AN ANALYSIS OF EXPECTATIONS IN INDUSTRIAL VALUE ENGINEERING PROJECTS

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ABSTRACT

This exploratory study addresses the need to identify specific and holistic upfront expectations into industrial value engineering projects for best tailored preparation of an efficient project execution. The analysis includes a total base population of 90 projects, which were conducted between 2010 and 2018 in 16 different industries. Out of those, 63 projects had a narrower value engineering context and have been analyzed with the support of a CAQDAS tool (Computer Assisted Qualitative Data Analysis Software). Analytical results show that participants' expectations in value engineering projects vary depending on their industrial environments, but cope with existing studies on critical success factors for project management. Based on the findings the author recommends further research on fast project execution, closing the gap between training- and project content as well as emphasizing the necessity of rigor with regards to the utilization and application of terminology, which includes sharpening the correct interpretation of value engineering, its tools and contents.

KEY WORDS

value engineering, project expectations, content analysis, CAQDAS

JEL CODES

O310, L230

1 INTRODUCTION

This introduction covers three aspects. First, in order to avoid and prevent misunderstanding and to foster a common clear understanding of the origin and the potential impact, the term 'value engineering' is elaborated in the literature review.

Second, as this analysis' driving force, the author's personal practical experience and arbitrary observations let one assume that a

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high degree of freedom rules practitioners' and stakeholders' interpretations and expectations in value engineering projects. On the same page, not all past projects have been closed with full satisfaction. But the analysis within this environment seems to show repetitive patterns. The consecutive question arises, if the project setup and planning preventively could have been prepared a better way upfront. A strong alignment of value engineering projects along project management's basic principles is evident.

Third, this analysis is based on a data collection, which was gathered during the last decade by the author as unique source. The general validity, its restrictions and limitations of this base require careful consideration. On the other side, the given set of data allows analysis, understanding and comparison of different industrial environments.

Therefore, this analysis provides insights into contemporary and subjective environment-dependent interpretations as well as improvement proposals for future value engineering projects' setup and upfront planning, including the consideration of participants' expectations in terms of potential goals, procedures and execution.

2 RESEARCH OBJECTIVE AND RELEVANCE

This research's relevance is based on three distinctive aspects. Generally, it aims to explore practical interpretation and application of value engineering projects in the industrial environment. The guiding idea is to analyze and understand upfront expectations into value engineering projects, in order to address them the earliest possible moment. This shall raise satisfaction with the projects and its results.

The first detailed supportive aspect of this study's relevance deals with the necessary precision of wording and terminology in order to enable exact and correct interpretation. It is relevant to embrace the contemporarily interpreted identity of any term, in this particular case the term "value engineering", in order to enable oneself to talk about this term with any other person without creating misunderstandings. One main force behind this research was the author's experienced increase of projects, which were labelled "value engineering", but pursued other non-value-engineering objectives as any other random project following loose, unclear and unbinding definitions. Any wrongly or imprecisely labelled project might lead to misconception and disappointment, if the label is used as a generic "one-for-all umbrella-term". This paper shall support sharpening the use and interpretation of the terminology by understanding contemporary interpretations and project expectations.

The second underlying aspect of relevance consecutively derives from the first one and deals about the best possible upfront preparation to potential expectations in upcoming projects. It is about the awareness of the spoken and unspoken objectives, goals and expectations, within and beyond imagination of all participants and stakeholders. One could argue, that it finally would not matter from the viewpoint of project success, which labels the assigned projects finally are given or which tools are being applied, as long as the project focal point, objectives and expectations are defined thoroughly and precisely for the sake of most efficient and successful project execution. Projecting this aspect even on to external influences, value engineering projects hypothetically and theoretically could be influenced by new trends or collateral effects, which were not covered back in the time, when value engineering was defined. There might be a new mainstream, which is worth being detected as collateral benefit of this work.

The third underlying aspect of relevance deals with general difficulties to compare different industrial project environments within one study due to restricted data access. This paper offers a unique opportunity to do that (in a limited way, and to compare different industrial project environments and uncover differences.

3 LITERATURE REVIEW

The idea of Value Engineering (VE) was initiated and formulated during the 1940s by Lawrence D. Miles (Lawrence D. Miles Value Foundation, 2016). Now it is manifested as a norm and as an internationally recognized standard in the European Community (DIN – Deutsches Institut für Normung, 2002) as well as on the American continent (SAVE International, 2018). The underlying core principle of the VA technique, as explained in these fundamental documents, is based on methods of the technical value- and functionprinciple and interprets the term "Value" as function-cost-ratio (SAVE International, 2018), a trade-off between utilization of a part and its cost of creation.

Value Management (VM), according to DIN EN 12973 (DIN – Deutsches Institut für Normung, 2002), is manifested in an international normative. There, it is defined as a management style, which has been developed from methods based on the value- and function-principle. Nowadays the utilization of the terms Value Management (VM), Value Analysis (VA) and Value Engineering (VE) is based on the same concept and applies the same toolset. According to Springer Gabler Verlag (2016a), the techniques VA and VE are being applied at different stages of a product's life cycle. VE is being applied during the early concept-, development- and engineering phase, where the majority of the cost still can be influenced before their allocation. In contrast, VA rather analyses and optimizes products, which are already readily developed, launched and produced on existing facilities with lower savings-impact and at costly design changes.

The main distinctive characteristics of the VE approach from other approaches is a strong primary focus on the customer, the customer requirements, the customer expectations (translated into customer functions) and an overall cost-optimization-thought. Miles (Lawrence D. Miles Value Foundation, 2016) quoted the challenges and core thoughts for VE as follow: *"All cost is for Function"* and *"Instead of thinking and talking in terms of 'things,' Value Analysis changes the thinking process to 'functions'."* From a practitioners' tool perspective, the VE-approach technically takes advantage of thinking in higher levels of abstraction by neutrally defining a product's functions and thinking in those.

In its very beginnings, VE aimed on improving the value of existing products, in terms of reducing and eliminating unnecessary cost. Later, it shifted its focus additionally towards functional improvement of a product, simply said: making its features better. Nowadays, VE is being applied on products, services, projects and administrative processes, regardless of their development maturity along the entire product life cycle.

VE is defined as an organized, systematic and cross-functional team approach with the objective to provide the required functions at lowest overall cost (DIN – Deutsches Institut für Normung, 2002). VE pursues a holistic integrative solution system. The required quality, performance, reliability, performance and market acceptance of a product are not being sacrificed for the sake of cutting cost or cheapening a product only.

