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RESEARCH PAPER

The Development and Experimental Evaluation of a Focused Business Model Representation

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Abstract Business models (BM) are the central concept to understand the business logic of an organization. Enterprise modeling contributes to the conceptualization of BMs by providing explicit representations. A proper BM representation helps to increase the understanding and communication about the underlying knowledge for the stakeholders within a company. However, the existing enterprise modeling languages have a different and partial focus on the BM concept due to their various backgrounds. This prevents the large-scale adoption of these representations in practice. Therefore a focused BM viewpoint is developed, which explicitly facilitates the understanding about the underlying BM components. To this end, existing diagrams of the value delivery modeling language were adapted to prescriptions of the physics of notations, which is a normative theory for cognitive effectiveness of diagrammatic representations. The effect on the understanding was evaluated by an experiment with 93 master students. The results confirm the research hypothesis that the new BM viewpoint increases the understanding of the modeled BM components.

Keywords Business model representation · Enterprise modeling · Value delivery modeling language · Experimental evaluation

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1 Introduction

The importance of the business model (BM) concept is recognized both in industry and academia. Since the rise of the internet, BMs help companies as a conceptual management tool to cope with increased competition and faster technological changes (Veit et al. 2014). The concept is particularly useful to bridge the design of the strategy and the processes within an enterprise (Andersson et al. 2009; Pijpers et al. 2012). Indeed, a BM represents the implementation of a strategy to create value and exchange it with the external value network (Shafer et al. 2005). Aligning the organizational strategy and processes is crucial to realize business-IT alignment, which includes communicating IT requirements to support business operations as well as identifying business opportunities that can be exploited by the use of IT.

Academic literature about e-business, strategic management, and information systems (IS) has been developing knowledge about BMs (Shafer et al. 2005). Nowadays, the BM research area is maturing as it aims to integrate different interpretations to facilitate the understanding and design of BMs (Zott et al. 2011; Osterwalder and Pigneur 2013; Veit et al. 2014).

IT support for developing BMs is an existing gap within the business and IS engineering field (Veit et al. 2014). This includes the use of enterprise modeling languages to provide a BM representation that creates a common language for the relevant stakeholders, such as chief officers (e.g., CEO, COO, CFO, CIO, etc.), marketers, and consumer groups (Gordijn and Akkermans 2003; Osterwalder et al. 2005). This results in a better understanding and communication about the underlying BM knowledge to bridge differences in background between business domains. Candidate enterprise modeling languages [i.e., capability maps (Hafeez et al. 2002), e^3-value (Gordijn and Akkermans 2003; Pijpers et al. 2012), resource-event-agent (REA) ontology (Geerts and McCarthy 2002), and value network analysis (VNA) (Allee 2008)] address different and partial aspects of BMs (Sect. 2.2), which prohibits their adoption in practice (Veit et al. 2014). This can be solved by developing a focused BM representation, which includes: the discovery of relevant BM components, the representation of these components by an enterprise model, and the evaluation to which extent this representation conveys the semantics of the modeled BM components (Parsons and Cole 2005; Osterwalder and Pigneur 2013).

The identification of the BM components was realized by previous work (Roelens and Poels 2013b), in which a framework is proposed based on existing integration efforts about the constituent BM components. Subsequent research identified the meta-model constructs of the value delivery modeling language (VDML) that are needed to represent these components (Roelens and Poels 2013a). VDML (OMG 2014) is our choice of representation language as it is proposed as a standard for enterprise modeling that can be used to provide a complete BM representation.

This paper focuses on how the VDML meta-model constructs should be combined in a new viewpoint to facilitate the understanding of the represented BM components. This is realized by applying design principles on the cognitive effectiveness of diagrammatic representations (Moody 2009) on the relevant VDML diagrams. The impact on the understanding is evaluated by an experiment that compares the new viewpoint with the existing VDML diagrams.

The structure of this paper supports the communication of a complete iteration of the build-and-evaluate process within the design science methodology (Hevner et al. 2004). This methodology guides the creation of research artifacts (i.e., the new BM viewpoint) through six steps: problem identification and motivation, definition of solution objectives, design and development, demonstration, evaluation, and communication (Peffers et al. 2007). The first two steps are described in this introduction and further clarified in Sect. 2, while the development of the new viewpoint is presented in Sect. 3. Section 4 describes the results of the experimental evaluation, which is based on diagrams that demonstrate the use of the developed viewpoint (see the questionnaire in Supplementary material; available online via http://link.springer.com). The last section concludes with the main findings and future research steps.

