

2 Research Approach

This chapter provides an introduction into general research philosophies and strategies (Sect. 2.1) used for Information System Research (ISR) investigations. In order to follow a rigorous research process we are describing corresponding strategies and methods (Sect. 2.2). Considering the thematic- and scientific perspectives this work chose a research strategy, which is outlined in a process using appropriate methodologies for data collection and data analysis.

2.1 Research Philosophies and Strategies

Research could be defined as a systematic activity that contributes to the understanding of a phenomenon. Within this work, the phenomenon can be described as the problem of enterprises in dealing with their EAM capabilities, which should be understood performing a research process and, based on its findings, new solutions should be developed. This research process-oriented approach is based on the theory of *scientific knowledge* and is part of the *epistemology*.

Epistemology deals with the identification of solutions that are available under realistic conditions. Such findings are defined as knowledge and a central object in the context of epistemology refers to scientific as well as non-scientific applications. In general, epistemology is considered as the “theory of knowledge” [323].

The philosophy of science as “*theory of scientific knowledge*” is concerned with those foundations presupposed within the scope of an *object science* and is used to acquire additional knowledge and skills [323]. Accordingly, there is a crucial difference between the philosophy of science and epistemology. On one side, the philosophy of science characterizes a specific theory of scientific knowledge that refers to results which were achieved by using general accepted scientific methods. On the other side, the philosophy of science represents some kind of meta-science that creates the basis for object sciences, like business information systems (extraction, transformation, applying results in scientific context) [323]. In the last years there has been an ongoing discussion about epistemological and scientific paradigm in the context of object sciences such as Information Systems (IS) [177,323,74,41,42], but this work is not intended to contribute on this scientific discourse. According to [186] and [74], selecting an epistemological position is both arbitrary and subjective and should not be taken randomly just by considering research strategies and methods.

In this context, two main strategies are mentioned in the ISR literature, which cannot be thought of being dichotomous [96,43].

1. The first strategy is formed by *behavioral research (BR)*, which was created in psychology science and thereby has its roots in natural sciences. In the context of IS, behavioral research seeks to develop and justify theories (i.e., principles and laws) that explain or predict organizational and human phenomena surrounding the analysis, design, implementation, management, and use of information systems. Behavioral science starts with a hypothesis, then researchers collect data, and either prove it right or wrong. Eventually a theory is being developed [96,6]. The behaviorist approach underlies logical positivism, which would not consider the hypothesis as acceptable scientific knowledge as long as it had not been allowed for being tested through observations [43].
2. The second strategy is the *design-science research (DSR)*, which is construction-oriented and in which a designer answers questions relevant to human problems via the creation of innovative *artifacts*, thereby contributing new knowledge to the body of scientific evidence. An *artifact* is a solution made by humans with the intention to solve a problem. Unlike the natural sciences, the design science research is fundamentally a problem-solving paradigm, whose final goal is to produce an artifact that must be built and then evaluated. The knowledge generated by this research informs us: how a problem can be improved, why the developed artifact is better than existing solutions, and can more efficiently solve the problem being addressed [96].

Table 2.1 presents an overview about the characteristics of each research strategy considering its research goal and perception [177,74,47,48]. Moreover, knowledge evaluation, structure and development process, including the interaction with the field of research represent additional characteristics.

Table 2.1 Characteristics of Behaviorist- and Design Science Research strategies, according to [177].

	<i>Behavioral Research</i>	<i>Design-Science Research</i>
Goal	Description and declaration of the reality with the aid of theories (<i>focus on reality</i>)	Changing the reality by developing and using artifacts (<i>focus on benefits</i>)
Perception of Reality	There exists an ontic reality that is responsible for perceiving a subject (<i>realism</i>)	There exists an ontic reality which is bound to a subject that creates distortions (<i>relativism</i>)
Knowledge Evaluation	Differentiation between knowledge development and application. Methodological principles and procedures guarantee knowledge quality. (<i>positivism</i>)	A logical separation between knowledge development and knowledge application is either not possible or not desired; only a few methodological standards; the grade of knowledge is determined by the quality of the argumentation (<i>pragmatism</i>)
Knowledge Structure	It is assumed that socio-technical coherences are explicable by empirical data (describe, explain and predict)	Data form a basis for constructing an artifact but are not applicable for drawing conclusion within the overall context called

	(<i>reductionism</i>)	contextual knowledge about the artifact (<i>emergence</i>)
Knowledge Development Process	Inquiry, evaluation, interpretation, generalization (<i>sequence</i>)	Problem analysis and formulation, Development and adaptation of concepts, evaluation and recalibration synthesis (<i>iteration</i>)
Interaction with the object of research	Actions that have an influence on the object of research should be omitted (<i>observer</i>)	Affecting opportunities for target-oriented modification of the environment are actively used (<i>participant</i>)

However, [186] points out that introduced characteristics do not necessarily have to be in a behavioral or design-science-oriented form only, combinations are also possible. Considering the research goal (*RG*), main research question (*RQ*) and follow-up questions (*RQ1* – *RQ2*) the selection of the corresponding research strategy is chosen in the next section.

2.2 Research Methodology

By finding an answer to our main research question (*RQ*), we will solve a practical problem under consideration of accepted research procedures in order to guarantee scientific rigor and achieve high-quality research results. Thus, this work is going to follow the DSR paradigm. The following paragraphs introduce the selected research strategy and the research process that is based on it, as well as the techniques used for data collection and analysis.

In general, the research activities of a DSR should provide a solution for a *problem*, which is caused from *practice* and represented by an *artifact*.

“A practice is defined as a set of human activities performed regularly and seen as meaningfully related to each other by the people participating in them.” [21,p.14].

Problems can be distinguished between wicked and tame problems. *Wicked problems* are specified as “*difficult or impossible to solve, because of incomplete knowledge, contradictory and changing requirements, complex interplay between related problems, any added effort can improve on a solution to a wicked problem*” [21,p.2]. Whereas *tame problems* are equipped with all required information for solving the problem as well as criteria for determining are clearly defined.