With cross-reference to product development, Ibusuki and Kaminski (2007) as well as Unger and Eppinger (2011) and Ho and Lin (2009) recommend utilizing VE, together with the principles of target costing, concurrent function deployment and concurrent engineering for product development processes.

In the United States and Canada, the application of VE shows a long mandatory project track in private, federal and governmental organizations (SAVE International, 2018). The Public Law 104–106 (104th Congress, United States of America, 1996) even mandates the application of VE for public procurement projects, for instance on construction, traffic, road construction, defense, security and space flights.

VE has a long history on its transition from pure cost optimization towards standardization and application in various industries, products, services and along the entire product life cycle.

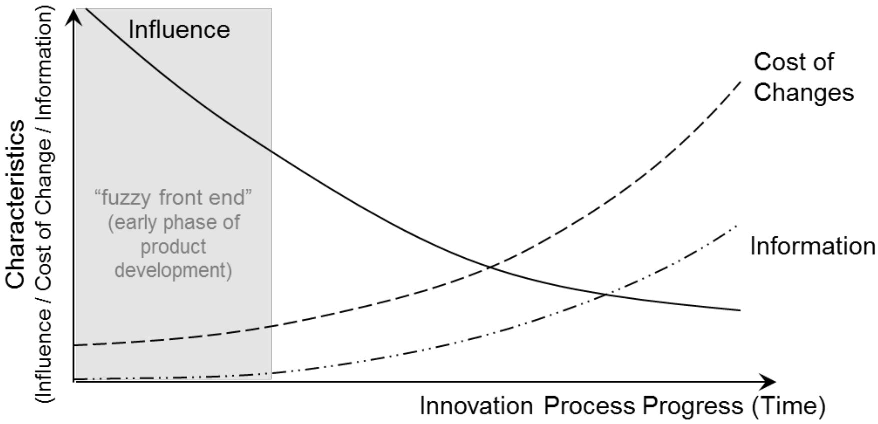

Fig. 1: Development of influence for change, cost of changes and information level along the innovation process progress (source based on Jahn, 2010; Herstatt and Verworn, 2004; von Hippel, 1993; modified by the author)

During the early innovation phase (see Fig. 1, "Influence" zone "fuzzy front end" during the very early phase of product development, sources stated below) design changes can be implemented relatively easy at lower change cost in comparison to design changes at a later point of time, where change cost are higher due to already allocated cost, such as already invested design-labor, material, machines, jigs, fixtures or tools among others – compare Jahn (2010), modified from and referenced to Herstatt and Verworn (2004), itself based on von Hippel (1993), see also Fig. 1.

Even though not stated anywhere explicitly within the standard, it is obvious, that the work plan of a value study (DIN – Deutsches Institut für Normung, 2002, p. 22ff) fulfils the definition of a project (Springer Gabler Verlag, 2016b). Any VE project is built on a clear project management setup.

Timewise on parallel to VE, Project Management has been developed as a generic management model (Atkinson, 1999; Müller and Jugdev, 2012) on its transition towards formalization and institutionalized standardization (Garel, 2013). This development path ever since was paired with the search for critical success factors, as elaborated by Müller and Jugdev (2012), who have analyzed and summarized the contribution of Pinto, Slevin and Prescot as (in their view) popular and dominant authors in the field of Project Management. In their summary on research referring to project management success factors, they have identified "impact on customers" and "business success" among others, which refer back on key features of VE, themselves. Lim and Mohamed (1999) reconfirm in their exploratory studies, that project success mainly depends on stakeholders' perspectives and has different meanings to different stakeholders. This copes with the above stated author's personal experience. Frefer et al. (2018) compare the findings of Pinto and Slevin (1988) on projects' critical success factors with other researchers' conclusion (Freeman and Beale, 1992; Khosravi and Afshari, 2011; Bryde and Robinson, 2005; Bahia and de Farias Filho, 2010; Al-Tmeemy et al., 2010; Mukhtar and Amirudin, 2016; Gomes and Romão, 2016; Omer, 2017), shown in adapted Fig. 2. "Time", "Cost", "Customer Satisfaction", "Effectiveness & Efficiency", "Requirements & Specifications", "Quality" and "Health, Safety, Environment" were identified as critical success factors by more than half of the researchers.

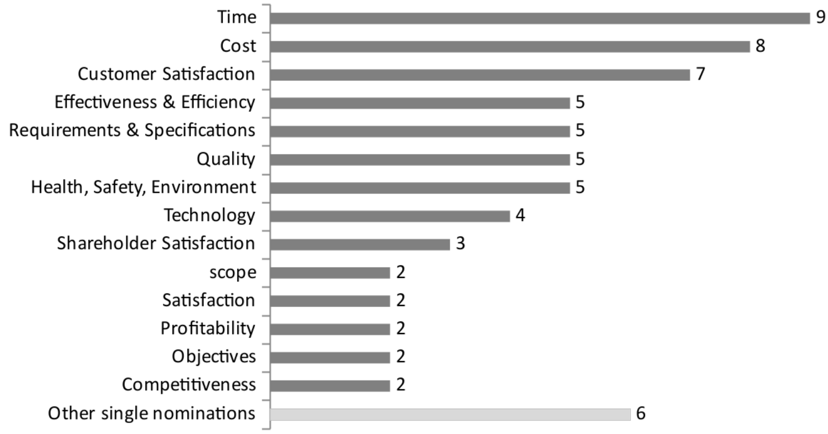

Fig. 2: Quantitative summary of success factors in projects (source based on Frefer et al., 2018; modified by the author)

4 RESEARCH DESIGN

The main goal of this analysis is to explore different aspects of project expectations and their impact direction for industrial value engineering projects.

Under the assumption, that project expectations of one specific project environment can be transferred from past and projected on future projects in a similar project environment and setup, also conclusions from past can be transferred and may be verified with future projects.

The analysis of this (past) information shall serve as improvement base for future value engineering projects' setup. This includes the consideration of participants' "ex ante" expectations (in the meaning of "original, before the project was started and not influenced by external factors") in terms of potential goals and on top of the hard project content goals, procedures and execution of the projects itself.

It is the goal of this analysis to identify the different aspects of upfront expectations into projects, which is linked to project satisfaction.

Therefore, this analysis' research question is: "What was past industrial VE projects participants' real upfront comprehensive, contemporary and particular expectation in those projects?"