2 Background

2.1 VDML

VDML offers an abstract representation of a company, which focuses on the creation and exchange of value, by nine viewpoints: capability map, organization structure, role collaboration, measurement dependency, value proposition exchange, value proposition structure, business network structure, capability management, and activity diagrams (OMG 2014). The last five viewpoints have the right level of abstraction for representing BMs as they capture the VDML concepts that are needed for this purpose (Sect. 2.2). Although the other viewpoints are beyond the scope of BMs, they are useful in other enterprise modeling domains. Indeed, capability maps enable the visual representation of a taxonomy of capability definitions, which breaks down high-level competences into operational capabilities (OMG 2014). An organization structure diagram defines the chain of responsibilities for resources, operations, and budgets within the company (OMG 2014). A role collaboration diagram focuses on products and services that are exchanged within a business network, but neglects the associated value. Still, it can be used in a general analysis of value networks, as done by VNA and REA value system modeling. A measurement dependency defines the relationship between measurements of business characteristics (OMG 2014). This supports performance measurement, which can supplement enterprise modeling techniques (e.g., by the creation of heat maps). This section is limited to the meta-model and the visualization of the viewpoints that are oriented towards BMs (Figs. 1, 2, 3, 4, 5). Definitions of the VDML constructs are given in Table 1.

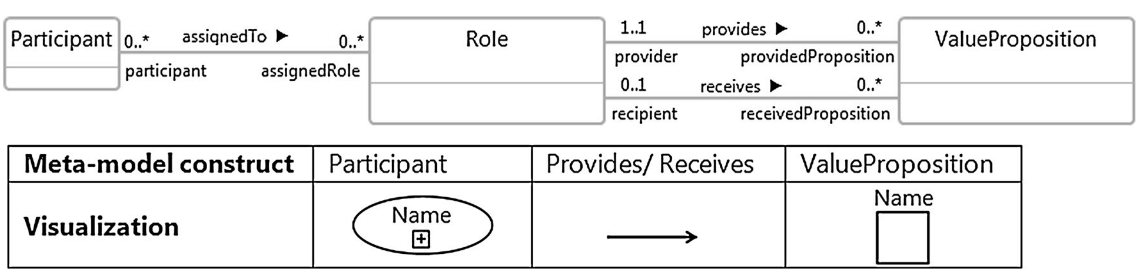
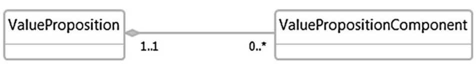


Fig. 1 Meta-model and visualization of the value proposition exchange diagram (OMG 2014)

The value proposition exchange diagram (Fig. 1) shows ValuePropositions that are exchanged between the Roles of a provider and a recipient. A Role is assigned to a Participant to represent the entity that fulfills this role. The structure of each ValueProposition is analyzed in a separate viewpoint that defines its components (Fig. 2). In the business network structure diagram (Fig. 3), a Participant is further specified as either an OrganizationUnit or a Community, which fulfills the role of a party in the BusinessNetwork of the company.

A capability management diagram (Fig. 4) shows the CapabilityOffers that are provided by an OrganizationUnit. These CapabilityOffers are supported by resources that are held in Stores, and CapabilityMethods, which are both owned by the company. Moreover, low-level capabilities that support organizational processes (i.e., CapabilityMethods) are also identified.

Activity diagrams (Fig. 5) model a process by BusinessItems that flow between Stores and High-Level Activities as two types of PortContainers that are owned by the OrganizationUnit. To enable this flow, a PortContainer makes use of ports [i.e., InputPort (s) and/or OutputPort (s)]. A ValueAdd construct is added to an OutputPort if the output of a PortContainer yields value for a company.

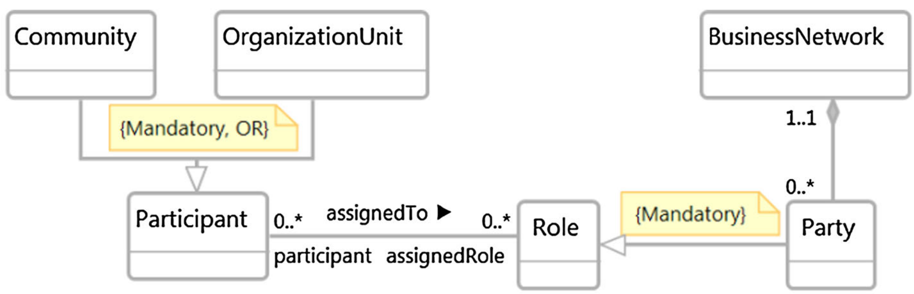


Meta-model construct	ValueProposition	ValuePropositionComponent
Visualization	*Text*	*Text*