To specify the practical problem solved in this work we define the term more precisely and distinguish two problem classes and two problem types:

A practical problem is defined as gap between a current state and a desirable target state, as perceived by the participants in a practice The current state could be represented by a neutral (type 1) or unsatisfying (type 2) situation whereas the target state embodies an improvement of existing solutions (for type 1 problems) or neutral situa-

tion (for type 2 problems) that should be reached by the help of an artifact involving a solution [21].

Social- and practical problems are often wicked problems whereas many engineering problems are tame problems. Consequently the methods used to solve a wicked problem are partially different from those used to address tame problems [21]. However, *design-science research investigations* should solve such practical problems (wicked, tame, type 1, type 2) via the creation of *artifacts*, thereby contributing new knowledge to the scientific body of knowledge.

An artifact is a solution made by humans with the intention to address a practical problem. It could be described by specifying its functionality, components and relations as well as its environment and effects on it [96,21].

In order to ensure that the artifact meets our (*RG*) in terms of scientific rigor and practical relevance the DSR guidelines (μ_{DSR1} - μ_{DSR7}) of [96] support the definition of an appropriate research process:

μ_{DSR1} : *Design as an Artifact*: Generate a functional and operational artifact represented by model, construct, method or instantiation.

μ_{DSR2} : *Problem Relevance*: Build a solution for a problem which is derived from a lack of operational concepts or shortcomings of existing approaches in theory and practice.

μ_{DSR3} : *Design Evaluation*: The value, quality and effectiveness of the designed artifact must be accurately proven by well-executed- and multiple perspectives evaluation methods.

μ_{DSR4} : *Research Contribution*: The research investigation must provide a clear and verifiable contribution to the knowledge base.

μ_{DSR5} : *Research Rigor*: A strict application of recommended DSR methods is required in order to ensure scientific rigor.

μ_{DSR6} : *Design as a Search Process*: Define an iterative process with at least an artifact generation and testing activity. Results of the artifact generation activity provide the input for testing against requirements or constraints from its environment in order to find alternatives for undesired outcomes. *“The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.” [152].*

μ_{DSR7} : *Communication of Research*: Technology- and management-oriented stakeholders (e.g., board level, business developers, line managers, application manager or developer) should be satisfied by communicating achieved results.

[96] provides a framework (Figure 2.1) that features three activity cycles in order to connect the environment, knowledge base and IS research area under consideration of the DSR guidelines (μ_{DSR1} - μ_{DSR7}). The environment column and knowledge base column serve as a starting point for the artifact creation (IS Research column). The connecting cycles are called: *Relevance Cycle*, *Design Cycle* and *Rigor Cycle*. The *Relevance Cycle* connects the environment/application area of the research project to the research activities by collecting business requirements (goals, problems, opportunities) and fulfillment tests (field testing). The environment describes the research field of application and involves the three dimensions: people (e.g. roles, skills, characteristics), organization dimension (strategies, structure & culture, processes) and technology (e.g. infrastructure, applications, communication architecture). The *Rigor Cycle*, instead, links the research activities to knowledge base (KB). The knowledge base provides foundations (e.g. theories, frameworks, instruments, methods) and methodologies (e.g. data collection and analysis methods) that can be used for artifact design, construction and evaluation to guarantee scientific rigor. The *Design Cycle* represents a construction component, because it is processed by the input of both the Rigor- and Relevance Cycle in order to build and evaluate the desired artifact. To contribute new scientific evidence in the field of business information systems the justification and evaluation activities are particular important in order to assess and refine the produced artifact. All three cycles must be visible within a research process in order to meet DSR conformity [13,96].

Based on contributions of [6,152,177], DSR could be divided into *Design Science* and *Design Research*:

1. *Design Science* is concerned with methodological question of constructing and evaluating artifacts and aims at creating standards for its rigor.
2. *Design Research* deals with the development of a solution (new artifact/ adoption of an existing artifact) for a specific class of relevant problems under consideration of a rigorous construction and evaluation process.

This investigation continues with design research, because its intention is the development of a solution for a practical problem specified by a set of requirements gathered from local practices by following a DSR conform research process. In the case of creating new or adapting existing artifacts [186] notes that not every construction of an artifact could be easily allocated to design research, because a design research solution should attain a global practice

(GP). Thus, this work is going to show, that the produced artifact is applicable to a variety of problems and could be used in a global manner.

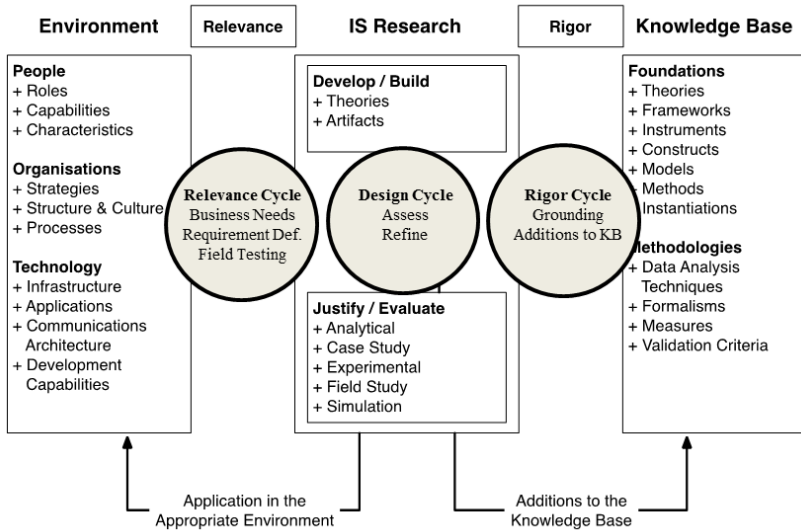


Figure 2.1 Design Science Research Framework [96].

In order to follow the design research guidelines and justify DSR as research strategy, our argumentation based on a three step research setup of [21,23], illustrated in Figure 2.2. The first step (1) consists the allocation of an initial problem situation including problems and requirements form local practices (LP) done by an environment analysis (*relevance cycle*). Furthermore, we described our research investigation which includes a clearly defined LP problem. In order to formulate a precise practical problem we performed an iterative problem definition process in terms of passing more than one adjustment cycle with the LP. In the second step (2), this work analyzed the existing knowledge base e.g. for existing theories and models that address similar problems as well as for scientific approaches supporting develop- and justification activities (*rigor cycle*). Finally (3), our research results and especially the generalized solution approaches will be discussed within the research community (ReC) by relating these results to the actual body of knowledge (relevant for ReC and GP) in terms of *scientific contributions*. Next to the ReC contributions like journals and conference papers the solution is disseminated to the GP through e.g. conferences for practitioners, book publications for professionals.