This research has an exploratory character. There is no upfront knowledge available, there are no given parameters nor variables to examine (Creswell, 2009, p. 18). Creswell (2009, p. 194) takes reference to Locke et al. (2013): *"The intent of qualitative research is to understand a particular social situation, group, …"*. Based on the given subjective baseline, the inductive constructionist research approach was chosen. Silverman (2017) defines it as focusing on social processes and constructing the reality socially by applying "How?" questions.

This is supported by the specific characteristics of the given research environment, which calls for qualitative research (Creswell, 2009, pp. 175 and 195). There is a natural setting, in which the author shall experience the issue when collecting input. The author is active part and a key instrument of research himself by observing behavior and interpreting when collecting data. With regards to VE projects, there are multiple sources of data, which need to be compared. By organizing the identified data from bottom-up, an inductive process is installed with working back and forth between sources, codes and the levels of abstraction. The research design is emergent and being developed during the research itself. It is not described a detailed way before beginning. The research topic demands a holistic view in terms of combining and comparing the findings of each single project stream.

For reaching the research objective, it is more important to fully understand the research field, opened by the various cases, than to focus on and apply methodologies (Creswell, 2009, p. 10). The author wants to identify and understand the dependencies, connections and exclusions between these different projects/cases and its expectations. This research objective does not require providing a post positivistic proof of a hypothesis, which cannot be identified based on the given starting base line.

Qualitative research has gained importance and application within social science, psychology and medical research in general during the last decade, where quantitative research was dominant and preferred before. Malterud (2001) underlines the importance of 'interpretive action' to be included in medical research, while Lamnek (1995) sees the advantage, that the interpretive procedure allows the reader or observer to uncover background information, which would not be possible with a quantitative approach. The content analysis as a forerunner of qualitative research comes from communication science and provides a procedure to analyze big amounts of textual material (Mayring, 2010). According to Mayring (2010), the qualitative content analysis combines the technical knowhow of, how to deal with lots of textual material, with the capability to perform interpretive and verifiable text analysis.

Creswell (2009, pp. 185–191) summarizes the key points for qualitative data analysis and interpretation as an ongoing process with continual reflection about open ended data, which has to be collected, organized, analyzed and structured by "coding" (which means to categorize), arrange the codes within a framework to start to form a theory and interpret the findings. The continual reflection from different perspectives is the base for triangulation of different data in order to provide validity.

In her introduction to Grounded Theory, Charmaz (1996) describes the means and procedures of qualitative studies as *"… a set of inductive strategies for analysing data. That means you start with individual cases, incidents or experiences and develop progressively more abstract conceptual categories to synthesize, to explain and to understand your data and to identify patterned relationships within it. You begin with an area to study. Then, you build your theoretical analysis on what you discover is relevant in the actual worlds that you study within this area."*

Following Silverman (2017, p. 326), the research strategy follows 4 steps: (1) focus on high quality date with easy access; (2) focus on one process within that data only; (3) narrow down to one part of that process; (4) compare different sub-samples of the population.

The only focal point for the research at hand was set within the above mentioned research question. Other potential areas of interest for studies, as for instance, success factors, success rates, and financial benefits of projects, organizational setups, and hierarchical support among others were not followed and specifically excluded. The only topic of interest was any potential upfront expectation into the project.

The inductive approach of qualitative content analysis was mixed with quantitative insights, in order to enlarge to a mixed methods approach. Silverman (2017) and Saldana (2016) underline the useful support of a CAQDAS (Computer Aided Qualitative Data Analysis Software) for such studies. The chosen software for this study is MAXQDA.

Applying triangulation supports this research in different ways. First, by analyzing the research question from different viewpoints, new knowledge is created (Flick, 2008). Data triangulation supports the research validity: *"… by combining methods and investigators in the same study, observers can partially overcome the deficiencies that flow from one investigator and/or method. (…) In this respect triangulation of method, investigator, theory, and data remains the soundest strategy of theory construction."* (Denzin, 1970). In this research, multiple cases from multiple industries and multiple different projects serve as subjects for this study and provide *"rich data"* (Silverman, 2017).

Fig. 3 demonstrates the study's design. It combines Silverman's (2017) 4-step approach and Charmaz's (1996) procedures. In a first step, appropriate projects from the author's professional past practice were identified, which

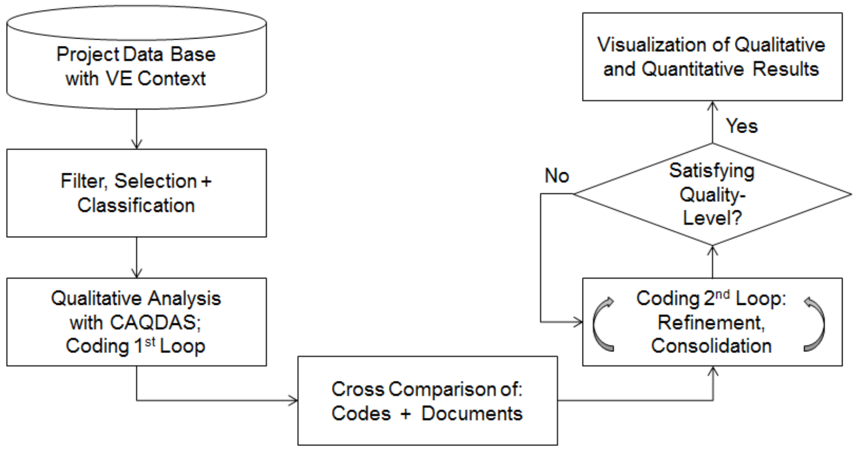

Fig. 3: Design of study

potentially could contribute to the research question. Filters were applied to focus on the most appropriate set of project data (see next sub chapter below). Then a Qualitative Content Analysis with first cycle coding according to Silverman (2017), Miles et al. (2014), and Saldana (2016) was applied by searching each single case by case for any potential hint on contribution to analyzing or answering the research question. Any identified information fragment was marked with codes. These codes emerged from the content and describe and summarize the content of the identified information fragments by descriptive notes. The MAXQDA software facilitates cross comparing the content of all identified information fragments of one code. Doing so, the coding was refined and consolidated in a second cycle coding, loop by loop. The software also supports cross comparison of the results of different document groups. Different combinations of document groups with codes finally were visualized a qualitative and quantitative way.

4.1 Sampling Technique

Due to the exploratory character of the study the author has applied purposive convenience sampling technique (compare Arber, 2001; Bryman, 2012; Denzin and Lincoln, 1994; Silverman, 2017). The samples conveniently were already available and accessible, which favored the examination of a larger population due to the timeadvantage. The selected base population for this study is all available cases, they are *"naturally occurring data"* (Miles et al., 2014), as most comprehensive and representative population (Arber, 2001).