Fig. 2 Meta-model and visualization of the value proposition structure diagram (OMG 2014)

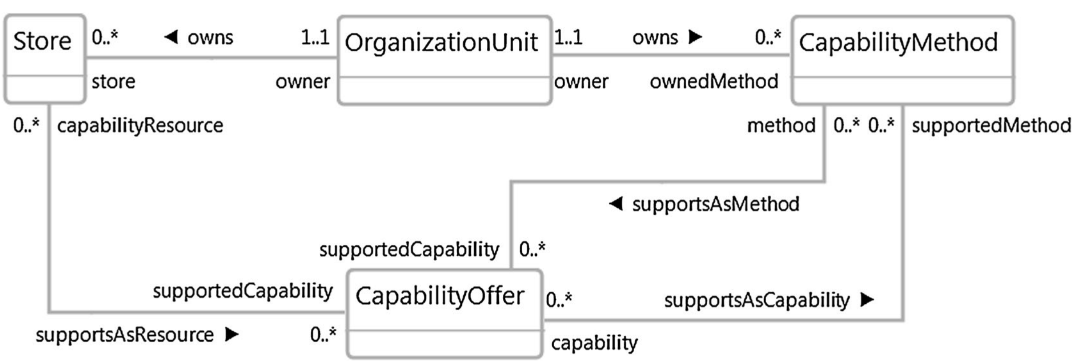
2.2 Previous Work

Previous work (Roelens and Poels 2013b) proposes a component framework for the BM concept, which solves the lack of a common conceptual basis as several research streams coexist. The literature review revealed seven BM



Meta-model construct	BusinessNetwork	Community	Organization-Unit	Consists of	Role
Visualization	Name	Name	Name		Text

Fig. 3 Meta-model and visualization of the business network structure diagram (OMG 2014)



Meta-model construct	Organization-Unit	Capability-Method	Store	Capability-Offer	Supports-AsMethod	Supports-AsCapability
Visualization	Name	Name	Name	Name		

Fig. 4 Meta-model and visualization of the capability management diagram (OMG 2014)

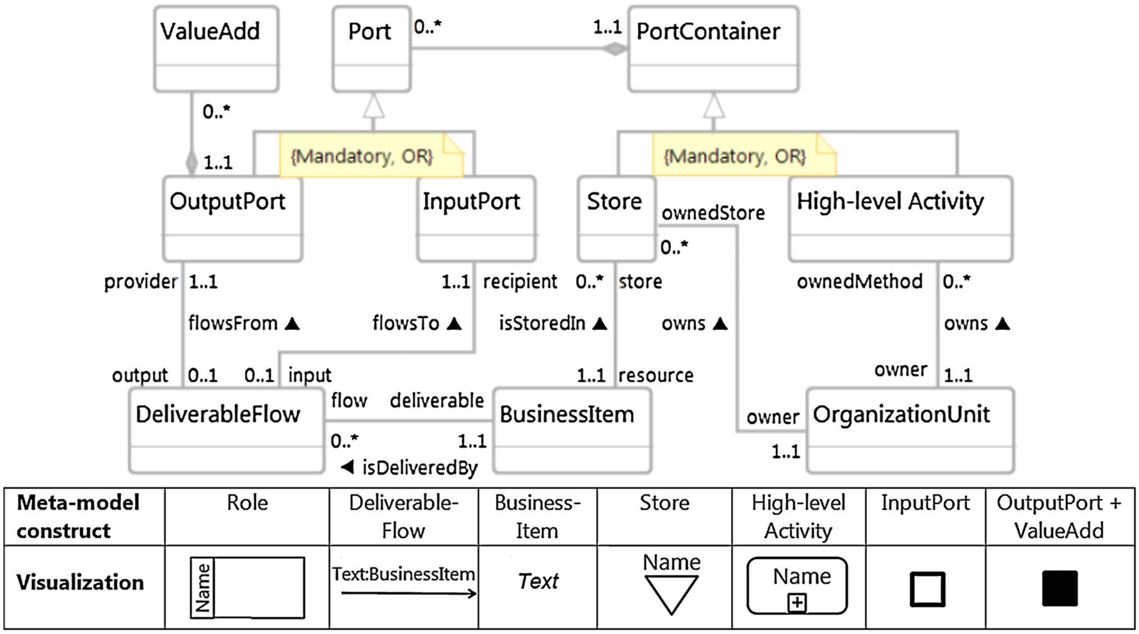


Fig. 5 Meta-model and visualization of the activity diagram (OMG 2014)