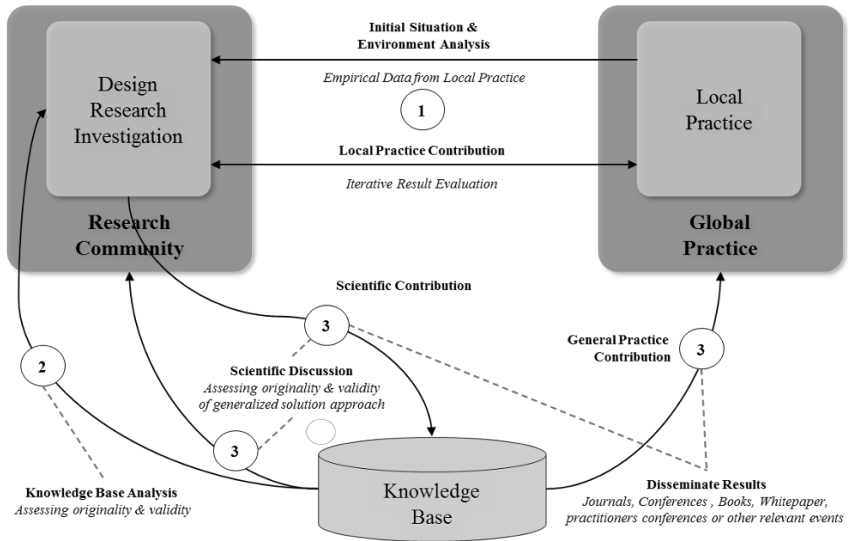


Figure 2.2 Local and Global Practices in a Design Research Investigation, adapted from [21,23].

Each research strategy uses a set of specific research methods, data collection- and data analysis techniques (Table 2.2). The requirements of each methods and techniques used within our investigation are described in more detail in Section 2.2.2 and Section 2.2.3.

Table 2.2 Research methods and techniques suitable for DSR projects, according to [21].

Definition	Elements
Research Methods	Experiments (field, labor), Surveys, Case Studies, Ethnography, Grounded Theory, Action Research, Phenomenology, Simulation, Mathematical and Logical Proof.
Data Collection Techniques	Questionnaires, Interviews, Focus Group, Observations, Document analysis.
Data Analysis Techniques	Quantitative Data Analysis, Qualitative Data Analysis.

In order to comply with the DSR strategy characteristics (Table 2.1), guidelines for DSR projects (μ_{DSR1} - μ_{DSR7}) and the key activities of design research (Figure 2.1) the literature recommends to define a well-structured research process [96,21,26]. Therefore, the subsequent section presents how we specify our research process under consideration of the argumentation above.

2.2.1 Research Process

In terms of illustrating the different research process phases this work used the IDEF0 Notation based on [21,137]. The key components of the IDEF0 notation are similar to most process modeling approaches. Its main components are *activities* (rectangle) and *channels* (ar-

rows). The *activity* transforms knowledge or objects provided by input channel (arrow from left) and produces new objects or knowledge outputs (arrow to right) by consuming resources (arrow from below). The control channel (arrow from above) governs the activity in terms of e.g. guidelines or principles or policies. The key elements of the IDEF0 notation and samples for its utilization within our research context are summarized in Figure 2.3. Personnel and organizational records from local practices as well as knowledge base data are examples for *resources*. Research strategy and corresponding methods, data collection and analysis techniques are classified as *controls*. Both channels influence the activities of the individual research process steps specified in the subsequent section.

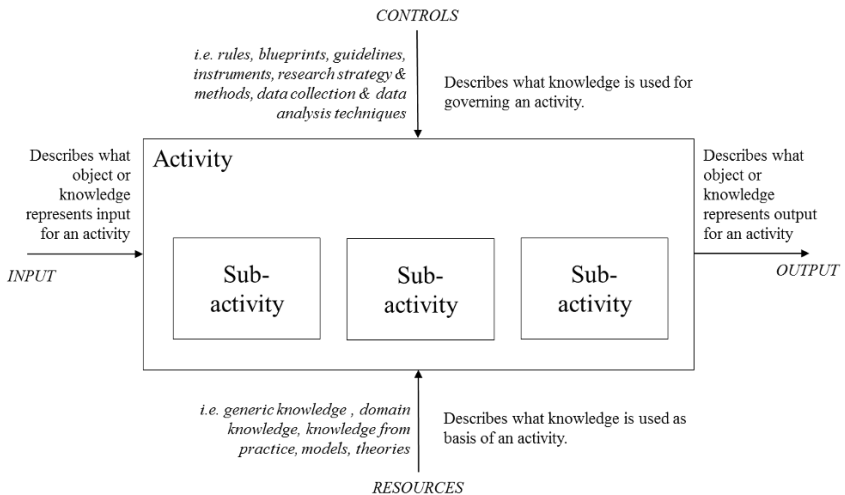


Figure 2.3 Research Process Notation using IDEF0, adapted from [21]

A variety of possibilities for DSR conform research processes are provided by academic literature [27,28,29,30,31,32,33,96,152]. We chose the design science research methodology (DSRM) by Peffers et al. [26], because it represents an aggregation of the previously referenced literature and it provides a *problem-centered design science research approach* as well. Problem-focused research projects investigate a root cause analysis in terms of comprehensive knowledge base and environment explorations. The findings provide indications for requirements for the artifact construction (design and development).

Our research investigation followed this problem- focused procedure and thus this work performed the whole DSRM. According to [26] combined with the explanations of [21], we performed the following six process steps: 1. *Problem Identification and motivation*, 2. *Define the objective for the solution*, 3. *Design and Development*, 4. *Demonstration*, 5. *Evaluation*, 6.

Communication. Each step involves a set of activities that are exactly explained from Chapter 4 to Chapter 8. Nevertheless, the following explanations provide a conceptual overview about each step summarized by Figure 2.4 and Appendix F.