According to Silverman (2017), the choice of cases for qualitative research should always be theoretically guided. Yin (2014) concludes that qualitative research (case studies in particular) can be generalized to theoretical propositions, but not to populations. According to Silverman (2017), the goal much rather is to *"expand and generalize theories (analytic generalization) and not to enumerate frequencies (statistical generalization)."* Hence for this particular study, generalization of the findings is of less importance than creating a first qualitative knowledge on one single and narrow focal point, which is the upfront expectation into VE projects (Bryman, 2012), (Silverman, 2017). Gobo (2007) proposes to apply *"interactive, progressive, and iterative sampling"*, in order to achieve representativeness.

5 DATA BASE OF CASES

The author is a trained, certified and practicing value engineer. As industrial consultant, he has participated in a 100+ projects across several industries for different companies over the last decade. The author's experience as consultant in industrial projects has facilitated the access to projects from several diverse industries. The majority of these projects were settled within a particular VE context but yet showed different VE-coverage, -relevance and -density.

These projects' technical content has to obey strict confidentiality. But keeping this research's subjects focused on upfront expectations into the projects only, does not violate any confidentiality restriction. Neither technical project content nor its particular hard goals are being discussed and distributed. Choosing the approach at hands, anonymous information is protected as required, but still can be analyzed and then shared. The large number of projects itself and its diversity with regards of industries, companies, participants and participants' functional roles supports anonymity, do not allow any reference conclusion back on single projects and provides biggest possible and representative diversity within the settled, limited environment.

The author's entire professional project track with more than 100 projects and cases was screened as first step (compare to "Project Data Base with VE Context" in Fig. 3). Applying a first upfront filter on the entire data base resulted in 90 remaining cases as initial data base line fulfilling all of the following characteristics: they were real projects, trainings or conferences; they were no concepts only, nor fragments; they took place during the last 10 years with the author's current work environment and work–scope as VE practitioner; they were embedded within a particular VE context; they potentially can contribute in answering the research question.

5.1 Filtering & Structuring the Project Data Base

As next procedure, a second, more specific filter was applied (compare step "Filter, Selection + Classification" in Fig. 3) on the pre-selected 90 cases. As result, 63 cases remained relevant for the study. 27 cases had to be excluded as not relevant for the study. Reason for exclusion could be any one of the following ones: referring to the research question, they did not contain any stated expectations in VE projects and, hence they could not contribute to answer the research question; they had no clear and specific value engineering reference on second view ("borderline cases") – that could be either one or both of the following cases: they did not have a clear focal point on functional improvement; they did not have a clear focal point on cost improvement; they were of repetitive character, had same or very similar content as other cases and, hence could not add additional contribution; they were of rather conceptual character, as for instance theoretic papers, which had been designed from one single party without reflection or discussion by other different parties; they lacked cross functional cooperation during creation.

Fig. 4 and 5 provide an overview of the cases' base population's classification after applying the first filters.

The vertical axis of Fig. 4 lists the industries, where the projects were nested in. The horizontal axis divides them a twofold way. The primary selection criterion is "relevant for analysis"/"not relevant for analysis" (second line in Fig. 4) for the further analysis as resulted after structuring as described in this chapter above. The secondary criterion (line three) describes the type of each single case. The initial "Project Data Base with VE Context" consists of a total number of 90 cases identified after the first selection, which reduced the original over 100 cases to 90 cases, as shown in Fig. 5.

Those 90 cases were later split into 3 subcategories as a consequence of the emerging differences during the later applied first-cycle

	Total Cases: 90							
	Relevant for Analysis				Not Relevant for Analysis			
	Conference	Project	Training	TOTAL	Conference	Project	Training	TOTAL
Industries	7	46	10	63	4	20	3	27
Auto OEM		1		1	1	8		9
Automotive Supplier		1	1	2		2		2
Compressor		11	3	14				
Consulting	1			1			1	1
Farming Vehicles		1		1				
Machinery		6		6		1		1
Marine		1		1				
Oil & Gas		8		8		1	1	2
Rail		1		1		1		1
Safety		5		5				
Semi Conductor		1		1				
Training			5	5			1	1
Valve	6	10	1	17	3	3		6
Bank						1		1
Ceramic						1		1
Mobility						2		2

Fig. 4: Data base characteristics for analysis

coding process throughout the qualitative analysis. For the ease of reading, these later emerged sub-categories are already shown at this point of time as anticipation. They split into 66 projects, 13 trainings and 11 conferences. All of those are assigned to 16 different industries, which are shown on the vertical axis of Fig. 4.

While the category "projects" refers to real practical industrial project work on technical cases, the categories "training" and "conferences" refer to a theoretical, conceptual frame with less interaction and rather one-directional information flow. The category "training" contains cases with theoretical VE education of the participants. The category "conferences" contains cases, where information was shared and discussed with an audience. This information could for instance refer to cutting edge project results, new approaches or lessons learned. In "conference" cases, new theoretical information, which had derived from real practical cases, was spread.

These three categories later showed different response behavior during the course of the analysis of the research question. Summarizing, Fig. 4 and 5 provide an imagination of the cases' diversity, even though they were obtained from one single source only.

Those were screened in a second filter, selected and classified (compare "Filter, Selection + Classification"). A total of 27 cases did not meet the four criterions of the second filter (group "Not relevant for Analysis" in Figure 4, they were "without clearly stated expectations" in Fig. 5). 63 cases remained "Relevant for Analysis" in Fig. 4 (labeled "Relevant Cases" in Fig. 5), with potential contribution to answer the research question. The "Qualitative Analysis with CAQDAS; Coding first Loop" was applied on those 63 cases.

The major share of projects or cases in Fig. 4 was conducted in the closely related industries of "valve", "compressor" and "Oil & Gas". But they were complemented with projects from very distinctive other industries, such as railway, marine, farming vehicles, automotive, semi-conductor and theoretical knowledge from consulting and training expertise.

