Research Note

From Expert Discipline to Common Practice: A Vision and Research Agenda for Extending the Reach of Enterprise Modelling

Abstract. The benefits of enterprise modelling (EM) and its contribution to organizational tasks are largely undisputed in business and information systems engineering. EM as a discipline has been around for several decades with a huge body of knowledge on EM in academic literature. However, EM is typically done by a limited number of people in organizations inclined to methods and modelling. What is captured in models is only a fragment of what ought to be captured. Thus, this research note argues that EM is far away from reaching its maximum potential. Many people actually develop some kind of model in their local practice without thinking about it consciously. Exploiting the potential of this "grass roots modelling" could lead to groundbreaking innovations in EM. The aim is to investigate integration of the established, often systematic and formalized practices of modelling in enterprises with local practices of creating, using and communicating model-like artifacts or objects of relevance for the overall organization. Starting from a brief analysis of challenges, the paper develops a vision for extending the reach of EM, identifies research areas contributing to the vision and proposes elements of a future research agenda.

Keywords: Enterprise modelling, grass roots modelling, research agenda

1 Introduction

Enterprise modelling (EM) as a discipline in academic research and as a practice in organizations has been around for several decades. The body of knowledge represented by academic publications is huge and includes modelling methods, meta-models, languages, case studies, guidelines for practice, organizational and value-related considerations, and much more (cf. Section 2). The benefits of EM and its contribution to organizational tasks, such as business model development, visualization, strategy development, enterprise transformation, IT/business alignment, and enterprise architecture management are largely undisputed in Business & Information Systems Engineering. New challenges for this discipline are addressed by ongoing research work [1] and will eventually be taken up by industrial practice. This inside-out view of EM as an established and quite mature discipline might be somewhat idealistic, but is shared by many in the discipline [2]. However, for initiating serious innovation an inside-out perspective is not very helpful because it fails to address some very serious hindrances to large-scale adoption of modelling in practice. Many organizational actors refuse to create and maintain enterprise models, find modelling and modelling methods complex and cumbersome, or do not utilize enterprise models for their design or development activities.

In this research note, the authors use an outside-in perspective to discuss the state-of-the-art of EM and propose a research agenda to overcome the above mentioned adoption challenge. We argue that EM is far away from reaching its maximum potential, has yet to prove its benefits for the majority of business stakeholders, and has not succeeded to be regarded mission-critical in most enterprises (cf. Section 3). EM is typically used by only few actors in the organization who are inclined to methods and modelling (cf. Section 2), e.g. because they have an enterprise-wide responsibility or have a modelling-affine educational background. What is captured in enterprise models by this small group and can be utilized for organizational purposes is only a fragment of what could be captured and used. Many people actually develop some enterprise model instance without realizing that they are modeling [3]. Examples are spreadsheets[1] used to capture essential features of products and their dependencies, presentation slides that comprise architectural designs or process descriptions, mind-maps or sketches in drawing tools that specify information flows, or even structured collections of organizational facts like, e.g., responsibilities. The content of such documents often is highly valuable to the stakeholders in the enterprise, but difficult or even impossible to retrieve [4], and not managed in a way that guarantees its quality and coherence with dependent content. It is content which often meets all characteristics of a model (e.g., abstraction, reduction for a purpose at hand, pragmatic use for a defined stakeholder group), but which is obstructed by a specific document format, or is even completely unstructured. The content is created by a domain expert who is focusing on a local, job-related perspective and who is usually neither interested in enterprise-wide content reuse nor aware of the EM state-of-the-art. Exploiting the potential of such wide-spread

[1] Much data relevant for engineers and other business professionals is developed and resides in office automation tools like Excel [4]

"grass roots modelling" and using the unexplored content in existing, non-modelling documents and conversations could lead to groundbreaking innovations in EM as a discipline as well as to significantly increased practice impact of EM.

As a consequence, this research note aims at investigating the integration potential of established, often systematic and formalized EM practices with local practices of creating, using and communicating model-like content, thereby leveraging the potential value of such local content for the entire organization.

Starting from a brief overview to the state-of-the-art in EM as a scientific discipline (Section 2), we develop a "modelling for the masses" vision by describing the problem (Section 3), elaborating the vision (Section 4), discussing the state of practice in areas contributing to the vision (Section 5), identifying the dimensions of the challenge, and finally proposing topics for future work (Section 6). The main contribution of the research note is an analysis of EM use in organizations and a proposal for increasing its potential impact by "grass roots modelling". Both contributions deserve to be discussed in the EM community – a discussion which we want to kick off with this research note.