Table 1 Definition of the VDML meta model constructs oriented to BMs (OMG 2014)

Construct	Definition
Participant	Anyone or anything that can fill a role in a collaboration
Role	Expected behavior pattern or capability profile associated with participation in a collaboration
ValueProposition	Expression of the values offered to a recipient evaluated in terms of the recipient's level of satisfaction
Component	Components that constitute a value proposition
BusinessNetwork	Collaboration between independent business or economic entities, participating in an economic exchange
Party	Roles specific to and contained in the BusinessNetwork
Community	Loose collaboration of participants with similar characteristics or interests
OrganizationUnit	Administrative or functional organizational collaboration, with responsibility for defined resources
CapabilityOffer	Ability of an organization to perform a particular type of work
Store	Representation of a container of a resource
CapabilityMethod	Collaboration specification that defines the activities, deliverable flows, business items, capability requirements and roles that deliver a capability and associated value contributions
PortContainer	Abstract class that associates Ports with CapabilityMethods and Stores
Port	Connection point to a PortContainer, used to handle inputs (i.e., InputPort) or outputs (i.e., OutputPort)
ValueAdd	Value contribution of a PortContainer that contains the associated OutputPort
DeliverableFlow	Transfer of a deliverable from a provider to a recipient
BusinessItem	Anything that can be acquired or created, which conveys a form of value, and that can be conveyed from a provider to a recipient

components that underlay the majority of the frameworks: resources, value chain, competence, distribution channel, value proposition, value network, and financial structure.

Afterwards enterprise modeling languages (i.e., the REA value chain and value system specification, VNA, capability maps, e^3-value, e^3-forces, and VDML) that are used for representing BMs, were reviewed (Roelens and Poels 2013a). It was analyzed which components of the framework were covered by these representations. As can be seen in Table 2, none of the representations covers the complete set of BM components, except of VDML. However, VDML lacks a viewpoint that explicitly models the constituent BM components. Hence the VDML meta-model constructs, which are needed to cover the BM

Table 2 Mapping between existing enterprise modeling languages and VDML (Roelens and Poels 2013a)

	Resource	Value chain	Competence	Distribution channel	Value proposition	Value network	Financial structure
REA value chain specification	Economic resource*	Process*					
REA value system modeling					Economic resource*	Enterprise* External business partner**	Enterprise* Monetary resource**
Value network analysis	Deliverable*	Transaction**		Transaction*	Deliverable*	Role***	
Capability maps			Competence*				
e^3-value		Value activity*		Value exchange*	Value object* Value offering** Value port***	Actor** Market Segment****	
e^3-forces				Value transfer*	Value object* Value offering** Value port***	Constellation** Market****	(Profitability sheets)
VDML	BusinessItem*	Capability-Method* Deliverable-Flow**	Capability-Offer*	Deliverable-Flow* Channel*	BusinessItem* Value-Proposition** Component** ValueAdd** Port***	Organization-Unit* Participant** Role*** Community****	OrganizationUnit* DeliverableFlow** BusinessItem**

Table 3 Design principles used for the development step (Moody 2009)

Principle	Description
Semiotic clarity	There should be a 1:1 correspondence between meta-model constructs and graphical symbols
Complexity management	Include explicit mechanisms for dealing with diagrammatic complexity, which is measured by the number of symbol instances on a diagram
Cognitive integration	Include explicit mechanisms to support integration of information from different diagrams
Graphic economy	The number of different meta-model constructs should be cognitively manageable as the human ability to discriminate between perceptually distinct alternatives is around six categories

concept, were identified. This was realized by construct mappings (see asterisks in Table 2) between the meta-model constructs of VDML and the other enterprise modeling languages.

This paper extends the previous work by combining the identified VDML meta-model constructs into a new BM viewpoint to facilitate the understanding of the underlying BM components (Sect. 3) and by evaluating the effect of the developed viewpoint on this understanding by an experiment (Sect. 4).

3 Development of the BM Viewpoint

3.1 Methodology

The existing VDML diagrams (Figs. 1, 2, 3, 4, 5) that collectively cover the identified VDML constructs (bottom of Table 2), provide a benchmark for the development step. To assess the degree to which these diagrams support human understanding, the design principles of the physics of notations (Moody 2009) are applied. This allows detecting flaws in these diagrams, which are solved by a re-arrangement of the existing VDML meta-models to develop the new viewpoint. Therefore, only those design principles, which affect the combination of meta-model constructs used in a diagram but not the redesign of the visual VDML syntax, are applied. These are the principles of semiotic clarity, complexity management, cognitive integration, and graphic economy (Table 3).