An even closer look on the project category "projects" (compare waterfall diagram of the 46 "Industrial Projects" in Fig. 5) in a third analysis loop, which also has emerged during

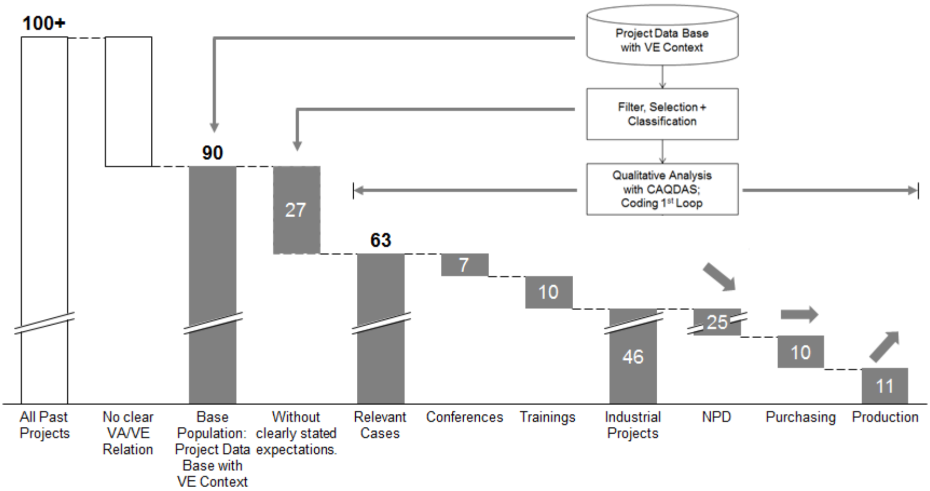

Fig. 5: Cases, their characteristics and timely development

the later second cycle coding process, has uncovered another interesting side effect.

The 46 Industrial projects later were even further split according to their functional environment. More than half of the projects were New Product Development (NPD) projects. Ten projects supported purchasing, mainly for preparation of vendor negotiations in terms of functional- or cost levers. The remaining 11 projects were settled in the production environment for supporting their efficiency at the interface to product improvements, which refer to changes of product functions, -dimensions or -specifications.

The bold dark grey arrows above the right 3 columns in the chart of Fig. 5 indicate the timely and numerous tendencies of projects per category. Despite of best and strongest VE-impact during early new product development projects (NPD) (compare “influence zone” in Fig. 1), the number of NPD projects was decreasing along the timeline. Projects in purchasing environment remained stable, while projects in production surroundings were even increasing along the same time period.

The decrease of NPD projects per time period in the current environment can be explained with the fact of limited number of real new product development projects per year. The higher share of NPD projects is a result of the chosen VE strategy in the current setting. In that the first focal point was set in the optimization of the new products in the development phase. It was then followed by stronger focal point shift to purchasing and production, once VE resources became released, when the NPD project backlog has ceased.

Fig. 4 and 5 proof, that the application of VE is not limited to NPD projects during early product life cycle phases only, but also offers good impact on cases, which – with regards to their development- and product-maturity – have reached already a later and more mature phase of their life cycle, as for instance in purchasing- or production cases.

5.2 Participants

Fig. 6 provides an overview of the recorded project participants including their functional and industrial background. The total number of participants, including the non-recorded ones, exceeds the recorded one. The vertical axis of Fig. 6 provides an overview on the 185 recorded-only participants’ professional role and their occupation. They are aggregated to reasonable main professional role clusters. The horizontal axis of Fig. 6 indicates the industry the projects were nested in. If a participant has participated in more than 1 Project, only the main project

				Recorded Participant Roles - Industry of Cases (Projects)													
			Total Participants	Automotive OEM	Automotive Supplier	Compressor	Consulting	Farming Vehicle	Other Industry	Machinery	Marine	Oil & Gas	Rail	Safety	Semi Conductor	Valve
Professional Role Cluster		Professional Roles	185	3	16	23	14	3	4	5	4	30	34	4	1	44
Consulting	29	Cost Consultant	11				6						5			
		Management Consultant	11				1	3					6		1	
		Purchasing Consultant	7				3						4			
Engineering	54	Engineering	26		2	7						6	2			9
		Methods	7			1						2				4
		R&D	20	1		1				1	3	3	2			9
		Technology Specialist	1									1				
Production	55	Production	19		3	8						2				6
		Purchasing	23		7	3				3		2	2			6
		Quality	7	1	1							1				4
		Supply Chain	6	1								2	1			2
Sales	18	Customer Service	3										3			
		Product Manager	8									1	1	4		2
		Sales	7			1						6				
Generic Function	29	Managing Director	6		1	2						2				1
		Project Manager	9		2		1			1	1	2	1			1
		Value Manager	14				3		4				7			

Fig. 6: Industries of projects and participants' functional roles

(in terms of largest project) was counted (no double count).

The table shows, that the majority of participants are engaged in production- and engineering roles. But they are well spread over different industries and very well represent all functional scopes, specifically contributing to the new product development process in an early stage (compare to the 'influence zone of the "fuzzy front end"', compare to Fig. 1), but equally also during the later phases of product life cycle.

From the data diversity viewpoint, the available data can be considered sufficient for the analysis. The matrix, which is opened by the project sourcing industries and the concerned participants occupation and functional roles, has points with higher density, but generally is well balanced. In return, this research's analysis shall serve as input for the functional roles of the last participant group of "Generic Functions" in similar industrial environments. However, other environments from contrary industries might require a similar approach, which could result in different analysis results.

6 QUALITATIVE CONTENT ANALYSIS

Throughout the course of the analysis different document sets have been formed. The first differentiation was chosen after first and during second cycle coding. The sets have changed based on the emerged findings and according the business environments of the author's current and past occupation environment. Within the current environment a second differentiation was drawn in order to distinguish practical industrial projects from theory-oriented trainings and conferences.

The qualitative content analysis was done with MAXQDA software for facilitating the processing and examination of large numbers of data and documents.

One single and leading question for the examination was defined before the start. This was a simplified version of the research question: “Which were the upfront expectations in the projects?”

Each single case of the entire case population was examined for any comment, which potentially contributes to answer the leading question. Each of these identified information fragments was marked with a code, which itself represented its content. The specific content description was formulated in a memo, which was attached to each code. This procedure was applied case by case. The codes were created inductively, they emerged from the content. Wherever it was appropriate, already existing codes from prior definitions on other information fragments were applied.

37 different codes existed after at the end of the first cycle coding process.

Some of the 37 codes seemed to be very similar, being redundant, or at least aiming into a similar direction. During comparing and contrasting the codes' description was refined and made more precise. Some very similar codes were combined and aggregated into one common code. An accordingly refined code description in the memos was adapted.

Five preliminary Groups of similar or complementing codes then were established, consolidated and defined during this procedure: (1) “Procedural Aspects”, (2) “Hidden Participant Agenda”, (3) “New Opportunities”, (4) “Organizational Aspects”, and (5) “Product Related”.

