

On the Application of the ISD Method Engineering Approach in Non-ISD Domains

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Abstract: Situational method engineering (SME) is concerned with the design, construction, and evaluation of methods that are aimed at the development of particular software products in well-defined development situations. The SME approach features characteristics such as flexibility, adaptability, modularity, reusability, and reference to situational aspects. These aspects may not only be useful for the engineering of software but also for the engineering of work systems, organizational structures, or enterprises. This paper therefore presents exemplary applications of the SME approach in domains that are different from software engineering. It furthermore discusses potentials and limitations of the transfer and application of SME principles, concepts, and techniques to those subject areas.

Keywords: Method Engineering, Business Engineering, Organizational Engineering, Process Engineering, Information Systems Development

1 Introduction and Motivation

Since the early 1990s, the situational method engineering (SME) discipline has been promoted in response to various drawbacks of information systems development (ISD) processes and practices [1-6]. ISD processes and practices are oftentimes predefined, rigid, and do not meet specific requirements or characteristics of the development project. However, real-world ISD projects do very well differ with respect to both project type-specific and context type-specific characteristics such as the project size, its duration, its importance and relevance to the organization, the system engineers' skills, etc. [7]. SME has been developed in response to these requirements: ISD processes/methods should become more flexible, adaptable, modular, reusable, and situational.

In this paper, we will argue that the characteristics of the ISD method engineering discipline – flexibility, adaptability, modularity, reusability, and reference to situational aspects – can be applied to other, non-ISD domains as well. After a brief introduction to the ISD method engineering approach (cf. section 2), we will discuss some examples of the transfer and application of the principles, concepts, and techniques of the ISD method engineering approach to other subject areas such as organizational change engineering, enterprise modeling, business process modeling, and IT process design (cf. section 3). All of these examples have been chosen from the current body of literature where a multiplicity of pertinent research activities can be observed (cf. e.g. the workshop series on business process modeling, development, and support [8, 9]). Section 4 is dedicated to the discussion of potentials and limitations of the application of the ISD method engineering approach in non-ISD domains. In doing so, we will focus particularly on the examples presented in the previous section. Finally, section 5 will summarize the main findings, conclude the paper, and present an outlook on further research activities.

2 The ISD Method Engineering Approach

Research in the discipline of ISD method engineering, and in particular SME, is concerned with the building of project-specific methods, so-called situational methods, from parts of existing methods.¹ According to Brinkkemper, a method is defined as “[...] an approach to perform a systems development project, based on a specific way of thinking, consisting of directions and rules, structured in a systematic way in development activities with corresponding development products” [3]. SME promotes the idea of retrieving, adapting, and tailoring either a certain base method (cf. e.g. [11]) or selected method components to the specifics of the IS development situation (cf. e.g. [3, 12]).

As outlined in the introductory section, the ISD method engineering approach is aimed at responding to the requirements of the ISD processes/methods. In order to meet these requirements, SME follows some basic principles. Rolland distinguishes the following four principles of the ISD method engineering approach [13]:

- **Meta modeling:** Commonly, a method’s meta model consists of a product meta model, a process meta model, and interconnecting elements (cf. e.g. [14]). Meta models can be used for method construction, formalization, comparison, and standardization.
- **Flexibility:** The flexibility principle is needed for the adaptation of ISD methods to the characteristics of different ISD projects. According to the “situational method spectrum” proposed by Harmsen et al., the degree of flexibility may vary between the two extremal values low (“use of rigid method”) and high (“modular method construction”) [1].

¹ We will refrain from discussing particular modularization constructs in SME due to the differing views on ME research and/or research backgrounds of the authors that have contributed to this research. In accordance with the outcome of the ME’07 panel discussion (cf. [10]), the terms/concepts “method fragment”, “method chunk”, and “method component” will be used synonymously in this paper.

- Reuse of methods/method components: The reuse principle allows for the construction of new ISD methods on the basis of existing ISD methods or parts thereof that have developed at an earlier point of time and/or for a different purpose and/or in the context of a different development situation.
- Modularity of methods: The modularity principle is necessary to assure both flexibility and reuse of ISD methods. According to this principle, a method is considered to consist of a set of method fragments/chunks/components (cf. [10]) that can be split up and put together according to the functional requirements and situational aspects of the IS development situation.