3.2 Results

The VDML diagrams that represent the BM components (Sect. 2.1) are either externally-oriented as they focus on the exchange of value between the company and its value network (i.e., value proposition exchange, value proposition structure, and business network diagrams), or internally-oriented viewpoints that model the organizational resources, processes, and competences (i.e., capability management, and activity diagrams).

The externally-oriented VDML viewpoints consist of multiple diagrams, which supports both the management of diagrammatic complexity and graphic economy. Nevertheless, the value proposition structure diagram only contains textual elements (Fig. 2), which is an important drawback. Cognitive integration is realized as overlapping elements (i.e., ValueProposition that appears in value proposition exchange and value proposition structure diagrams and Role in value proposition exchange and business network structure diagrams) support the integration of information between the diagrams. However, a ValueProposition is encoded graphically in the value proposition exchange (Fig. 1) and textually in the value proposition structure diagram (Fig. 2), which violates semiotic clarity. Furthermore a Role construct is graphically visualized in the business network structure (Fig. 3), but not in the value proposition exchange diagram (Fig. 1).

These drawbacks are solved in the business network diagram (Fig. 6), which integrates the externally-oriented viewpoints. Although diagrammatic complexity is increased by using a single diagram (e.g., the ‘Is a’ relationship is included to link a Participant with a Community or an OrganizationUnit), graphic economy is obtained by omitting a graphical symbol for a Role, a BusinessNetwork, and the ‘consists of’ relationship. The resulting decrease of semiotic clarity is solved by incorporating these elements in the supporting definitions (Moody 2009). Consequently, the definition of a Participant (Table 1) is adapted to ‘anyone or anything that can be assigned to the role of a Party in a BusinessNetwork’. Furthermore by integrating the externally-oriented meta-model constructs, cognitive integration is increased and each construct is visualized either by a graphical (i.e., Community, OrganizationUnit, Participant, ValueProposition, ‘Is a’ and ‘Provides/Receives’) or textual symbol (i.e., ValuePropositionComponent).

The internally-oriented VDML viewpoints (Figs. 4, 5) are linked by the element of an OrganizationUnit, a Store, and a CapabilityMethod/High-level Activity. As a result, the principles of complexity management and graphic economy are supported. Still, it is a drawback that organizational processes appear as CapabilityMethods in the capability management diagram and High-level Activities in the activity diagram. In fact, a high-level activity is a more general concept that refers to the work that is performed in a collaboration, of which a CapabilityMethod is a specialization.

Diagrammatic complexity could be improved in the capability management diagram (Fig. 4) as it combines the supporting relationships between Stores and CapabilityOffers (i.e., SupportsAsResource: low-level capabilities provided by resources), CapabilityMethods and CapabilityOffers (i.e., SupportsAsMethod: organizational competences supported by the value chain), and the inverse relationship of CapabilityOffers supporting CapabilityMethods (i.e., SupportsAsCapability: low-level capabilities that support processes).

VDML employs hierarchical modeling to visualize subprocesses, which includes the use of an activity diagram (Fig. 5) for the overarching process and separate activity diagrams for the sub-processes. Although this technique results in a decrease of diagrammatic complexity, it reduces the overview of the value chain as there is lack of an integration mechanism between the diagrams. This drawback is important as the value chain is a main element within the BM (Roelens and Poels 2013b).

These problems are overcome in the new low-level capability diagram (Fig. 7) and value stream diagram (Fig. 8). In a value stream diagram, organizational processes are represented by CapabilityMethods as previous work indicates that this construct is most suitable for representing processes in the context of BMs (Roelens and Poels 2013a). This includes the use of the corresponding InputPort and OutputPort visualizations to model the inflow and outflow of BusinessItems. The PortDelegation relationship links the Ports of a CapabilityMethod to those of its constituting parts. This allows modeling overarching processes and constituent sub-processes in a single diagram, which increases cognitive integration. As BMs adopt a high-level view on processes (i.e., by making abstraction of individual activities), the increase in diagrammatic complexity is limited.