In the second cycle coding phase, all text fragments of each single code were cross-compared and contrasted with the MAXQDA software. The subject of examination changed from the cases (in first cycle) to the codes, which were compared from the view of the identified information fragments in the cases. The focal point was set on the applicability of the newly defined groups of codes, the proper qualitative description of the codes for all marked information fragments and the general fit of the code.

Finally, 18 consolidated, different codes emerged from the initial 37 ones. The reduction was carried out by combining similar codes into aggregated ones.

Data was considered saturated, when findings became repetitive and no new idea emerged during the iterative loops (Czarniawska, 2014).

Fig. 7 shows the 18 resulting codes sorted in descending order of their absolute nomination quantity over all cases. 615 information fragments throughout all 63 analyzed documents have been coded in total. “Cost Transparency” is the pre-dominant expectation set in VE projects.

The prior upfront classification of cases (compare Fig. 4) also was re-structured as an emerging side-effect during second cycle coding. The former document groups “projects”, “conferences” and “trainings” were re-arranged. “Trainings” and “conferences” both had a rather theoretical character and were merged into “Conferences and Trainings”. One case from the preliminary group “projects” moved to “Conferences and Trainings” as well. The remaining “projects” were split according to their industrial environment into “Current Project Environment” and “Former External Environment”. This split makes more sense, since differences between these two environments could be detected during second cycle coding, and both are settled within a practical application environment compared to the theoretical group of “conferences and training”.

Fig. 8 provides an overview of the code frequency as the percentage of documents, which have been coded with each particular code in the four new document-sets. Multiply applied codes within one document are not considered. The codes are sorted in descending order of their frequency on the set “all documents” in Fig. 8.

The patterns of the frequency barcodes in Fig. 8 obviously varies between the 4 different above-mentioned document sets. These different environments apparently have a different importance in between the codes and a different sequence of upfront expectations. The high contribution share of the document set “current project environment” explains the similarity of the barcode patterns between the two groups

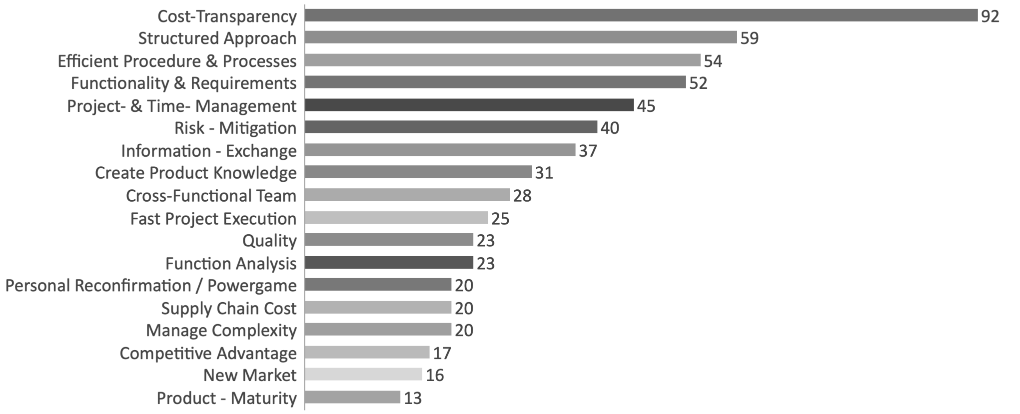

Fig. 7: Codes for expectations with absolute nominated quantity

Codes	ALL Documents (63)	Current Project Environment (38)	Conferences & Trainings (18)	Former External Environments (7)
Cost-Transparency	84,1	97,4	66,7	57,1
Efficient Procedure & Processes	60,3	63,2	55,6	57,1
Functionality & Requirements	52,4	63,2	33,3	42,9
Information - Exchange	50,8	50,0	33,3	100,0
Structured Approach	49,2	44,7	44,4	85,7
Create Product Knowledge	41,3	52,6	16,7	42,9
Fast Project Execution	38,1	63,2	0,0	0,0
Project- & Time- Management	38,1	36,8	50,0	14,3
Personal Reconfirmation / Powergame	31,8	50,0	5,6	0,0
Risk - Mitigation	31,8	34,2	22,2	42,9
New Market	25,4	42,1	0,0	0,0
Competitive Advantage	23,8	29,0	11,1	28,6
Quality	23,8	23,7	16,7	42,9
Cross-Functional Team	22,2	10,5	44,4	28,6
Function Analysis	20,6	13,2	22,2	57,1
Supply Chain Cost	19,1	15,8	16,7	42,9
Product - Maturity	15,9	7,9	27,8	28,6
Manage Complexity	11,1	7,9	5,6	42,9

Fig. 8: Code frequency for expectations – sorted in descending order on all documents

"all documents" and "current project environment".

Interestingly, two gaps between the categories "Current Project Portfolio" and "Conferences & Trainings" become evident, even though the trainings particularly shall prepare and support the application of VE projects in the current environment. The Expectations "Fast Project Execution" and "New Market" are nominated in the current project environment, but were never nominated during any conference and training. See also Fig. 9.

During the second cycle coding process the codes were re-structured and re-grouped with updated and better meaning and fit. The meanings of the new structure of document groups also were taken into account. The 7 new groups have emerged during the second cycle coding and are shown in Tab. 1 and 2. Their emergence was not influenced by any other prior study or theory, their structure and sorting was formed an uninfluenced way through comparing and contrasting. They formed the new fine-tuned thematic focal points of the expectations. In Tab. 1, they are already sorted in descending order on an overall view on all 63 cases. They are (1) "Cost", (2) "Time Management & Efficiency", (3) Organizational Aspects", (4) "Quality-, Risk & Maturity Management", (5) "Function Analysis", (6) "New business Opportunities", and (7) "Hidden Agenda".