2 Enterprise Modeling – A Brief State-of-the-Art

The state-of-the-art summary in this section can only touch on published research work and the principal contributions to the field of EM. The intention of this section is to illustrate the broad spectrum of existing work. EM addresses the systematic analysis and modelling of processes, organization and product structures, IT-systems and any other perspective relevant for the modelling purpose [16]. EM has already become a research discipline with a long tradition and a large body of knowledge. A detailed account of EM approaches is provided in [17].

The scientific literature identifies several central aspects of EM (see, e.g., [17, 20, 21]), such as the *modelling procedure* or *method*, the *model* that results from modelling, the *tool support,* and the *organizational structures* that frame modelling. However, not all scholars in the field agree: some consider constructional and functional structures as part of modelling methods and argue that they cannot be separated [22]; others emphasize the importance of meta-models and modelling languages for capturing different perspectives [23]. Tool support is often considered inseparable from modelling approaches and notations [24], but is sometimes reduced to a modelling aid [17].

In addition to these topics, participative modelling and involving different stakeholder groups in EM also has a long tradition (e.g., [18]), and domain-specific modelling languages (DSML) [19] attempt to offer EM that targets specific stakeholder groups. Other research areas include meta-modelling and language development [63], method engineering [65], reference modeling [67], approaches and tools for analysis and transformation of models [66], frameworks and techniques for evaluating and improving the quality of models [12], and approaches for investigating the value of EM [62]. Areas like enterprise architecture management [6], service engineering [64] and capability management [81] also use, extend and specialize the body of EM knowledge.

Due to this plethora of topics and concepts, a recent study among EM experts suggests that one of the most important topics for future research is model simplification: "To a great extent, this can be explained in that the variety of different components […] exhibit a high degree of complexity of the subject area, which needs to be reduced in future research efforts" [25].

3 The Problem

Starting from the hypothesis that there is a lot of unexploited potential of EM which would require a wider integration of local practices, this section explores causes for the current "problem" in EM from the perspectives of driving stakeholder concerns and sustained model utilization. Stakeholder groups that have a holistic, long-term perspective (like, e.g., IT or corporate management), believe or at least should believe that architecture is no emergent feature of a complex system, but needs to be explicitly planned, implemented, controlled and adjusted [5]. Their concerns require models to cover multiple aspects, to cover all relevant artifacts (usually a large amount), to ideally cover complete artifact life cycles, and to be coherent - the traditional motivation for EM and its use in enterprise architecture management. The EM discipline matured over the last decades by [6]:

1. diversifying its modelling object from IT infrastructure, software and data over IT applications, business processes, business functions/capabilities, organizational roles/responsibilities and products all the way to value creation, financials, or business models,
2. widening its modelling scope from single solutions over functional/business areas all the way to enterprise-wide or even cross-enterprise models,

3. extending its scope from a single object layer (IT artifacts or business artifacts) all the way to the complete business-to-IT stack (Enterprise Architecture), and
4. representing not only as-is or to-be states, but also roadmaps or scenarios in order to cover the entire life cycle of modelled objects and to support evolution (or even transformation).

In contrast to the above mentioned 'enterprise-wide' concerns of certain stakeholder groups, most other stakeholder groups in organizations have interests that are more focused or short-term. They mostly prefer an opportunistic systems development process with architecture being an 'emergent' feature. Their concerns require models that cover selected aspects, comprise only artifacts that are 'locally' relevant, focus on their current design problem, and do not necessarily have to be fully coherent with other focus models. As a consequence, a plethora of 'local' models [7] can be found in organizations that are used by only one stakeholder group for 'local' analysis and design, or that serve as boundary objects [8] between two or few stakeholder groups. The co-existence of different concerns in organizations leads to a co-existence of enterprise and local models at various levels of scope, rigor, and (potential) impact that are not necessarily coherent.

As the benefits of EM were increasingly appreciated by large, complex organizations, the EM discipline matured, and various 'architect' role models were established in such organizations. Although many architects aimed at positioning themselves 'between' corporate management, business/project owners and IT, their backgrounds and competency profiles often kept them close to the corporate IT function [9]. A recent study revealed that "more mature architectures do not necessarily lead to business value" [10, p. 1]. In contrast to the historical value perception and impact increase of EM, a turning point might have been reached where additional EM effort is not justified by appropriate impact gains any more [6].

The authors of the mentioned study believe that the capped impact results from the fact that EM is driven primarily by architects and is valued primarily by IT people, so that its effects in an organization are often limited to these stakeholder groups. EM thus appears to be an elitist discipline. It may be possible to reach other stakeholder groups with EM, e.g., by implementing tight governance mechanisms that enforce local model coherence and certain completeness requirements for local models. However, such measures would not only require a high (maybe too high) governance effort, but they would also not gain acceptance with the "90% of an organization" [11] that have primarily local, focused concerns.