The problem of diagrammatic complexity is overcome by separating CapabilityOffers that are supported by CapabilityMethods (i.e., the SupportsAsMethod relationship in in the value stream diagram) from CapabilityOffers that are supported by Stores (i.e., the SupportsAsResource relationship in the low-level capability diagram). The overlap between the two diagrams is restricted to the OrganizationUnit as a direct related element of the Store concept. This ensures the cognitive integration between the diagrams. Furthermore, the relationship between CapabilityOffers supporting CapabilityMethods (SupportsAsCapability relationship in Fig. 4) is omitted as it can be derived by the overlap of Stores between the two diagrams. Indeed, as Stores are input for a specific CapabilityMethod in the value stream diagram, the CapabilityOffers that are provided by these Stores in the low-level capability diagram will support the CapabilityMethods to which these

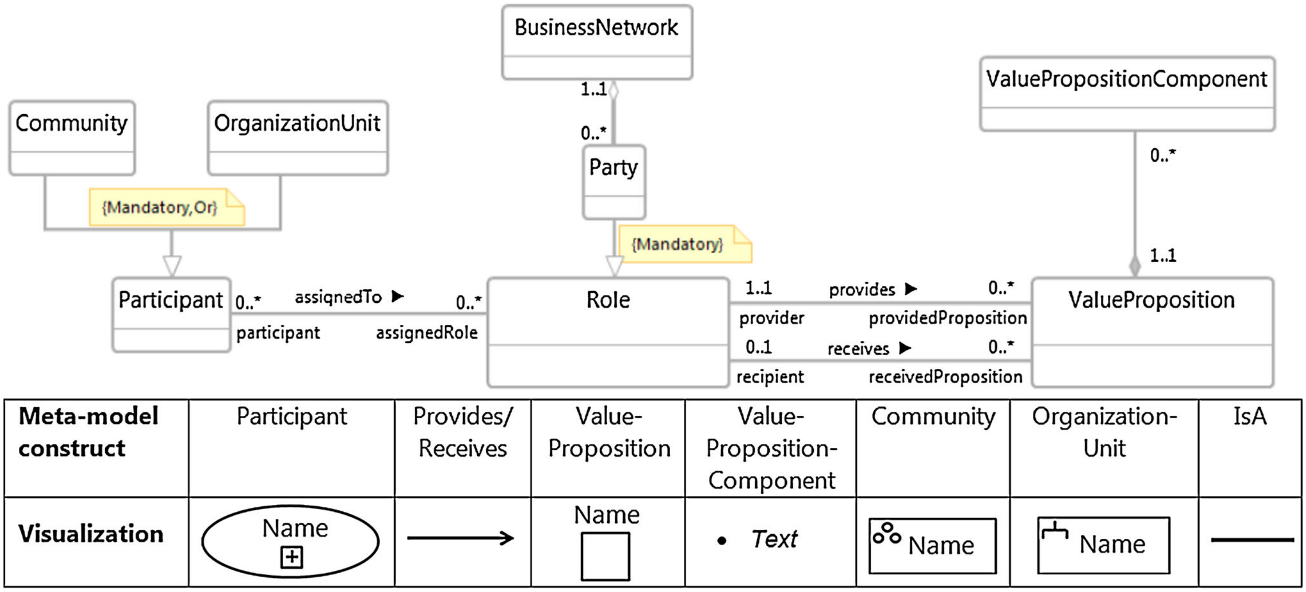


Fig. 6 Meta-model and visualization of the business network diagram

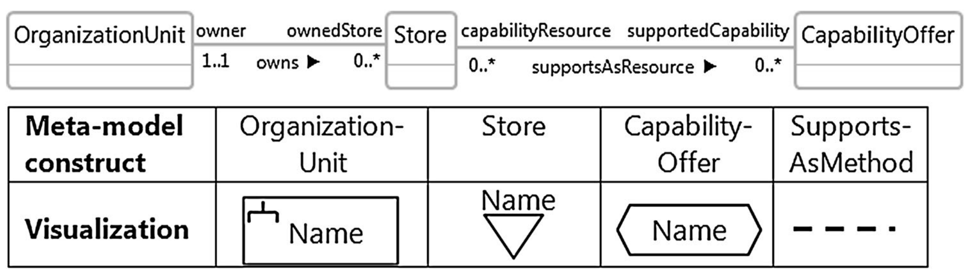


Fig. 7 Meta-model and visualization of the low-level capability diagram

Stores are input. As such, the symbol deficit does not lead to a decreased semiotic clarity.

4 Experimental Evaluation

4.1 Methodology

4.1.1 Purpose

The experiment analyzes the effect of the new BM viewpoint on the understanding of the underlying BM knowledge. This section describes guidelines to ensure the reproducibility of the experiment and to limit possible threats to internal validity (i.e., interference with the independent variable) and external validity (i.e., limitation of the generalizability of the results).

