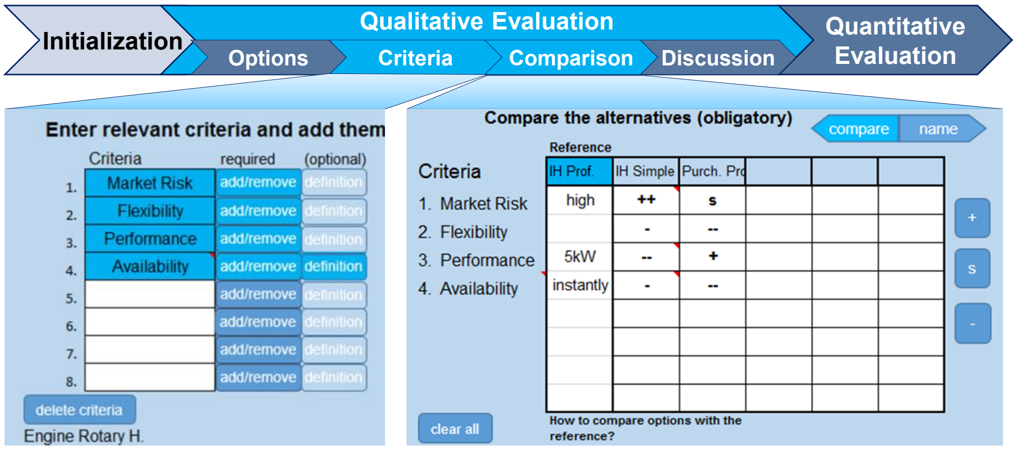

Figure 4. Qualitative evaluation phase of the prototype

The first screen regarding the quantitative evaluation (Figure 5) enables to compare the importance of each criterion. For the following selection of the value function, there are two different screens.

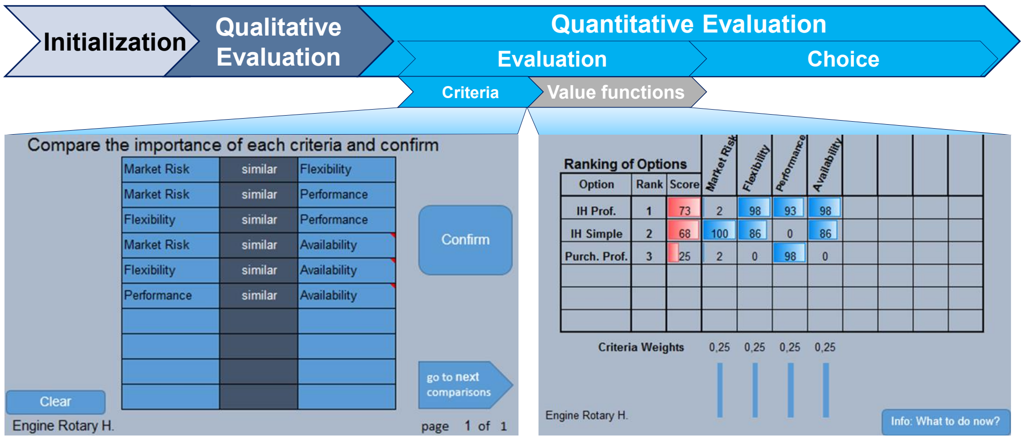

Figure 5. Quantitative evaluation phase of the prototype

The first screen provides an overview of all criteria with their assigned value functions. For a rough and quick evaluation linear value functions are set for all criteria as default. For a more precise evaluation it is recommended to set value functions depending on the criteria. For unexperienced users this is easier on the second screen, where the value function of one selected criterion can be analysed in detail, as the chosen options are located in this graph. Thus, it is visible, which value measures are assigned to which option. Furthermore, the value function can be changed in this screen, so the user dynamically sees how the value measures are changing. With this functionality, the right value functions for each criterion can be chosen easily. Finally, the ranking or final results calculated by the app are visualized in the last screen (Figure 5). There is also an info button on this screen, which gives further instructions on how to interpret the results or what further steps can be done next.

5.3 Application, Evaluation and Implications for further Development

The main objective of the prototype was to demonstrate the concept of the WeDecide App and to test its functionality in order to derive implications for the further development of the app. Thus, the application of the prototype took place during a SIG Decision Making Workshop organized by the authors during the last Design Conference. After working on several case studies in evaluation teams by using the prototype of the app, the participants of the workshop were asked six questions about the functionality, usability and usefulness of the app. Furthermore, they gave feedback on the whole concept of the app (e.g. of the combination of the two aforementioned decision-making methods).

Based on the feedback of the participants in the workshop, implications for the further development of the prototype and the app were deduced. Some of those implications – clustered in the categories usability, transparency, functionality, methodology – were already considered and implemented in the prototype described in Chapter 5.2.

As the *usability* of the app-concept received some negative evaluations in the workshop, among others, a starting screen with basic information on how to use the prototype as well as instruction boxes for each screen, were implemented. Furthermore, worksheet protections with error and information messages were implemented to prevent wrong user input.

To improve the lack of *transparency* regarding the app´s calculation processes, among others, a more detailed screen of value functions was created. On this screen, the assignments of value measures m to each option are visualized. This helps to better understand the role of value functions in the process.

Within the feedback, also the missing group *functionality* of the prototype and the limited number of options and criteria to be inputted, were mentioned. This will be considered in future app versions.

In the concept of the app, as well as in the prototype, all criteria are considered to be independent to each other. However, in reality, often goal relationships exist (e.g. complementary goals, competitive goals, and substitutable goals). Thus, regarding the *methodology*, considering goal relationships for a future version of the app was suggested.

6 CONCLUSION AND OUTLOOK

As higher requirements towards decision making in product development occur, a concept for a smartphone app was developed to support collaborative decision making in product development. The presented concept is based on the combination of a qualitative (Pugh Matrix) and a quantitative (Scoring Method) decision-making method. Within the first method, a common understanding of the decision, including the relevant criteria and existing options, is created among the participants. This helps to avoid the common mistake in collaborative decision making, where team members have different knowledge which is rarely shared between one another. The second method finally helps to choose the right option wherefore it identifies the decision maker`s preferences through pairwise comparisons of criteria. Moreover, it transforms the qualitative evaluations of the first method into quantitative information. Based on these results, a ranking of alternatives is created which acts as a recommendation for the choice. By combing the quantitative and qualitative decision making method (Pugh Matrix and Scoring Method), the decision-making process can be well supported by the app. However, it is difficult to measure product development success (Bender and Marion, 2016). Thus, it is difficult to state, whether choices done by this app result in better outcomes than without using it.

Testing a prototype of this concept within a workshop, leads to the assumption that the concept mainly can support decisions with a middle complexity during the early phases of product development where little detailed information is available.

Generally, this concept promises to support collaborative decision making in product development. In particular the Pugh Matrix is a collaborative decision-making method, where several participants give their input and discuss possible disagreements. As a consequence, it entails aspects of negotiation and communication, but also simply calculates a ranking based on the user input. As it uses the input of the qualitative method also for the quantitative method, the required input is minimized. This gives the chance to make decisions quickly. Moreover, the concept is easy to understand not only for decision-making experts. Laypersons can easily be involved in the decision-making process without conducting detailed training.

In the future, the authors aim to improve the concept and to integrate further functionalities by implementing the presented concept as a real smartphone app (on an ANDROID and/or APPLE iOS platform) and find an appropriate use cases for more realistic application tests.

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