1. *Problem Investigation:* At this stage the practical problem to be solved is extracted from local practices and its relevance for the global practice under consideration of the knowledge base is exposed. We do this to ensure that the developed solution does not solve a situational problem, but a problem of general interest. Due to its problem-centered initiation, the investigation is based on a review of EACN project motivation in order to extract an initial problem description. In order to analyze the initial problem in more detail, we selected and analyzed several expert interviews and project documents from different *local practice partners* with similar problem prerequisites. Thus, a set of local practice problems were gathered which provides the base for a root cause analysis and a knowledge base review. Both analyses were conducted to encapsulate the central problem description and justify its practice- and scientific relevance. Outputs of this process step is the explicated problem as well as investigations about capability research, EAM in theory and practice published in [59,64,65,66,90,134,136,190], which are precisely described in Chapter 4.
2. *Define Requirements:* This phase delivers an accurate description of the artifact to be developed by the formulation of its type. Artifact requirements are derived from root cause analysis and collected practical problems of the previous phase. The requirements are categorized in conceptual-, method implied- and qualitative requirements. The specifications of the 31 identified requirements are described in Chapter 5.
3. *Design and development:* Based on creative methods, defined research goal, findings of knowledge base- and practice analysis the artifact is designed and developed (Chapter 6). Under consideration of specified requirements we gathered additional feedbacks and thought-provoking impulses using questionnaires carried out to both, scientific and practitioner audience. In order support conclusions on the artifact development we initiated additional literature reviews based on empirical results. Outputs of this process step are the first version of the artifact as well as developed concepts and procedures published in [52,84,85,87,133].
4. *Demonstration:* Within this phase the current state of the artifact is presented to users from local practices in order to test feasibility in single use cases (Chapter 7). By executing two expert interviews, we collected data that provides us indications about how and why the artifact works as well as receive change request in terms suggestions of improvement [243]. Thus, we got an overview about the development state and certainty that the artifact can solve an instance of our explicated problem. Due to our research process design, this step passed through iteration in order to realize minor adjustments

caused by change requests. An output of this process step represents the demonstrated artifact which is published in [300].

5. *Evaluation*: Based on the demonstration phase the concept, quality and benefits of the developed artifact has to be evaluated by appropriated research methods (Table 2.2). The demonstration and evaluation activities lead to further refinements of the artifact in terms of different increasingly improved versions. For this purpose, we used appropriate measures and analysis methods that evaluate both qualitative- and quantitative data of the artifact evaluation in order to make statements about e.g. usability, quality, benefits and research goal achievement. The whole set of activities is described in Chapter 8. The evaluated and adjusted artifact represents the final output of this investigation and will be published in a monolithic doctoral thesis.
6. *Communication*: Individual research results have already been published in corresponding phases in form of peer-reviewed books, chapters and conference papers as well as technical reports. Section 1.4 provides an overview and categorization of relevant publications.

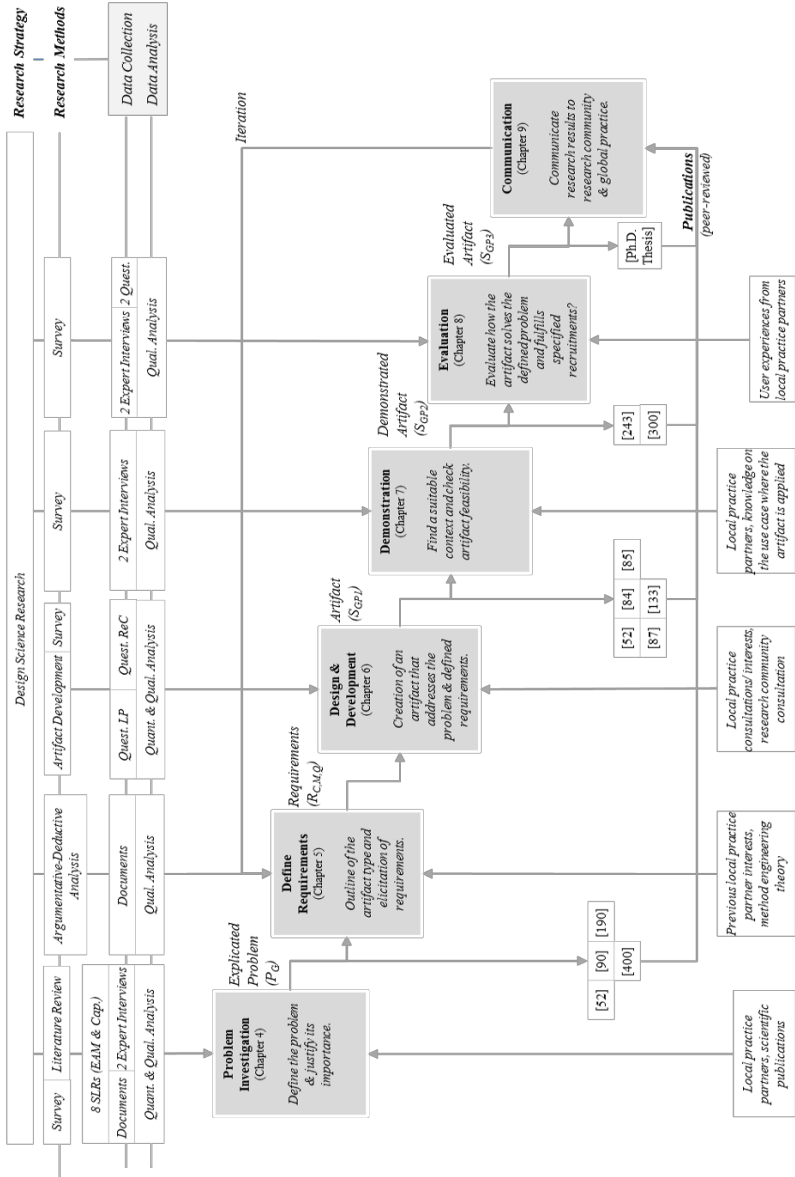


Figure 2.4 Overview Research Process.