4.1.2 Hypotheses

Model understanding is measured through comprehension questions, which can be explicitly answered by means of the diagrams, and problem-solving questions that require a deeper understanding of the problem domain. Relevant dependent variables are interpretational effectiveness (i.e., accuracy of comprehending the diagram and extracting information) and interpretational efficiency (i.e., resources used to interpret the diagram) (Gemino and Wand 2004; Burton-Jones et al. 2009). In case of opposite outcomes, efficacy (i.e., the ratio of effectiveness to efficiency) is used to assess the resulting effect of a treatment (Bodart et al. 2001; Poels et al. 2011).

As design principles are applied on the existing VDML diagrams to improve the understanding about the underlying BM components, it is expected that comprehension effectiveness, efficiency, and efficacy of the new BM viewpoint is higher than that of the existing VDML diagrams.

H_c: the comprehension effectiveness (H_{c1}), efficiency (H_{c2}), and efficacy (H_{c3}) of the new BM viewpoint is higher than the H_{c1}, H_{c2}, and H_{c3} of the existing VDML diagrams.

This paper focuses on improving the understanding of the diagrams (i.e., knowledge that is explicitly

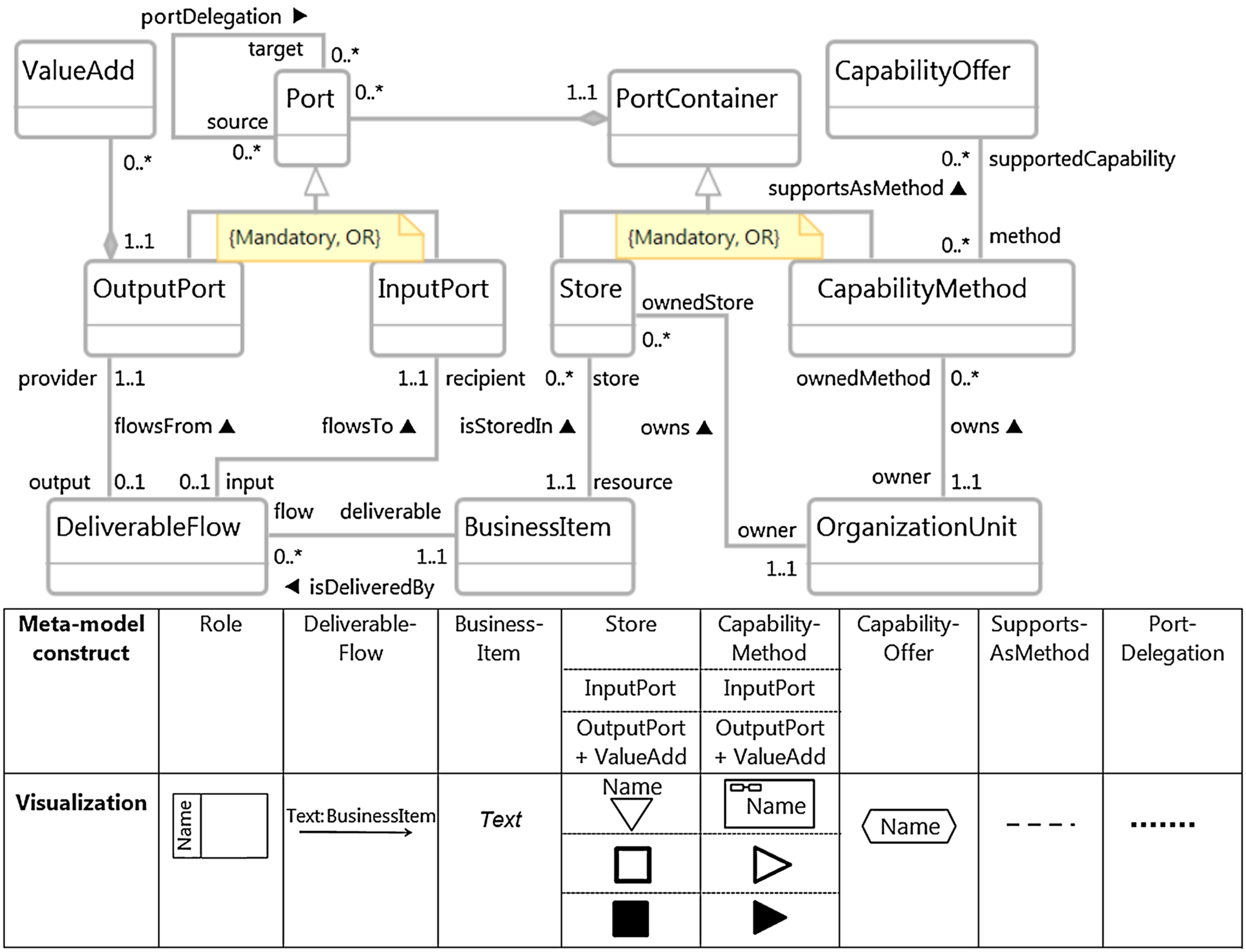


Fig. 8 Meta-model and visualization of the value stream diagram

represented) and not on the interpretation of diagrams (i.e., knowledge that can be inferred, but not necessarily represented). As a result, it is expected that the effect of using the new BM viewpoint on the problem-solving performance measures will not be significant (Burton-Jones et al. 2009).