A straightforward remedy would be to conceptualize lightweight EM approaches that do not necessarily focus on traditional EM qualities like completeness and coherence, but instead on usefulness and impact. Such approaches would need to be designed to support not only architects and corporate IT, but also the majority of organizational stakeholders that might benefit from improved modelling/models supporting their local analysis, design and/or decision problems.

Another aspect of the "problem" of current EM results from the fact that models are used for many different purposes. In [12], the following areas of use are mentioned: model mapping, human sense-making, communication between different stakeholders, model analysis, quality assurance, model deployment and activation, systems development, model implementation and standardization. Many traditional applications of modelling are limited to one usage area, and thus provide limited value. The long-term added-value of modelling in and across organizations, however, can only be realized when models are used over a longer time and also across different areas of use [13]. To enable this potential, though, a broader and long-term usage has to be considered right from the start and needs to be systematically pursued to spread knowledge across the organization [14]. When trying to develop models into organizational memory which were originally designed for sense-making in a limited group of actors, one will often experience limitations that originate from the modelling approaches and modelling tools originally deployed [15]. Few actors retain ownership over these models over a long time span so that models gradually decay, unless appropriate mechanisms are put into place to keep them alive and up-to-date as organizational practice.

Both aspects of the "problem" in EM point into a similar direction: The traditional understanding of enterprise models as an instrument of architects and certain roles in project teams to ensure qualities like enterprise-wide coherence or alignment, have to be extended to include additional stakeholder groups that have decentral concerns, thereby also providing a broader organizational embedding of enterprise models – which in turn helps to create sufficient added-value to justify the EM invest.

4 The Vision

Organizations need to share knowledge, and a precondition for knowledge sharing are artifacts and practices that support representing and transferring knowledge across time and space. Whereas in most areas of human conduct, one-dimensional (textual) languages, either informal (natural language) or formal (as in mathematics) have traditionally been used for this purpose, we observe a growing importance of two and multi-dimensional

representational forms, such as EM. In order to extend the impact of EM, we propose technologies and approaches that overcome the elitist character of EM and also enable 'normal' knowledge workers to be active modelers, both by adapting the applications they are using to support their daily work tasks and by providing support for specific non-routine situations.

Our vision for EM in an organizational context is as follows:

Ten years from now, the majority of organizational stakeholders uses enterprise modelling (often without noticing it) to capture, store, distribute, integrate and retrieve essential knowledge relevant for their local practices in a way that supports long-term, cross-concern organizational objectives.

This vision includes many aspects that need further elaboration and refinement, some of which are the following:

- Modelling is embedded in everyday work, instead of being perceived as a distinctive practice: Non-experts in modelling do modelling, sometimes even without knowing it;
- Different kinds of model content, formats and purposes can be extracted (or mined), combined, integrated and federated on demand, either through primarily human intervention or driven by a symbiosis of humans and intelligent agents;
- Local practices in capturing knowledge can be specific yet integrative with other local practices;
- Modelling by non-experts (a.k.a. grass-roots modeling) and professional modelling co-exist in synergetic use. Models are not primarily developed for one specific purpose, but can be more flexibly used for several purposes, e.g. by using viewing mechanisms to tailor the model for different usages;
- Completeness, coherence and rigor requirements to models and modelling languages are softened towards possibilities for incomplete, partly formalized and contradictory model components, an issue and approach being discussed in work of interactive models. Modelling quality and alignment between models that maybe are partially incoherent is not enforced by tight governance mechanisms, but primarily subject to local decision-making. Enterprise-wide concerns are implemented by influencing local stakeholders;

Modelling is not an end, i.e. a purpose on its own, but a means to an end. Exemplary EM ends are business model/business process innovation, performance management, communication support and sense-making (e.g., enabled by visualization), IT/business alignment, integration, standardization, or local decision-making problems of any kind.

5 Research Areas Contributing to the Vision

For attaining the vision outlined in the previous section, approaches, methods and technologies from various areas in computer science, business information systems and social sciences will have to be involved, some of them already existing but many others to be adapted or even newly developed. This section identifies and briefly summarizes contributions from 5.1 Practice Theory and Supporting Modelling Practice, 5.2 Knowledge Management and Semantic Web as well as from 5.3 Architectural Thinking.