2.2.2 Data Collection

For a better understanding of the practical research problem under consideration we used a set of different data collection techniques. In order to enhance accuracy of results we used a *mixed method approach* for data collection [287,288,289] by combining qualitative- and quantitative data collection methods performed by different people in different studies and publications (Figure 2.4). Therefore, we used surveys i.e. questionnaire and interview techniques as well as the document analysis i.e. literature review and organizational records. This section describes the used methods, its techniques and limitations.

2.2.2.1 Survey

Surveys are used for descriptive, exploratory, or explanatory research by gathering data about people in terms of e.g. its activities, beliefs, attitude and/or knowledge. For our investigation we used two common forms of a survey: the *questionnaire survey* like a self-administered *internet questionnaire* mainly used for quantitative data collection and the *face-to-face survey* in form of e.g. semi- structured *expert interviews* primarily used for qualitative data gathering [286]. The *questionnaire survey* includes a set of questions to be distributed (e.g. email, website, social network, mail, electronic documents) to a number of respondents intended to capture responses in a standardized way (Sect. 2.2.2.1.1). Whereas *interview survey* is based on personal face-to-face communication and interaction with an individual, who could be a person with access to privilege knowledge or experiences in terms of an expert interview (Sect. 2.2.2.1.2). For the sake of completeness, *observational surveys* are used to study the behavior of people (without using them as respondents) under consideration of a list of questions, which is not used within this investigation.

The major challenge determining results from a survey is represented by the involved amount of questioned individuals, which is called *sample*. Thus, the right selection of individuals within a population is essential for generalizing results to the population from which it has been drawn [21,291]. In this context it can be distinguished between a *representative-* and *exploratory sample* [285,286]. A *representative sample* tries to select a subset of individuals that are representative for an entire population. Therefore, the most common sampling technique is *random sampling*. In order to avoid researchers influence on the selection process of the subset, *random sampling* should ensure that each individual of a population has an equal chance to be part of the chosen subset [21,286]. An *exploratory sample* represents a first attempt to learn something about a phenomenon or explore new approaches without being representative for a population. In contrast to random sampling, *purposive sampling* tries to select a small number of individuals, which provide very specific and valuable information for a research investigation. According to [21], researchers may personally invite the respective individuals, because of its privileged knowledge or advanced experiences concerning a desired topic.

On one side, the speed as well as the possibility to gather large amounts of qualitative- and quantitative data by relatively low efforts represents the advantages of using surveys. On the other side, the usage of surveys is characterized by a set of limitations. Thus, [286] mentioned some general limitations of using surveys like low-response rates, social desirability in terms of avoiding negative opinions, recall bias terms of motivation to respond, and/or common method bias in terms of spurious covariance between independent and dependent variables measured at the same time by different methods. Furthermore, each survey form comes along with particular set of limitations that are described in corresponding sub-sections. Table 2.3 summarized the purpose, key concepts and activities as well as forms and limitations of the survey method.

Table 2.3 Overview Research Methods: Survey, according to [21,286].

Purposes	Key concepts	Key activities	Used Forms	Advantages	Limitations
Investigate some aspects of a phenomenon to get an overview	Representative sample, Exploratory sample	Sampling (random, purposive)	Internet based surveys, interview based surveys	Real user, flexible due to a number of instruments, adaptable to focus and circumstances, quickly derived and performed, several kind of media are usable	Limitation to measurable aspects, low-response rates, social desirability, recall bias, common method bias, low-medium cost, low risk to participants

2.2.2.1.1 Questionnaire Survey

Originally, a questionnaire was a pen-and-paper instrument to gather information by asking questions [285]. Nowadays, questionnaires can be classified by the nature of its *distribution type* (electronical vs. personal) and its *administration form* (self-administrated vs. group-administrated). Situational aspects, in terms of when a questionnaire is replied (e.g. at work vs. leisure time, frequently vs. delayed), has to be discussed for each form individually [285,286,291].

A questionnaire includes a set of questions to be distributed to a number of respondents intended to capture responses in a standardized manner.

In general, we could distinguish between *electronical* and *personal* distribution of a questionnaire. Nowadays, the *internet / electronic questionnaire* represents the most common distribution type, because it could be setup, managed and distributed via several internet based communication channels like. Email, social networks (facebook.com, xing.com, linked.com), electronic documents (e.g. e-mail integrated, prepared PDF, MS Excel, MS Word files) or messenger services (e.g. WhatsApp, SMS). Due to its availability, recipients are location-independent in processing and completing the questionnaire [285]. The results are captured by a service provider, chosen for the hosting and administration of questionnaire. The service provider and its range of services has to be aligned with own requirements like access limitations (e.g. password, time limit), export functionalities (e.g. CSV, SPSS, database access), messaging services (e.g. Email or SMS reminder, bulk Email service) and evaluation services

(e.g. participation rates, statistical calculations). Thus, this distribution type allows low cost distribution and easy participation, to some extent evaluation services and the possibility of reusing or modifying the questionnaire for further research activities [286].

A questionnaire is *personally distributed* when it is performed via *mail*, *telephone* or *face-to-face*. If a questionnaire is *mailed*, the recipients can answer the survey at their convenience and personally return it via postage-prepaid envelopes (in most cases). Next to low response rates, standard postal mail represents the most time consuming distribution type (distribution until participation) [285]. Telephone based questionnaires represent the first “real” personal based interaction between a respondent and an interviewer. Respective distribution type is quite expensive due to a sequential 1:1 respondent-interviewer process. Simultaneously, this type generates higher response rates and shortens the investigation period. A *face-to-face interview* represents the most personalized form of distributing a questionnaire and the interviewer directly interacts with the respondent asking questions and documenting the answers. Next to the required skill set of the interviewer this distribution type is classified as the most expensive one in terms of the allocation of resources. The face-to-face interview is characterized by the shortest time span between questionnaire distribution and participation as well as by the highest response rate. The *expert interview* represents one form of a face-to-face distributed questionnaire, which is explained more detailed in the next sub-section.

A *self-administrated questionnaire* is distributed to a large number of recipients. The recipients can respond at their convenience and return via a pre-planned procedure depending on the distribution type (mail, email, confirmation on a website). Thus, self-administered questionnaires have to fulfill certain requirements to be reliable, comprehensive and clearly evaluated data such as predefined series and precise formulated questions [285]. However, this kind of questionnaires next to the advantage to address a large number of people, researcher are challenged with low response rates, long delays and a continuously monitoring of tracking answers and sending reminders [286]. In order to counteract respective challenges, *self-administrated questionnaires* should be used to gather simple facts, preferences, and/ or opinions.