Various authors have proposed frameworks for the classification of reuse mechanisms in SME (cf. e.g. [7, 15, 16]). Bucher et al., for example, differentiate between situational method composition on the one hand and situational method configuration on the other hand [7]. While this differentiation represents a bird's eye view of reuse mechanisms, Nehan and Deneckère as well as Becker et al. go into details and distinguish between the instantiation, assembly, extension, and reduction approaches [17] as well as between analogy construction, aggregation, configuration, specialization, and instantiation [16], respectively. Most of these reuse mechanisms can be mapped onto each other. To make an example, situational method composition, the assembly approach, and method aggregation refer to one and the same kind of reuse mechanism.

3 Exemplary Applications of the Method Engineering Approach in Non-ISD Domains

In the following, we will discuss examples of the transfer and application of the principles, concepts, and techniques of the ISD method engineering approach to other subject areas. All examples have been gathered from recent scientific publications or research projects in which the contributors to this paper have been involved.

3.1 The St. Gallen Approach to Method Engineering and Organizational Change Engineering

Based on a review of different approaches to method construction and method implementation carried out at the beginning of the 1990s, Heym [18] and Gutzwiller [19] identified five constituent elements of a method: design activities, design results, roles, techniques, and the information model of the method. Albeit implicitly mentioned by Gutzwiller, a sixth element – tools in support of techniques – has been established as self-contained descriptive element of a method not until some ten years later by Alt et al. [20].

Design results take the center stage of the method description. Specification documents provide a detailed view on particular aspects of the work system under development. Design results can be subdivided into parts or, conversely, composed and therefore organized hierarchically whereupon the entirety of all design results is referred to as documentation model. Design results are the outcome and, at the same

time, the basis for design activities which in turn represent the execution of a particular task. Similar to design results, design activities can be structured hierarchically. Moreover, design activities can be arranged sequentially. The entirety of all design activities and their operational sequence is denoted as the method's procedure model. At least one role is allotted to each design activity. Roles are exercised by persons and can be characterized with respect to particular participation types (e.g. "responsible", "advising", "exercising", and "approving", cf. [19]). The preparation of design results is supported by techniques that provide detailed instructions and recommendations on how the method's deliverables are to be produced. Computer-aided tools support the efficient application of techniques. Finally, the information model describes the design objects of the method and represents the conceptual data model of the design results, thereby defining the scope and solution space of the method (cf. [19-21]).

By analyzing a total of twelve scientific contributions to the ME body of literature, Braun et al. [21] validated the aforementioned set of elements that can be used for the description of generic methods. Based on these findings, it is reasonable to conclude that the six constituent elements of work system design methods described above represent a core meta model (cf. Fig. 1).

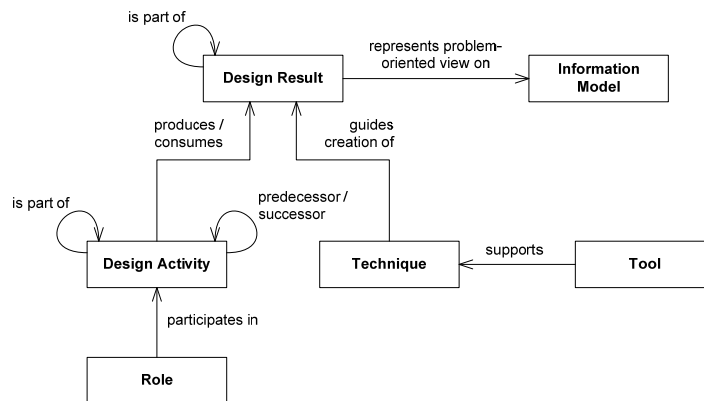


Fig. 1. St. Gallen meta model of method engineering (on the basis of [19])

Following the St. Gallen meta model of method engineering, a multiplicity of methods pertaining to the business engineering domain have been developed. Business engineering methods support, for example, requirements engineering, process engineering, business model engineering, goal system engineering, and information flow engineering.