5.1 Contributions from Practice Theory and Supporting Modelling Practice

Organizational research [37, 38] and workplace studies [39] have taken a "practice turn" in recent years. While there is no coherent practice theory, researchers can learn from philosophers (Heidegger, Marx, Wittgenstein) and sociologists (Bourdieu, Giddens) that human actual practices are fundamental to a human identity and cognition and are an essential building block in understanding higher level concepts like organizations, power and knowledge [40]. Studying practices leads to an understanding what human actors really do, how they make sense of what they do and how they communicate this knowledge to others. This perspective has appealed to researchers of Computer Supported Cooperative Work who wanted to understand frequent failures and unexpected obstacles in adopting collaborative technologies in the field (see e.g., [41, 42]). Typically, those workplace studies have a focus on how artefacts (traditional or digital) are embedded in human activities, e.g., as a tool, as material, as knowledge repository or as symbol. We see a great potential in applying the tool set of practice theory to enterprise modelling. The study of EM practices enhances our understanding what both modelling laymen and experts really do, when they model, what the role of modelling artifacts really is, how several actors collaborate in modelling or using models, how EM practices blend into their other work practices, and how structures like power and information flows are shaped by EM practices.

Based on such an understanding, researchers reject applying inflexible models not meeting the information demand of stakeholders or heavy-weight tools to manage architectural information [45, 51]. They rather propose

to use light-weight *collaboration tools* to support enterprise modelling activities. A model-based working environment [51] empowers information carriers and enterprise architects to collaboratively and incrementally develop and manage a model in a bottom-up fashion by using "Hybrid Wiki", i.e. Wiki pages enriched with types and attributes. This approach enables the emergent enrichment of unstructured content (e.g., free text or documents) with structure (types, attributes, and relationships) achieving a collaborative model-based collaboration environment that supports the evolution of both the user-model and its data [53, 54]. The Hybrid Wiki approach combines both modelling approaches, namely top-down modelling (model-first) and bottom-up modelling (data-first). Its goal is to empower non-expert users to collaboratively gather and consolidate information in a flexible meta-model-based information system (SocioCortex), which acts as a model-based collaboration environment for members of the organization [54].

Participatory modeling investigates how multi-touch tabletops and mobile devices or data-glasses can be applied in EM, what differences in group productivity, role distribution or model acceptance exist compared to conventional modeling on plastic walls and whiteboards and what adaptations in notations and supporting tools should be made (see, e.g., [70, 71]).

Assistive technologies for model development and model improvement aim at improving or complementing computer-based EM tools. They include the use of functionality from recommendation systems to support modelers in finding suitable constructs or modeling elements [69], the use of semantic technologies to interpret the meaning of labels and detect similar constructs in other models [35] or to investigate model patterns or model fragments [72] which could be reused to make models more detailed or precise, or to extend them. In doing so assistive technologies can also make modelling more accessible to broader user communities.

Visual Languages aim to enhance a better understanding of all stakeholders. The focus here is the interaction of humans and machines through visual representations on computer screens [48]. Although the technical realization of visual languages in the context of EM is today often accomplished using meta modelling platforms such as Eclipse-EMF, MetaEdit, or ADOxx, the theories and innovative approaches developed in visual language research are very valuable. Examples include the technique of visual semantic zooming recently proposed by Yoon and Myers for better understanding and interacting with changes in program code [49] or approaches for recording, processing, and visualizing changes in diagrams [50].

Through gamification researchers strive to improve not only model understanding, but most of all making models and modelling easier, more accessible for stakeholders, more ‘usable’ [46], and even more engaging. Here, modelling activities are framed as games [47]. Essential ’modelling game elements’ and ‘game mechanics’ constitute dialogue games. The core of such games (typically collaborative in nature) are conversational moves in which modelers propose, discuss, accept or reject model elements, while rapidly switching the specific focus of the dialogue in a goal-driven fashion [3, 47]. Collaborative ‘modelling games’ can assist modelers with respect to guidance and facilitation (partly or fully automated) and the structured registering of discussion and decisions concerning a model [60, 68].

5.2 Contributions from Knowledge Management and Semantic Web

Knowledge engineering [26] and enterprise knowledge modelling [27] contribute to systematic development and reuse of knowledge by offering methods, tools and approaches for capturing knowledge in defined representations in order to support the entire lifecycle of organizational knowledge management [28]. Knowledge management from an organizational perspective addresses how to establish systematic knowledge management in an organization in terms of activities and organizational structures required (e.g. [29] [30]). Already in her seminal case study "Learning from Notes", Orlikowski [82] shows that successful knowledge management depends on appropriate incentive mechanisms for sharing knowledge. In many situations, the success of an employee depends on his knowledge and sharing may endanger his career. Recently, knowledge management has moved away from "heavy-weight" conscious structured data capture to "light weight" approaches relying on enterprise social media and knowledge farming from company structured and unstructured data (records, documents, communication traces).