A *group-administrated questionnaire* is characterized by the spatial and temporal situation of the respondents, because they all have to (independently) answer its questions at a certain time and location [286]. Thus, high response rates and respondents support is assured by conducting group-administrated questionnaires. The respective administration form could be performed where the group to be interviewed is currently located and/or feels good, such as in its company, hotel or at a conference. Upcoming data can be electronically captured via video and/ or audio recordings, documents or protocols.

Within this investigation we conducted two self-administrated internet questionnaire for describing current EAM challenges and the *problem investigation* (Chapter 4) as well as one self-administrated electronical document based questionnaire and one group-administrated questionnaire within the artifact *design and development* phase (Sect. 6.2.4). Table 2.4 provides an overview about the conducted questionnaire types, topics and participants.

Table 2.4 Overview Data Collection via Questionnaires.

No.	Questionnaire type	Topic & Participants	Activity (Section)
1	self-administrated, internet based, random sampling, local practices	Current state and challenges of EAM: <i>IT Industry, small and medium-sized enterprises, Germany, 2013</i>	Description of EAM challenges (Sect. 3.3.4) Problem Investigation (Sect. 4.2)
2	self-administrated, electronical document based, purposive sampling, local practice partner	Integrated Capability Approach: <i>alfabet AG, Boston, USA, 2013</i>	Design and Development (Sect. 6.2.4)
3	group-administrated, printed document based, purposive sampling, research community	Integrated Capability Approach: <i>Master Class, Practices of Enterprise Modeling conference, Riga, 2013</i>	Design and Development (Sect. 6.2.4)
4	self-administrated, electronical document based	CMG v2.0: <i>ACL Ltd., Vancouver, Canada, 2016; AIDA Cruises - German Branch of Costa Crociere S.p.A., 2016</i>	Evaluation (Sect. 8.3.1)

2.2.2.1.2 Expert Interview Survey

In empirical research interviews are frequently used as reconstructive procedures (the interviewee reconstructs his knowledge and experience) with asymmetric communications (the interviewee develops and formulates his own thoughts, whereas the interviewer switches between silent listening and dedicated dialogue partner) [241]. For the success of the interview the interviewer needs to retain control over the course of interview, without disturbing the communication process [284]. Nevertheless, the interviewer needs to be neutral and open to new knowledge and interpretation patterns [284]. The result must be inter-subjectively verifiable by conducting a scientific interview with utmost care. This includes, among others, recording the whole conversation on tape [281]. Interviews can be categorized by its level of structure or number of interviewees. Regarding the interview structure, there are basically three gradations: open / little structure (basically no rules), partially / semi-structured (interview guideline sets out questions, the order could, but not has to be strictly followed), fully structured (written questionnaires, given answers) [283]. The number of interviewees is divided into the individual interview, the group interview, and a study [283].

Expert interview is a theory-based method of data collection and is used for producing specific and concentrated knowledge by particularly selected individuals relating to a confined topic [280,281].

These particularly selected individuals are defined as experts in this context. An expert has domain-specific knowledge / skill and experience of many years. On one side, intelligence

and memory is only of minor importance, whereas the dependency of the experts' performance area and years of experience are extremely important on the other side [281].

An expert is a person with privileged access to information in a particular field of study, because he is focused on problem-solving responsibility in design, development, implementation and / or control [282].

Experts can be a direct target group of research and can evaluate various hypotheses and questions with experts' knowledge and perspective [280]. Basically, all interviewed experts had many years of experience in the practical handling of EAM - more expertise is described in the individual interview preparation phases.

The expert interviews carried out in this investigation are semi-structured each with a guideline as basis. The interview guideline is a coarsely structured, written question scheme serving the interviewer as a memory aid [290]. The guideline shall not restrict the interview, but ensures that all issues are fully addressed and supports the conversation organization [281]. The guideline contains all questions and connecting passages for each question block [281]. The content of each question block represents the research problem in specific interview questions [241]. Furthermore, we used the guideline to ensure the comparability of different interview results.

In order to ensure that the conclusions of the interview appropriately reflect what we were investigating (*internal validity*), we consider a number of control questions within the scope of the interview guideline creation. Therefore [283] suggests the following six control questions: (1) *Is every question necessary?*, (2) *Does the interview contain repetitions?*, (3) *Are all questions clearly formulated?*, (4) *Can interviewees answer the questions potentially?*, (5) *Is there a danger to ask question, which can embarrass interviewees?*, (6) *Have leading questions been avoided?* In regard to preparation, execution and quality management, we conducted the expert interviews based on the following process [284]:

1. Development of the interview guideline.
2. Pre-test of the interview guideline.
3. Choice and contact approach of interviewees.
4. Execution of expert interviews.
5. Recording the expert interview.
6. Saving the results (record or transcription).

The development of the interview guideline, the course of pre-tests, the execution as well as the evaluation are described in the respective sections in more detail.

In addition to the quality of the interview design, several effects must be considered, which can affect the quality of results. These *interview effects* are caused by the interviewer (most often unaware), for example by difference in age, gender, or appearance of the interviewer [283]. Another aspect is *response distortion*, which is caused by the experts. A low level of self-disclosure or the effort to please the interviewer, are often the reason for response distortion. Furthermore, there is the so-called *Hawthorne effect*, which describes that the sole participation in a scientific study can have impact on the response of the experts [283]. Another effect is based on the *information asymmetry* between the parties as well as the terminology of the experts, which effects the proper evaluation of results due to superficial standard answers or answers which require too much prior knowledge [280]. A final category of interview effects can be described as *interaction effects*, which relate to the cooperation between interviewer and experts in the interview conduct [296]. For instance, the expert can withhold obviously available information due to mistrust and lack of interest (*iceberg effect*); a good-natured but dominant communication guidance of experts will determine the importance of information (*paternalism effect*), the feedback of question-response in which the expert asks the interviewer counter-questions (*feedback effect*) and, finally, the staging of oneself is focused by the interviewee (*catharsis effect*). The presented effects usually occur only temporarily [284], therefore the avoidance has to be ensured in the design and implementation phase through an adequate process (see above) and the occurrence has to be particularly reflected in the data analysis, which also has to be ensured by a standardized process.