Another example of the St. Gallen approach to SME is the proposal of a situational method that supports organizational change projects [22, 23]. The examination of various change projects, case studies, and established methods pertaining to organizational change has shown that change projects require individual methods tailored to the respective development situations. Baumöel therefore proposes a construction process for the aggregation/composition of a situational change method that closely follows established method construction processes from the ISD domain (cf. e.g. [2, 3, 14]). Strategic agility in managing organizational change can therefore

be gained through the methodological approach of flexibly adapting to new requirements on the one hand and the potential of information technology that provides the infrastructure for supporting the change project as well as the newly developing organization on the other hand [22].

3.2 Enterprise Modeling

Enterprise modeling (EM) is the focus of many research activities related to business engineering [24]. The enterprise model integration (EMI) approach suggested by Kühn et al. aims at overcoming the diversity of models and modeling languages of the EM field [25]. This approach assures the integration of meta models of modeling languages that can be used to describe different aspects of an organization. Among other approaches that have been proposed to enhance EM, the one of Zivkovic et al. uses principles of the ISD method engineering approach for the integration of modeling languages [26].

To enhance the EMI approach, Zivkovic et al. suggest extending it by the inclusion of mappings and integration rules. This approach proposes to map source meta models from both language modeling and enterprise modeling in an assembled target meta model. Therefore, they define a set of mapping variants expressing possible interaction of meta model elements and a catalogue of integration rules defining how to proceed for integration. For both mappings and integration rules, language definitions are specified.

Their integration approach is based on several concepts: heterogeneity, mappings, and integration rules that are organized within a catalogue. First of all, the authors define different types of meta model heterogeneity (syntactical, structural, and semantic) which are crucial for further analysis. The mapping represents a structural and semantic correspondence between concepts of two meta-models. The structural correspondence deals with different mapping variants: mapping structure (e.g. class-to-class, attribute-to-attribute, relationship-to-class, etc.) and mapping cardinality (one-to-one, one-to-many, and many-to-many). The semantics allow to distinguish different types of mappings: equivalence, relation (generalization, aggregation, composition, association, and classification), and non-relation.

Based on the mapping concept, the authors introduce the notions of integration point and integration rules. Integration points allow selecting mappings that are important for a given integration. Integration rules include a rule condition (identified mapping) and a rule action which must be undertaken in a given situation. Furthermore, a catalogue of generic integration rules is introduced to provide a set of solutions for recurring meta model integration problems. The authors distinguish two main rule categories: alignment rules (when concepts can be merged into one concept, mapped in order to preserve their previous structure, or abstracted with a more general concept) and connection rules (according to the mapping type, the following rules are identified: generalize/specialize, aggregate, compose, associate, and classify).

In this manner, the described approach suggests a flexible integration of modeling languages. The applicability of the proposed approach is illustrated using the case of integrating the Business Process Modeling Notation (BPMN) meta model with the

meta model for organizational modeling of the ADONIS BPMS method. The main result of this work consists in a better support of the assembly and reuse of the method chunks in the field of domain specific modeling languages in order to provide a fast, adapted, and high-quality solution.

The following basic ideas and concepts of the ISD method engineering approach can be identified in this contribution:

- Based on ME principles, the authors distinguish between product and process parts (mappings and integration rules) which are independent, reusable components.
- The authors extend an existing approach (in this case EMI) with new components.
- The authors use techniques for integrating meta models based on the assembly-based approach of SME [27].

All of the aforementioned characteristics aim at providing modularity, adaptability, and reusability in meta model integration. A similar example of an existing method extension in the field of ISD is presented by Saeki [28]. The author uses meta modeling in order to integrate metrics into information systems development methods by assembling them into a measurable method.

3.3 Business Process Modeling

This section discusses a framework for business process (BP) modeling that is compatible with the assembly-based SME approach in the ISD domain. This framework is discussed in detail by Nurcan et al. [29-31]. Let us briefly recall that ISD method engineering approaches promote the construction of a method by assembling reusable method fragments stored in some method base in order to match the situation of the project in the best possible way [2, 12, 14, 27, 32].