If companies structure their information, they increasingly rely on approaches and tools of the semantic web. The concept of a “semantic web originated from the vision that machines are enabled to conduct automated reasoning and can thus infer information from resources on the world-wide-web [31]. In contrast to semi-formal approaches in the area of conceptual modeling that primarily build on a formal syntax with semantic expressed in natural language [32], approaches based on semantic web technologies typically strive for logic-based models that enable automated processing [33]. The spectrum of using semantic web technologies in EM thereby stretches from the use of distinct ontology languages for describing enterprise models to the transformation of enterprise models to formal ontologies, e.g., [34], up to the lightweight approaches of using semantic annotations for processing enterprise model content, e.g., [35]. New standards and vocabularies for open data exchange mean

that open semantic data may in the future increasingly overlap with EM. They offer new uses of enterprise models for new types of users. For example, open semantic data sets can be used both for enriching and mining enterprise models, and enterprise models can be used to help users by making sense of, providing context for and offering access to semantically annotated information relevant to an enterprise. The research challenge is to connect the implicit, but often tacit, semantic assumptions made in enterprise models and EM languages [59, 61, 56] to link them to the bottom-up web of semantically annotated data where anyone can contribute anything about any topic using their preferred vocabulary [36]. Research on these aspects has to combine approaches from traditional conceptual enterprise modeling with techniques primarily found in areas such as artificial intelligence, semantic web, and linked data.

5.3 Contributions from Architectural Thinking

Architectural Thinking (AT) [3, 6] offers an interesting perspective on how to widen stakeholder involvement in organizations. AT is understood as *the way of thinking and acting throughout an organization*, i.e. not restricted to architects and system developers, *that considers holistic, long-term system aspects as well as fundamental system design and evolution principles in day-to-day decision making* (e.g., change requests). A traditional approach to implement AT is to 'bring architecture to the business', i. e. to build up modeling and model-based analysis competences and responsibilities in business lines (and not in a central architecture unit or in the IT unit), thereby enabling many additional people in the organization to 'architecturally think and act'. As many organizations however failed to motivate business lines to 'architecturally think and act', research has been addressing the creation of enabling conditions for AT. Weiss et al. [44] adopted institutional theory as a lens to analyze the obvious reluctance of many organizational actors to comply with enterprise-wide norms and guidelines. They show that social legitimacy, efficiency, organizational grounding and trust have significant influence on the actor's response towards "restriction of design freedom" [45] and propose that, as a consequence, supportive conditions need to be created in the form that

- actors gain social fitness inside the organization when complying with architectural guidelines (social legitimacy),
- actors become more efficient when following guidelines (efficiency),
- architecture management is anchored within the organization's values in terms of strategy definition, top management support or the position in the organizational hierarchy (organizational grounding), and
- actors are confident that the architecture does the right things right (trust).

While governance-based architecture management cannot directly 'create' AT, it can create conditions under which AT is more likely to develop and sustain.

6 Elements of a Future Research Agenda

Future research in the field will have to tackle various challenges related to our vision. As a means to structure the challenges, we propose to consider seven dimensions which are also expected to help structure a future research agenda:

- Stakeholder dimension: Who is creating and using models? At least four stakeholder categories have to be distinguished: grass-roots (i.e. everybody in an enterprise without any particular modelling competence create/use models on their own or in collaboration with peers), participative (participation of domain experts in a modelling process led by modelling experts), expert (modelling experts create/use models), and computer (machine-generated or interpreted models, e.g. from enterprise information sources or by integration of existing models). A better understanding is required about how models or model-like content is created and used by non-traditional enterprise model users.
- Concern dimension: What role do models have for which stakeholder concerns? In order to exploit the full application potential of models, better understanding is needed concerning which types of concerns of which stakeholder groups can typically be supported by which types of models and which types of content.
- Model understandability dimension: How easily understood is a model for different stakeholders, also in view of its level of formalization? Some representations are relatively easy to understand for certain stakeholders (e.g., visual models or tailored model views for experts), others difficult to understand (e.g., formal ontology representations for grass-roots stakeholders), and many levels in between these extremes. The formality of a representation is often related to its understandability.

- Model scope dimension: In what scope is the model relevant? Categories could be that a model is relevant for individuals only, for an organization unit, for a group of people within the enterprise, for the enterprise as a whole, or for an ecosystem of organizations.
- Model processing dimension: What tasks have to be supported across different model representations, scopes, purposes and local practices? Examples for such tasks are alignment, visualization, ambiguity detection, approximation (find similar models), annotating or linking. How can different models be semantically integrated and processed? What extent of ambiguity can be accepted by an organization? How can the semantics of models gradually evolve?
- Value and quality dimension: Which factors affect quality, success, failure, utility of modelling? How are they related to semantic vocabularies and to other information sources?
- Model lifecycle dimension: What phases of model lifecycles are to be distinguished? Are these lifecycle phases different for different model kinds and do they show different paces?