During this research investigation six *expert interviews* were conducted, in each case two are distributed on *problem investigation* (Sect. 4.2), *demonstration* (Sect. 7.2) and *evaluation* (Sect. 8.3.2). Table 2.5 provides an overview about the conducted interview types, topics, experts' roles and companies.

Table 2.5 Overview Data Collection via Expert Interviews.

No.	Interview Type	Topic & Participants	Activity (Section)
1	unstructured interview	EACN project demand analysis: board member, alfabet AG, Berlin, Germany, 2012	Problem Investigation (Sect. 4.2.1)
2	Semi-structured interview	EAM capability demand analysis: advisory board member, alfabet AG, Berlin, Germany, 2012	Problem Investigation (Sect. 4.2.2)
3	Semi-structured interview	Feasibility test of the capability management guide version 1.0: EA Architect, Stadtwerke Rostock AG, Rostock, Germany	Apply Artifact (Sect. 7.2)
4	Semi-structured interview	Feasibility test of the capability management guide version 1.0, IS Strategy Manager, Bombardier Transportation GmbH, Berlin, Germany	Apply Artifact (Sect. 7.2)
5	Semi-structured interview	Usability test of the capability management guide version 2.0: Consultant, ACL Ltd., Vancouver, Canada	Design & Execution Evaluation (Sect. 8.3.2)
6	Semi-structured interview	Usability test of the capability management guide version 2.0, Digital Transformation Manager, AIDA Cruises - German Branch of Costa Crociere S.p.A., Rostock, Germany	Design & Execution Evaluation (Sect. 8.3.2)

2.2.2.2 Literature Review

Literature reviews are common data collection techniques based on documents (e.g. academic publications, books, organizational records, social media streams, government publications, personal communications, newspaper). In order to accomplish robust and sustainable data analysis results [21,98,99], we primarily used academic publications i.e. peer-reviewed journal-, conference-, book publications as well as organizational records and publications provided by private research institutes and industry consortiums. Therefore, we used two literature review approaches:

- *explorative / ad hoc literature reviews* (ALR) [100] and
- *systematic literature reviews* (SLR) [38,100].

The *explorative/ ad hoc literature review* starts to form initial search activity in terms of looking for sources of the desired topic by using appropriated terminology as search terms. Initial search results (single document or pool of literature sources) provide insights into the bibliography and references that are used to look up additionally related literature and communities in terms of key researcher, research groups, scientific journals and conferences. For refinement purposes, research results, used methods and frameworks solving a problem are analyzed. Within an iterative process the accuracy and focus of related work or root causes is improved.

In contrast to *explorative/ ad hoc literature reviews* [101], a *systematic literature review* provides the systematically identification, evaluation and interpretation of relevant sources to answer defined research questions by using a standardized process. In this regard, the review process guarantees scientific rigor in terms of considering related work, ensuring traceability, originality and validity [38,98,99,102]. Consequently, in order to secure a transparent and repeatable knowledge base analysis, we have chosen the systematic review approach for our data collection and analysis. Referred to Kitchenham et al. [38] we performed three key stages and corresponding sub-steps that need to be processed to conduct a SLR. The first stage deals with the *review planning* and provides research questions, literature resources and time frame definitions for the investigation. In order to differentiate research questions from our research statement (Sect. 1.2) we renamed “research question” into “analysis question” for this work. The second stage is called *performing the review*; here we selected relevant articles and collect data for answering the analysis questions (AQ), realized in the final step: *review report*, the conclusion is summarized.

Within three years seven teams from the Universities of Reutlingen and Rostock performed the same structured SLRs procedure. The entire procedure and respective results are summarized within this work and distributed in *problem investigation* (Sect. 4.3) as well as *design*

and development (Sect. 6.2.4). Table 2.6 provides an overview about the conducted literature review types, its sources and time period of the individual reviews.

Table 2.6 Overview Data Collection via Literature Reviews.

No.	Literature Review Type	Sources and Time Period	Activity (Section)
1	Systematic literature review, conducted 2013	IEEE Enterprise Distributed Objects Conference (EDOC); International Conference on Advanced Information System Engineering (CAISE); European Conference on Information Systems (ECIS); Journal on Information Systems; Journal on Software and Systems Modeling, 2000 - 2013.	Problem Investigation (Sect. 4.3), Design and Development (Sect. 6.2.4).
2	Systematic literature review, conducted 2014	AIS Electronic Library (AISeL) basket of conferences, 2000 – 2014.	
3	Systematic literature review, conducted 2014	AIS Electronic Library (AISeL) basket of journals, 2000 – 2014.	
4	Systematic literature review, conducted 2014	The Practice of Enterprise Modeling (PoEM) - 2008 – 2014; Perspectives in Business Informatics Research – 2001-2014; IEEE International Conference on Commerce and Enterprise Computing (CEC) 2009 – 2014.	
5	Systematic literature review, conducted 2014	IEEE Hawaii International Conference on System Sciences (HICSS), 1999 – 2009.	
6	Systematic literature review, conducted 2014	IEEE Hawaii International Conference on System Sciences (HICSS), 2010 – 2014.	
7	Systematic literature review, conducted 2015	Journals and Conferences: SpringerLink, ACM Digital Library; IEEE explore; AIS Electronic Library (AISeL); Wiley Online Library; Scencedirect; only 2015.	
8	Exploratory literature review, conducted 2016	Private research institute & industry consortiums: Gartner Inc., The Open Group, Architecture & Governance Magazine and CEB CIO Leader Council.	Demonstration (Sect. 7.2.4)

2.2.3 Data Analysis

In order to find answers on the motivation question or explain a phenomenon under investigation, respective data has to be prepared, analyzed and evaluated. Therefore, data analysis derives valuable information from gathered raw data to draw conclusions on the phenomenon under investigation [21]. Therefore, we use the inductive and deductive argumentations within our work. Deductive reasoning is understood as the following “*From a general theoretical understanding, the researcher derives (deduces) an expectation and finally a testable hypothesis.*” [34,p.49]. Consequently it starts with asking “Why” and moves to “Whether”. Inductive procedures mean the opposite direction gaining a general conclusion by specifying e.g. single observations from local practices [34]. Two different approaches can be distinguished: *Quantitative- and qualitative analysis* of the collected data, summarized in Table 2.7 .