Within the above mentioned framework for BP modeling, the key issue is to give rigor in well-structured BP modeling, and flexibility and adaptability required in ill-structured and even ad-hoc BP modeling. This is done by allowing the description of the invariants of the organization in terms of objectives and strategies before the specification of the manner of making them operational in a particular organizational situation. Among other key concepts of the framework, the concepts of business map, BP chunk, and BP chunk integration/orchestration are closely related to method engineering. According to Nurcan et al., the purpose of business maps is to provide an intention/decision-oriented definition of BPs on the one hand and to define orchestration of the islands of BP chunks and their support systems on the other hand [31]. This concept is based on the map model defined by Rolland et al. [33]. We will briefly recall the map model. A map is a labeled directed graph with intentions as nodes and strategies as edges between intentions. It consists of a number of sections each of which is a triplet $\langle \text{source intention } I_i, \text{target intention } I_j, \text{strategy } S_{ij} \rangle$. An intention is defined as a goal that can be achieved by the performance of a process. A strategy is defined as a manner to achieve an intention.

A map has associated guidelines for the selection of the next intentions and strategies on the one hand as well as for the achievement of the selected strategies on the other hand. Guidelines take into consideration the situation at hand. According to Nurcan et al., business intention and strategy selection guidelines describe the know-how of the business decisional level. These are decision process chunks [31]. A map

is multi-model. It contains a finite number of paths from the start node to the stop node, each of them prescribing a particular way to develop the product (e.g. a service to be delivered to a customer). Thus, each path of the business map is a BP model. The actual path is constructed dynamically according to the guidelines mentioned above. A business map section can be refined as another business map. Business map sections that cannot be refined any more using intention/decision considerations can be made operational using BP chunks.

Therefore, well-structured BPs could be represented as a component BP chunk having individual activities at the lower level of the decomposition. Ill-structured BPs could be represented as a “bag” of BP chunks. The map model defines the integration/orchestration for all those islands of BP chunks.

With regard to ISD method engineering, this framework offers a solution aiming at helping the business process engineer in the combination of BP chunks that best fit the situation at hand to reach the business goals. We believe that it is compatible with the SME approach. That is, method chunk selection techniques such as those proposed by Plihon et al. could be well-suited for the selection of the appropriate BP models and BP chunks implementing a given section [34]. In addition, method chunk/fragment assembly techniques such as those proposed by Ralyté et al. could be appropriate for the integration/orchestration of BP chunks [27].

3.4 Creation of Organization-Specific IT Processes

An organization needs to manage and control IT resources using a structured set of IT processes that deliver the required information services in order to provide the information that the organization requires to achieve its objectives.

IT processes and other business processes in organizations are defined by the following interrelating factors: organizational structure, culture, technology, and people [35]. They form a complex system from both the sociological and technological point of view. Practice shows that it is nearly impossible to define universal IT processes that are suitable for every organization. For that reason, IT processes should be constructed that are both acceptable for the organization and at the same time suitable for optimal use of IT resources. However, the field of IT process construction lacks a systematic approach. Many important decisions about the structure of IT processes are made according to the IT process consultants’ personal experience and subjective opinion. The goal of research by Zvanut and Bajec [36] is to generalize the principles of ISD method engineering approaches into an approach for the engineering of an arbitrary IT process by considering technological and sociological parameters of organizations. IT processes are defined according to the COBIT (Control Objectives for Information and Related Technologies) framework that was developed by IT Governance Institute (ITGI). COBIT is a framework and supporting toolset that allows managers to bridge the gap between control requirements, technical issues, and business risks. For each IT process, COBIT provides a high-level control objective statement with key goals, metrics, and detailed control objectives (as generic action statements of the minimum management best practices to ensure the process is kept under control). COBIT defines 34 IT processes (e.g. manage service desk and incidents, manage problems, manage changes, etc.).

In order to determine if principles suggested by ME can also be used for IT process construction, the authors studied various ME approaches to see which one best fitted their goals [36]. It turned out that the most suitable approach was the process configuration approach (PCA) proposed by Bajec et al. [37]. The reasons for the choice are twofold: the simplicity of the PCA approach and its process orientation.

The idea that lies behind PCA is relatively simple and can be explained as follows (cf. left hand side of Fig. 2): For each individual project, a specific process configuration (project-specific method) is created. This is done by selecting components from a method that has been specifically designed for the organization and thus reflects its actual performance on the projects (“base method”). The configuration is done by processing the rules that specify in which project situations it is compulsory, advisable, or discouraged to use a particular component. The rules are part of the base method and are defined together with other base method elements. The base method is the most important prerequisite for PCA. It is a formal representation of how a particular organization is performing its projects.