The topics to be included in a future research agenda have to address the above dimensions for all aspects of our vision. This leads to a two-dimensional research agenda illustrated with its elements in Table 1, i.e. the dimensions are put in relation to the vision's aspects identified in Section 4. As an initial step to identify relevant elements of the research agenda, the areas discussed in Section 5 were analyzed for relevant topics. The identified topics were positioned in Table 1 according to the aspect of the vision and the dimension they address. The topics are presented in more detail in the following sections, each section addressing a different aspect of the vision, i.e. one row of Table 1.

Table 1: Research topics relevant for attaining the vision

Dimension **Vison's Aspect**	**A. Stake-holders**	**B. Model represen-tation**	**c. Model scope**	**d. Concern / purpose**	**e. Processing**	**f. Value & Quality**	**G. Lifecycle**
1.Modelling is embedded in everyday work	Under-standing grass roots model use and creation, improve social legitimacy	Model-generated workspace, model visualization	Model views, simplification of EM methods	Interactive model support	Integrate modelling tools and platforms in enterprise environments	Comprehension of 'just sufficient' models	Model at run-time, from ad-hoc model to elaborated model
2. Model combination, integration, federation on demand	Semantic enrichment when maturing models	Semantic aspects of model representation	Going from local to global scope	Model integration, support of reuse situations	Understanding model semantics by intelligent agents	Manual and automatic quality assurance of models	Model federation and integration lifecycle, value of models
3.Specific but integrative local practices	Light-weight practices for local workers. simplification of EM tool	Local representations, semantic annotations, DSML	Local practice, models as boundary objects	Sense-making and local communication	Visualization, sematic integration of models + documents	Model comprehension and stake-holder agreement	Projects and work tasks, knowledge services for EM
4. Grass-roots and professional modelling in synergy	Practices for expert modelers and local workers	Transition between light- and heavy-weight modelling approach	Organizational practice	Alignment of local practices	Semantic enrichment, model merging	Model availability using agreed syntax	Organizational memory
5. Softened requirements to completeness, rigor	Local workers, modeling games	Local representations, multiple stakeholder environments	Local practice, hybrid models/methods/tools	Sense-making and local comm., limited degree of enterprise wide integration	Process unstructured model content, e.g. NLP, document and EM mining	Model comprehension and stakeholder agreement	Short-term projects and local work tasks

6.1 Modelling is embedded in everyday work

One of the central elements of the vision is that modelling has to be embedded in everyday work; people do modelling without noticing it.

From a *stakeholder perspective*, more work is needed to understand how grass-roots model creation and use can be supported and stimulated, and in what situations what kind of support is required. Modeling methods need to be examined in view of what kinds of roles and tasks can be performed without traditional modeling tools. Furthermore, more knowledge is required on how to increase and create social legitimacy of models, i.e. to make light-weight model creation and use acceptable and normal in a community. Work from CSCW might provide starting points for future work.

Presentation and representation of models has to take into account how everyday work happens and what can be adequate for situations of model creation and use. A potential area of research is light-weight conceptual modeling approaches and how they can immerse into work environments. Context-orientation is another relevant topic since model use by different actors requires adaptations to actual work contexts. Model-generated work environments, which allow for model manipulation as part of model use, could be a way of merging work environment and subject of work.

Scope of models must be managed to ensure that the right content is represented in the right way for each actor. Research is needed on how to automatically derive and maintain simplified enterprise model views that are tailored to particular purposes. A related question is how to integrate and federate locally created view models in global enterprise models.

One aspect of future research regarding the *model concern dimension* is whether the concerns typically supported by modeling methods are exhaustive and sufficient. Models are known to capture "as-is" or "to-be" situations, transitions between these situations, strategic, tactical or operational purposes, etc. When modeling is embedded in everyday work, thinking in such categories might not be adequate since the concerns often change dynamically during stakeholder communication.

When it comes to *processing of models*, there is hardly any integration between modeling tools on the one hand and information systems, office and groupware products on the other. Only a few exceptions exist, e.g., enterprise architecture management and active knowledge modeling, which attempt such integration. Here much more research is required for embedding modeling-like functionality and work tasks in enterprise tools which traditionally are not related to modelling. This integration should not only be explored for model creation and use but also for linking, combining and integrating model content with the subject or content of enterprise systems.

Regarding the *quality of models* we need to understand which of the established quality criteria too strongly constrain grass-roots modeling and which ones are so important that they need to be observed. Furthermore, research is required on what transient model quality might be, i.e. for models which are formally notated. Many other characteristics of model quality, like semantic or pragmatic quality, need better understanding of how a certain application domain or community of modelers influence these characteristics.