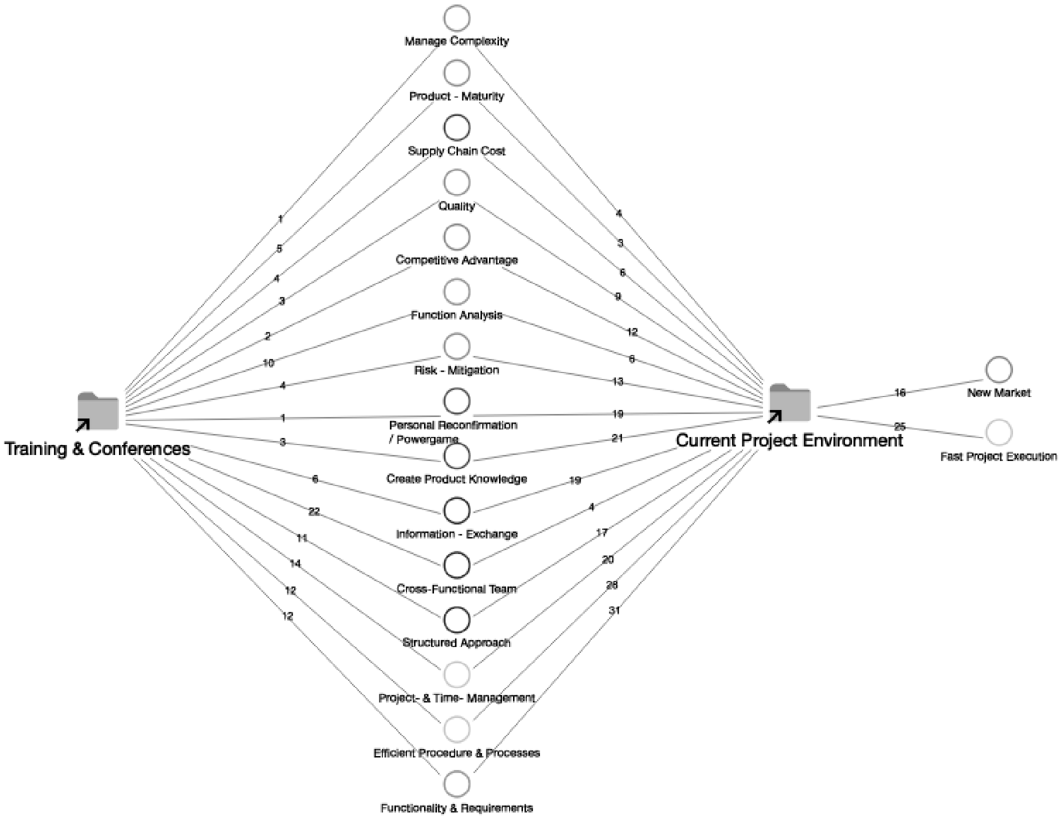

Fig. 9: Two case comparison between trainings and applied projects

7 INTERPRETATION OF SINGLE AND GROUPED EXPECTATIONS

7.1 Single Expectations

In both Fig. 7 and 8 the code "cost transparency" is the most cited code and outweighs all others. Also, in the other 2 documents sets "current project environment" and "conferences and trainings" it is the dominating code, while the emphasis on "information exchange" and "Structured approach" is higher for the former external business environment in a different industry.

A remarkable gap between the theoretically driven "conferences & trainings" and the practical "current project environment" can be found. The codes "fast project execution" and "new market" have a significant role within the practical projects ("current project environment"), while they were not mentioned at all during "trainings and conferences". Fig. 8 and 9 visualize this gap. The two codes on the figure's right end are only mentioned in the document set "current project environment" (quite frequently), while all other codes were cited in both document sets. Future training should take care for this fact. Rethinking the future training focal points towards a more application-tailored content makes sense.

Even though all selected projects were settled in a Value Engineering environment, the specific VE aspect of "function analysis" only is represented at the bottom of the current projects' importance in expectations (compare

Tab. 1: Expectation groups with absolute frequencies

Thematic groups of expectations	**Current project environment (38 cases)**	**Training & conferences (18 cases)**	**Former project environment (7 cases)**	**All cases (63 cases)**
Cost	78	28	37	143
Time Management & Efficiency	73	26	25	124
Organizational Aspects	40	39	45	124
Quality, Risk- & Maturity Management	29	13	54	96
Function Analysis	37	22	16	75
New Business Opportunities	28	2	3	33
Hidden Agenda	19	1	0	20

Fig. 8), while it had a much more dominant role for the projects in the former external project environment.

Surprisingly, in this specific given VE environment, not even one expectation referred into a fundamental VE focal point, namely the customer, and the customer behavior. This is a remarkable gap between theoretic VE from VE-practitioners' view and applied or interpreted VE from participants' or stakeholders' view.

Based on finding these differences between different sets of documents, the author adapted his research strategy from "finding any hint on an expectations into projects" to "identifying commons and differences" between different sets of cases on expectation group level, as explained in the following text.

7.2 Expectation Groups

Tab. 1 shows the newly formed groups of expectations in a descending order on all 63 cases. In an overall view (far right column), cost, time, organizational aspects and quality were the driving expectation groups ahead of VE's core distinctive element, the function analysis. New business opportunities and hidden agendas were least important expectations.

Expectation Group "Cost". The most predominant group of expectations with 143 nominations was basically defined by 3 main thoughts: (1) Create product knowledge by gaining insights and understanding of the product's features, characteristics, functions, advantage for the customer and manufacturability. (2) Create cost transparency on a systematic and detailed level and a feeling for the cost drivers and -levers. Consider influence options on costs and create plausibility. Develop strategies to encounter implausibility or to optimize cost structure. (3) Think in total cost of ownership. Include thoughts on logistics chains, landed cost view, value chain depth, distribution cost and -time, as well tradeoffs as for instance expediting vs. on-time-delivery.

Expectation Group "Time Management & Efficiency". The second most nominated expectation group with 124 nominations is dealing with the time constraint and is defined with the following thoughts: (1) Ensure fast project execution. (2) Consider product creation dimensions: on-time-delivery, throughput time, lead time. Include most efficient and reasonable use of capacities and resources.

Expectation Group "Organizational Aspects". The other second most nominated expectation group with also 124 nominations is dealing with the tactical issues of organizational aspects and is defined with the following thoughts: (1) Apply cross functional setups in order to ensure efficient processes and best possible information exchange. (2) Ensure a structured approach. Consider capacity and competency. (3) Ensure information- and data integrity and data completeness.

Expectation Group "Quality, Risk- & Maturity Management". This expectation group is risk-oriented. It was nominated 96 times and is defined with the following thoughts: (1) Consider complexity in terms of product variants, geography or restrictions. (2) Apply risk mitigation strategies on technology, time,

Tab. 2: Themes of expectations (normalized on number of cases)

Thematic groups of expectations	**Current project environment (38 cases)**	**Training & conferences (18 cases)**	**Former project environment (7 cases)**	**All cases (63 cases)**
Cost	2.05	1.56	5.29	2.27
Time Management & Efficiency	1.92	1.44	3.57	1.97
Organizational Aspects	1.05	2.17	6.43	1.97
Quality. Risk- & Maturity Management	0.76	0.72	7.71	1.52
Function Analysis	0.97	1.22	2.29	1.19
New Business Opportunities	0.74	0.11	0.43	0.52
Hidden Agenda	0.50	0.06	0.00	0.32

quality, finance, procedures, processes and cost. (3) Consider application of maturity-levels with regards to project, product, production processes, vendors, customer acceptance, on time market-release, on-time product-development.