The right hand side of Fig. 2 represents the application of PCA in IT process construction (in the following referred to as PCA-IT). The core element of the approach is the definition of best possible IT processes that are “perfect for perfect organizations” [36]. This means that they include all possible fragments and, what is more important, conform to the highest possible maturity level (e.g. they are defined, measured, and optimized) [38] and thus assure the highest possible quality. Of course, in typical organizations it is rarely the case that we can afford to set up perfect IT processes as doing so requires/implies a lot of overhead in terms of people and money. The question is therefore: What is an optimal maturity level that a particular IT process should reach in a particular organization? This level could be assessed by careful consideration of various socio-technical characteristics of the organization in question. These are then input factors that help us configuring a “perfect IT process” into an IT process that best suits the needs of a particular organization [36].

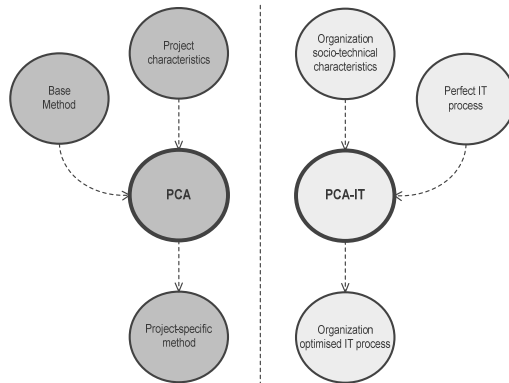


Fig. 2. Construction of organization-specific IT processes and project-specific methods [36]

4 Discussion of Potentials and Limitations

In the ISD community, it is common belief that disciplined methodological approaches are indispensable for successful development. This led to the emergence of several complex and detailed ISD methods which were developed and introduced in organizations. However, it was soon that practitioners found out that the prescribed methods were not applicable to the diverse situations they had to deal with, and they started to ignore them. Several empirical studies have confirmed that methods-in-action (i.e. the actual ways of performing projects) differ considerably from the prescribed methods (cf. e.g. [39-43]). Today we know that there is no uniform method that could suffice for the performance of a variety of projects and that the activities, techniques, and tools that we employ in a particular step of a project depend or at least should depend on socio-technical characteristics that define the context of a current situation (cf. e.g. [37, 42-44]).

As shown in the previous sections, the ISD method engineering approaches offer some very useful mechanisms that can help us to improve software engineering practice. Most importantly, with applying ME we achieve higher levels of

- adaptability (i.e. methods are not rigid and can be adapted to suit particular development situations),
- suitability (i.e. methods are made more sound, both technically and socially, with a particular development situation), and
- reusability (i.e. methods are composed of methods fragments which are reusable).

These features, however, are not a peculiarity of the software engineering field. There are also other domains that suffer from the lack of adaptability, suitability, and reusability. The application of the principles of ISD method engineering approaches might be an answer to this problem. Current business environments are becoming more and more complex and dynamic. In order to survive, organizations need to be amenable to changes and must continuously transform their business processes and organizational structures to satisfy the current requirements. We believe that the

principles of ME and the various approaches that have been developed to make methods more useful in the ISD discipline provide also an excellent theoretical basis for the engineering of organizations and businesses. In fact, we believe that ME theory could contribute to any problem domain where there is no unique approach to handle problems but instead we have to combine, in some intelligent and systematic manner, different methods, techniques, and tools as well as knowledge and know-how from similar development situations in the past.

Let us now look more deeply into some domains where the potentials of ME principles are straightforward.

Many current researches stress the importance of modeling flexible business processes (c.f. e.g. [45-47]). We can also find research papers that emphasize the need for context-awareness in business process modeling (c.f. e.g. [48, 49]). Furthermore, Rolland and Prakash claim that, by modeling variability, families of business process models can contribute to adequate design allowing the installation of situation-specific business process models in different organizations or in different situations [50]. Different approaches have been proposed in the past for the construction of business processes from existing parts. An example of such an approach is the use of business engineering building blocks [51]. The idea behind the approach is to enable the construction of business processes by selecting and linking suitable building blocks that communicate through well-defined interfaces. Another example is the use of general business patterns to construct business processes [52]. Appropriate patterns are selected, adapted to specific circumstances, and linked into a complete business process. We believe that in the context of business process engineering there are at least three ways in which ME principles can contribute:

- Firstly, the ME theory offers powerful mechanisms that can be used for the selection of business process parts and their integration into consistent business processes that are optimized for achieving preset business goals.
- Secondly, method engineering approaches could be used for the adaptation of business process patterns. For instance, a certain business pattern could be automatically adapted to suit a set of initial criteria (e.g. business type, business size, number of people involved, etc.). This would provide an organization with the possibility to continuously adapt and improve its business processes to suit the current business needs in the best possible way.
- Another benefit of applying the ME principles in the domain of business process engineering is the codification of knowledge about processes. In order to define a particular business pattern or business process component as well as the context in which this pattern or component should be used, we need a deeper understanding of the business processes themselves. This particular knowledge is very often present only in the heads of particular employees and is not available to others. Following the ME practice, this rather tacit knowledge become explicit and available to all business process participants.

Another domain in which ME could contribute is organizational engineering. As defined by Salton [53], organizational engineering is “a branch of knowledge which seeks to understand, measure, predict, and guide the behavior of groups of human beings. This is achieved by viewing human beings as information processing organisms. Groups of human beings are seen as an information exchange network which is guided by fundamental principles and observable structures.”

While traditional organizational development is based on psychological and sociological theories, organizational engineering aims to take a formula-based approach in which people can be plugged into an organizational environment equation that may be used to predict an outcome. Again, the ME theory can offer useful mechanisms to formally describe various components that organizational environments consist of and also the rules that help to form appropriate networks of organizational components as an answer to particular organizational situations or needs. Some roots of these ideas can be found in the paper of Braun et al. [21]. The authors discuss different approaches of method construction in order to reveal their potential capability to support organizational engineering. Another interesting research on the use of ME principles to support organizational engineering can be found in the contribution of Popova and Sharpanskykh [54]. The authors of this paper propose a formal framework for the modeling and analysis of organizations.

However, there are also limitations to the application of the principles of ISD method engineering approaches to the aforementioned domains. An important limitation in the domain of business process engineering is the level of changeability of a process. Many business processes do not change considerably. Once such processes have been optimized, they normally do not require changes for longer periods of time. Therefore, it does not seem rational to use method engineering approaches in such cases. In other cases, however, processes need to be more adaptable. For instance, certain processes in public administration depend on many different factors and are therefore often performed differently. An example of such an administrative process is a process of issuing a building permit that depends on location, type of a building, existing infrastructure, etc. The potentials of the application of ME principles in such cases are numerous. Another limitation is imposed by the complexity of business processes. Studies in the field of expert systems have shown that it is very difficult to acquire complete knowledge about complex processes. As the complexity of such processes rises, the number of rules needed for process construction grows exponentially [55]. Furthermore, the ME principles might contribute only in organizations that have an appropriate culture and attitude towards the formalization of the business and the organizational environment. For example, it is not possible to formally adapt a process to different situations if the process under consideration is not even well-defined.

Another important issue that hinders the use of method engineering in practice is its inherent complexity. The complex adaptation mechanisms and formalizations behind the ME approaches are difficult to understand and implement. Therefore, practitioners are oftentimes discouraged from employing method engineering techniques. The use of appropriate computer support is therefore indispensable.

5 Conclusion and Outlook on Further Research and Activities

The paper at hand has been authored in response to a meeting of the task group “Method Engineering” during the ME’07 conference [56]. During that conference, it became obvious in various presentations and discussions that principles, concepts, and techniques of the ISD method engineering approach may very well be transferred

to other domains, especially to those concerned with business and organizational engineering. Our research has highlighted some examples and discussed benefits and limitations of the application of the ISD method engineering approach in other subject areas.

However, it is quite obvious that the scope of the research at hand is limited. In order to be able to make more accurate and resilient statements that could be generalized, more than just a couple of exemplary applications of the SME approach in non-ISD domains need to be analyzed. What is more, further research should concentrate on the systematic examination of which SME principles, concepts, and techniques are transferred to non-ISD disciplines more frequently than others. By doing so, we strive to establish SME as a systematic, target-oriented approach that aims at the engineering of methods which, in turn, are aimed at the creation of certain products/results – be it software, information systems, work systems, organizational structures, or enterprises.

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