A *lifecycle view* on models is sometimes used during tool selection or method discussion. The lifecycle view probably needs to be changed or split up into several lifecycles. When modeling is embedded in everyday work a model might come into existence earlier than in conventional expert modeling. A collection of terms or notes taken for defining business rules might be considered first stages of modeling even though they do not include any formal elements. Stakeholders might also consider models finished much earlier, i.e. at the end of the lifecycle, when expert modelers still would require more refinements of a more solid use of the notation.

6.2 Model combination, integration, federation on demand

As already mentioned in 6.1, research is also needed to make grass-roots modeling, embedded in everyday work, much more localized than today's expert enterprise modeling. Grass-roots modeling will tend to produce, change and use model views that are detached from global enterprise models. Combining, integrating and federating local models on demand therefore becomes an important research area, as well as re-integrating them back into global enterprise models.

Research on semantic enrichment can potentially inform on-demand integration or federation of local models. For example, natural-language analysis techniques can be used to extract semantics from labels or annotations in local models, offering evidence of semantic connections between elements in different models. The tasks of semantically annotating and linking models resemble standard problems in text analysis and semantic clustering. Seamlessly integrating local models and embedding them within global ones can therefore benefit from current advances in machine learning. Annotated gold standards to bootstrap supervised learning approaches are yet missing.

Research is also needed to explore how standard identifiers - ranging from personal ids like email addresses through product ids to standard IRIs used in the linked open data cloud [57] - can be used to define unambiguously which elements in which models should be merged - or at least tightly connected - because they represent the same thing, event or concept. The modelling languages (or formalisms) themselves are also a source of semantics that can be leveraged for model integration and federation. Model integration and federation become easier if the semantics of global enterprise models are already well defined. Research is therefore needed on how existing work for semantically describing models and modelling languages [59, 61, 56, 60] can be used or extended to interoperate grass-roots along with professional models.

Research on usage context can also be used to identify and better support local modelling practices, for example inspired by research on making web information retrieval more precise [58]. Research should investigate whether and how similarities in modelling contexts can help identify models that should be used or managed in similar ways, or that are candidates for integration or federation.

A final research area is whether and how user-created local models embedded within global ones can encourage workers to balance their attention between a local, task-oriented and a global, strategic focus.

6.3 Specific but integrative local practices

The technical environments used for enterprise modeling today are still rather complex. This hinders capturing knowledge from users who are not familiar with underlying concepts. Existing local practices for capturing knowledge thus need to be integrated with enterprise modeling approaches. This results in lightweight enterprise modeling practices that do not require extensive familiarity with underlying formalisms. A recent example can be found in quality management where the analysis of local practices led to a domain-specific EM method for business process improvement [77]. At the same time, the development of modeling tools based on formal specifications will be considerably eased through the availability of distinct development languages[2] [78]. The resulting enterprise modeling tools will rely on interaction and interface paradigms that represent the standard in office environments, e.g. today using browser-based applications and in the future, deviceless interaction methods [80]. The locally-adapted model representation formats and domain-specific modeling languages can subsequently be enriched for enabling machine-based analyses [73]. This can either be accomplished through traditional adaptations of a modeling language or through semantic annotations that do not require modifications of an underlying modeling language [40, 75]. Through local practices, the scope of enterprise models will be widened to act as boundary objects between domain experts and machine-processing mechanisms. Besides the establishment of interfaces to complimentary disciplines such as big data analysis [77], this will lead to the exploitation of new domains for enterprise modeling. An example is model-based support for professionals in the legal domain [76]. The processing of model information needs to be accomplished via new approaches for visualizing model contents and the semantic integration of models [79]. Recent notable examples include an approach for conceptual modeling to manage the complexity in Smart City planning [74]. The additional value of models thereby stems from the easier comprehension of models and the facilitation of stakeholder agreements. These practices are used for projects and work tasks as well as in the context of knowledge services for enterprise modeling, i.e. to integrate local modeling practices.

6.4 Grass-roots modelling and professional modelling in synergy

In addition to the existing methods for participative EM other *stakeholder-centric* approaches are needed for creating synergy between expert modeling and grass-roots modeling. One aspect is how to create an organizational culture and mutual acceptance of diverse stakeholder groups as well as ways to exchange modeling results, develop joint practices, and establish a heterogeneous community of modelers. Another aspect is the development of methods that allow for dynamic role distributions and results within the modelling and use processes.

Although some experience exists how to migrate from light-weight to stricter or heavy-weight *model representations*, much more research is required. The representation of light-weight models usually only has a few type and entity or relationship categories, if any, whereas conventional modeling languages provide many more, depending on their expressiveness and specialization. Future work could include type migration strategies, loose type coupling or informal mappings from light-weight representations to conventional representations.