Table 2.7. Overview quantitative- and qualitative Data Collection Techniques, according to [301].

Quantitative Analysis		Qualitative Analysis
Research Perspective	Centered around the (subjective) hypothesis of the researcher	Centered around the meanings and experiences of affected individuals, phenomenon
Objective	Data quantification and extrapolation of results	Receive detailed understanding of an issue and the underlying thoughts
Research Context	Replicable data	Realistic data

Data	Numbers, numerical data	Text, images, videos, sounds
Research Process	Static	Dynamic
Theory relation	Agreement of predefined hypothesis	Definition of hypothesis by the research results
Analysis	Statistical	Interpretive
Prior Focus	Analysis of causal relations within huge populations	Research of environment and interactions
Popular Methods	Experiments, observations, interviews, population surveys	expert interviews, group discussions, observations
Number of Participants	Large	Small

2.2.3.1 Quantitative Analysis

The quantitative data collection can be basically conducted by any research method. Questionnaires and observations are primarily used for this purpose and corresponding quantitative mechanisms are used for its evaluation [21]. For the measurement, a number of data types have to be defined on which the following evaluations are based on [302]. Therefore, firstly the type of data and secondly the type of evaluation can be differentiated. The type of data essentially determines the possible evaluation mechanisms, which are mainly based on statistical methods. In this context, the data types can be distinguished as follows:

- *Nominal Data*: This data type has a finite set of characteristics (no numerical characteristics) and cannot be ranked (categorical data).
- *Ordinal Data*: These data also have only a finite number of possible characteristics. However, they can be ranked (ranked data), but no intervals between the individual characteristics can be calculated. It is only possible to determine if a characteristic is larger than another.
- *Interval Data*: Interval data can take all characteristics within a specified range. In this context, it is usually real numbers on a scale. On this particular scale distances can be calculated.
- *Ratio data*: This data type is similar to the interval scale, except the fact that absolute zero is defined like the age of a person. All arithmetic operations are only useful for this data type.

These data types can be analyzed in the quantitative analysis by two evaluation mechanisms, on the one side by *descriptive statistics* and on the other side by *inferential statistics* [21]. Descriptive statistics is a sub-section of statistics and relates only to a given sample of data, which are depicted by tables, graphics and characteristics such as mean, median, mode, range, standard deviation. For conclusions on the statistical population based on the samples, the *inferential statistic* is required. The relationships are considered in particular between individual variables (correlation coefficient) and their generalization to the whole statistical

population. The mechanisms used are explained within the corresponding analysis sections (Sect. 4.3.3, Sect. 6.2.4, Sect. 8.3.1).

2.2.3.2 Qualitative Content Analysis

Qualitative data analysis techniques are commonly used to investigate data in the field of social science, which should measure phenomena within its real world settings. In particular, *qualitative content analysis* is based on large amounts qualitative data in terms of text and mainly produced by e.g. *un- or semi-structured interviews*, *open questionnaires*, *group discussions*, but it can also include photos, images, sounds and video clips [21]. According to [297], *qualitative content analysis* is desirable when an investigation aims to understand a phenomenon in-depth.

This section describes the qualitative data analysis approach (*content analysis*) we used in order to analyze contents of conducted expert interviews in detail. The technique describes the procedure for systematic / methodical text analysis [209]. The respective analysis is commonly based on recorded interviews and documents in text format, due to the fact that this is the only option to perform a fully rule-based analysis [208]. Therefore the interview has to be converted into text format, which can be done by tape transcription or by writing a memory protocol. Memory protocols have to be written immediately after the interview to ensure a significant contribution to the analysis. The disadvantage of this text format is the fact that the content has been significantly reduced by the author and that it only depicts a limited range of information [208], because transcripts strongly rely on the interviewer. This aspect has been weakened by adding a third person for generating an appropriate memory protocol besides the expert and interviewer.

Due to the fact that *qualitative content analysis* is a scientific method, it must be conducted methodically by explicit rules, guided by theory and thereby inter-subjectively verifiable [208]. In this context the text analysis were performed using the following process [210]:

1. *Text selection*: The text selection determines underlying material of the analysis, which may only be altered during the analysis in certain cases.
2. *Situation analysis*: The situation analysis describes the conditions, under which the material has been generated. The author, the plot background, the target group of the research and the specific situation origin are essential.
3. *Formal characteristics*: Formal characteristics describe the form of the material. The starting point of the analysis is usually a specific text and spoken content as interviews / discussions (recordings), which have to be converted accordingly into text format (transcription). The entire procedure has to be documented. Furthermore formal characteris-

tics describe what kind of data has been added and in what way the document has been created.

- 4. *Analysis focus*: The starting material can be analyzed in different directions. The analysis focus determines if, for example, the text object, the effect on the target group, or the background of a specific text should be considered in particular.
- 5. *Theory-driven differentiation of the issue*: The analysis follows a theoretically justified question / target position. Theory-driven implies a progress in knowledge, based on the gained experience over a specific research subject. Therefore the question of the analysis needs to be clarified.
- 6. *Definition of analysis method*: A summary, explication, structuring or a combination of the three methods can be selected as analysis method. A summary reduces the material to its main content. An explication adds further material to vague text parts for better understanding. Structuring filters specific aspects by fulfilling predefined criteria (Table 2.8).

Table 2.8 Analyzing Techniques, according to [210].

Analyzing Technique	Technique	Variants
Summarizing		Summarizing; inductive category definition
Explication		Strict explication, wide explication
Structuring		Formal, content, typesetting and scaling structuring

- 7. *Definition of analyzing entities*: The definition of analyzing entities determines the entity of codec, content and evaluation. The codec entity defines the smallest part of the text, which is allowed to be evaluated and can be categorized. The content entity defines the greatest text piece. The evaluation entity determines the ordered sequence of entities, which are to be evaluated.

This process is executed and documented for all conducted expert interviews. The individual executions are described within the corresponding analysis sections (Sect. 4.2.1, Sect. 7.2.3, Sect. 8.3.2).

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