Expectation Group "Function Analysis". This expectation group with 75 nominations is the core of any VE project. Within a given VE-project-environment, it is placed on fifth position in terms of expectation frequency only. It is defined according to VE approach (compare Chapter 3), including function-fulfillment. This includes product functionality, product characteristics and requirements, and product performance improvement.

Expectation Group "New Business Opportunities". This expectation group with 33 nominations is challenge-oriented and defined with the following thoughts: (1) New market: benchmarks, competitive analysis, market requirement definition, customer expectations. (2) Competitive advantage: clear leadership on technology or cost, product performance, impact of optimized product creation processes or supply chain variants.

Expectation Group "Hidden Agenda". The least, but still nominated expectation group with 20 nominations is dealing with mainly interpersonal and emotional issues, such as power games or personal preferences. This could be for instance: (1) Wishful thinking or self-fulfilling prophecies. (2) Reconfirmation of opinions. (3) "Who is better? Who is right?" in terms of negotiations, as technician, as purchasing, manufacturer, process specialist. (4) Defense or acquisition of area of influence.

7.3 Normalized View on the Same Set of Data

Referring to Fig. 8, the huge influence of the largest document group on the overall results became evident. In order to overcome that shortcoming from the viewpoint of comparability between document sets, the author applied a simple form of normalization, as shown in Tab. 2.

The normalization was conducted easily and straight forward by dividing each frequency by cases per set, for instance "cost" on "current project environment": 78/38 = 2.05. The result expresses the average frequency per case. Considering the different number of cases in the new classification shifts the importance and their emphasis clearly, especially in between the distinctive document sets.

This view results in higher amplitudes on the bandwidth of each document set. "Cost" still is the dominant expectation group in the practical groups, while "organizational aspects" shape the expectations and are of higher concern in the conferences and trainings. This gap indicates a mismatch in content between trainings and practical applications. Future training design should take care for this gap.

With regards to the document set of "former project environment", the amplitudes of the single nodes are much more spread (0.00 to 7.71) than with the other sets (0.06 to 2.17). It is evident, that the group with the largest number of cases is more leveled and shows a band width of 0.50 to 2.05 only. The Question arises, where this effect might derive from? Is this influenced by the higher number of cases, are they "leveled out"? Future studies could consider this idea and analyze accordingly. This question might be a fact to consider for future study-updates.

The first 3 expectation groups in the "former project environment", quality, cost, and organizational aspects outweigh the remaining groups by far. Only the expectation-group "time" stays in reach. The conclusion is, that in that given environment a very strong emphasis was set into these 4 expectation groups in literally every project. That could depend on the personalities of the project participants in that environment.

8 DISCUSSION

The analysis at hands is a first attempt to describe upfront expectations into industrial VE projects. This study's research question was formulated as: "What was past industrial VE projects participants' real upfront comprehensive, contemporary and particular expectation in those projects?"

Answering this research question, this study has elaborated 7 groups of expectations and 18 coded expectations along the course of this qualitative content analysis as outlined in the Chapters 6 and 7. They can serve as a preliminary checklist for future searches of spoken – and more important – unspoken expectations.

All selected projects serve as *"naturally occurring data"* (compare to Miles et al., 2014; Silverman, 2017; Saldana, 2016) for the qualitative part of this analysis. The initial base population consists of 90 projects. They are settled in 16 different industries and ensure richness (Silverman, 2017) and diversity of the data base (Holstein and Gubrium, 2016).

In total, 185 recorded participants from various functional backgrounds have contributed to the single cases. They cover nearly all facets of functional areas and can truly be considered cross-functional. Some of them have contributed to multiple cases. A larger non-replicable number of participants on top were not recorded participants. They were participating on demand and on specific occasions or questions, contributing from their functional point of expertise.

Summarizing, both, data richness and data diversity can be considered sufficient for this research at hand.

VE as a cross-functional approach supports diversity. The diversity of this analysis' input data was granted through the large number of projects, covered industries and the diverse functional and personal backgrounds of all participants. They span over a large array of rich and diverse viewpoints, inputs and interests.

But there is a constraint on the data-set. The projects source is a restricted collection from one source's environment only: the author. Further research and analysis would need to testify this analysis' conclusion on other input data from other environments, sources and industries.

The findings of Fig. 8 and Tab. 1 and 2 demonstrate that projects, which are settled within different industrial environments, might result in different upfront project expectations. Nevertheless, "cost", "time", "quality" and "organizational aspects" are of nearly same importance for either environment.

The findings of this study at hands cover up largely with the findings of Frefer et al. (2018) on general project management critical success factors. Also they see "time" and "cost" on most frequent positions with regards to demanded success factors, and quality on position 4.

The assumption can be drawn, that expectations in projects and their critical success factors are widely the same. On the other hand, the nature of VE projects is mainly project management, as outlined in Chapter 3. Considering that, one should not be surprised by this high degree of cope between the results of those two studies – regardless of the different environments, industries, participants, and their experiences and preferences. The nature of VE projects demands generic project management as fundament. Hence the same critical success factor can be applied, and translated into upfront expectations.

It also became evident, that the expectations and content of training does not cope with real projects' expectations. The identified gaps should be addressed and considered in future training designs. Those gaps specifically referred to the absence of an exact customer definition and explanation of expected customer behavior, but also in the expectation of "fast project execution" and "new markets". While the author sees connection between exact customer definition and new markets, the "need for project speed" remains a necessity, which should be analyzed in future research.

9 CONCLUSION

Summarizing, the author recommends four main further analysis directions and work packages to address this research's findings. First, the training content should expectation-wise be tailored to the practical needs. Second, further investigation would be needed to identify ways to address the expectations in the project speed factor. Exactness and rigor in definition and usage of terminology has to be emphasized. VE projects are mainly projects. But they offer their main distinctive factor: the function analysis, which strongly works with the impact of abstraction and requires a proper and most exact definition of customers and their environment (market). Apply the identified expectation codes, groups of expectations and their detailed description mandatorily in future projects. Refine the descriptions and checklists with any new perspective in continuous improvement loops.

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