[2] See also the recent publicly available specification of a DSL for modeling methods: http://austria.omilab.org/mm-dsl (last accessed 2017-02-28)

The *scope of modeling* in an organization to a large extent depends on the organization's practice regarding the use of expert modeling. Grass-roots modeling may not only contribute to but also extend the established organizational scope. Research in this area needs to investigate potential strategies for extending it efficiently and systematically.

When it comes to the *modelling concerns*, we need to better understand how the concerns of local practices and communities differ from concerns of expert modelers, and which of the concerns are suitable for exploring the use of grass-roots modeling. Case studies or non-invasive ethnographic approaches could help understand how modeling could be used and why it is not applied yet.

Tool-related research should investigate how to automatically extract local view models from model-like content, ensure that they remain synchronized over time, and present them in ways that are well-suited for local users. Research should also investigate how analogical reasoning and other approaches can suggest opportunities for reuse of knowledge and experience captured in local views across organizations. Many of these tasks should be performed quietly by autonomous agents that monitor and maintain the model and its domain, leading to a new type of smart model, which not only passively captures organizational knowledge, but actively maintains, expands and potentially enacts it.

Both *value and quality of models* and modeling will have to more clearly integrate the perspective of grass-roots modelers. Non-expert modelers so far have been primarily considered as users of models with value and quality being defined from this perspective. When grass-roots modeling puts more focus on model creation and models as carrier of knowledge, other value and quality aspects need to be investigated. Grass-roots modelers and experts do not necessarily have to agree on joint criteria, but the perception of quality in both groups should not be contradicting and mutually accepted.

A synergetic view on expert and grass-roots modeling would benefit from joint view on the *lifecycle of models* which could serve as a guideline how to organize modeling for different purposes, and the transition between resulting models. For organizational memories, a lifecycle can be an aid to structure models, put them into potential contexts of use and help to integrate them in local practices.

6.5 Softened requirements to completeness, coherence and rigor

Going from using mostly traditional modeling approaches to a more generic set of representations (going from unstructured text, presentations and tables, to more structured visual representations), the number of different stakeholders and their need for traditional model quality varies more. Going from an informal representation to more formal often means to improve the model quality in a way found beneficial within the organization. How to motivate people for such shifts is a research issue.

In general the combined set of knowledge carriers will be in different forms, thus even for models being part of the organizational memory not all knowledge should be represented as a formal model. Also, in this case there is a need to combine visual models, diagrams, tables, structured and unstructured text. What is the right balance of representational forms is an important research topic.

In particular when supporting local practice, one would expect informal representations to be of most importance. On the other hand, if one can instill at least the use of semi-formal notations for certain types of knowledge (e.g. simple process models used in quality systems in [13]), this improves the potential spreading of knowledge on an organizational level, and also supports reorganizations and migration of workers internally. Again, what is the right balance is an interesting research topic. One could argue that all new knowledge is created among individuals, and local communities of people, only some of it needs to mature and reach organizational-wide use and relevance. Research is needed to investigate when such maturing of enterprise knowledge, which will entail the need for at least some sort of formalization, is beneficial.

As discussed relative to interactive models, social quality of models in the sense of agreement is perhaps not as important when assumptions can be readily tested in the real world, at least when being used among a limited number of people. How to soften the requirement to model quality but still have the models proving appropriate coordination needs to be investigated.

The formality of the approach is quite different if the modeling is for local sense-making or for maintaining organizational memory. Again, research on the need and useful mechanisms for knowledge maturing and model reuse is important.

7 Summary and Future Work

Motivated by current challenges in EM, we have proposed a new vision for the field: *"from expert discipline to common practice"*, aiming to better exploit the potential of EM in future enterprises. We have identified mid-term and long-term research challenges towards this vision and pieced them into a research agenda. Future work will both have to address the challenges themselves through new research efforts and to continuously revise and extend the agenda in light of the results. An important precondition is to discuss the vision and its consequences thoroughly in the enterprise modeling community.

Many of the issues and concerns we have raised are related to *people*: how they use models, what concerns they have, with whom they need to communicate, etc. Eliciting (model engineering) requirements alone may not provide sufficiently broad and deep understanding, unless it is augmented with behavioral and social perspectives that provide insights on motivations, perceptions, concerns, emergence, etc. This calls not necessarily for a methodological evolution of the EM discipline, but for a better integration with other (IS) research communities. With broader foundations, new innovative approaches to mass user-oriented modeling, human-model interaction and the processing of information contained in models can be developed and shared across communities.

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