H_p: the problem-solving effectiveness (H_{p1}), efficiency (H_{p2}), and efficacy (H_{p3}) of the new BM viewpoint and the H_{p1}, H_{p2}, and H_{p3} of the existing VDML diagrams are equal.

4.1.3 Measures

The percentage of correct answers is suited to measure the interpretational effectiveness of the comprehension questions (Bodart et al. 2001). As the number of correct problem-solving answers cannot be determined upfront, absolute numbers are used to measure its effectiveness (Bodart et al. 2001). Time is proposed as the measure for the interpretational efficiency of both comprehension and problem-solving questions (Bodart et al. 2001; Gemino and Wand 2004). As a result, the ratio of the percentage/absolute number of correct answers to the time needed for answering the comprehension/problem-solving questions is used to measure the interpretational efficacy (Bodart et al. 2001; Poels et al. 2011).

4.1.4 Experimental Design

A mixed design is applied, which includes the type of treatment as a within-subjects factor, while the type of case [i.e., manufacturing case (OMG 2012b) or healthcare case (OMG 2012a)] and the order in which participants receive the treatments, are used as between-subjects factors. This design restrains the effect of personal characteristics and skills as the same person performs the experimental tasks for the two treatments. As the cases are existing VDML examples, it is prevented that they are developed in favor of the new BM viewpoint. It is also ensured that a group receives each case once, which mitigates the learning effect that results from applying the same case. The effect of the learning effect from applying a certain treatment is controlled by counterbalancing treatments between groups.

4.1.5 Instrumentation and Experimental Tasks

The instrumentation consists of four sets of diagrams: the existing VDML viewpoints and the new BM viewpoint applied on the healthcare and the manufacturing case (URL in Sect. 1). Information equivalence is maximized by applying the adaptations (Sect. 3.2) on the existing VDML case diagrams, without adding new information, as well as by controlling for background knowledge concerning the case topics (Burton-Jones et al. 2009).

The experimental tasks include the same comprehension questions and problem-solving questions (Appendix) for both cases. The comprehension questions also provide hints about which elements to consider while answering a question to ensure that the same information is available for both treatments. The experimental tasks are pre-tested to verify the formulation of the instructions and the questions.

4.1.6 Selection of Participants

The participants are master students in business engineering without prior knowledge about VDML. While students differ from business professionals, Parsons and Cole (2005) argue that the use of experts can threaten internal validity as background knowledge is dominant while performing the experimental tasks. Moreover, a homogenous sample allows controlling for differences in skills and personality traits. Still, personal questions are used to control for domain knowledge (Gemino and Wand 2004; Parsons and Cole 2005; Burton-Jones et al. 2009), modeling experience (Gemino and Wand 2004), and gender. Domain knowledge is measured by a working experience of at least 3 months in the healthcare or manufacturing industry, while the modeling experience of participants is verified by the MIS courses and an eventual MIS master thesis in their curriculum.

4.1.7 Operational Procedures

The experiment is implemented as a voluntary class room exercise. Upfront, the participants are randomly assigned to four different slots corresponding with the experimental groups. The students are also informed that the answers are processed anonymously, the experiment can be aborted at any time, and the tasks can be fulfilled at their own pace.

As the set of acceptable answers for the comprehension questions is based on the information in the diagrams, the questions are solved by one researcher and validated by another. One point is assigned for each correct answer within this set, while half a point is distracted for additional answers. However, a small variation between the treatments for the first comprehension answer of the healthcare case needed to be solved to ensure comparability between the comprehension scores. The answers of the problem-solving questions are corrected by three researchers who discriminate between right and wrong answers. The final score is obtained by assigning one point to the answers, which are considered correct by all researchers.

4.2 Results

4.2.1 Attendance

The experiment attracted 126 participants, which validly answered 93 questionnaires. The dropout was due to the ambiguous formulation of the first problem-solving question of the manufacturing case, which resulted in the use of the wrong case by participants.

4.2.2 Statistical Method

As the experiment is characterized by a within-subjects design, which results in correlated data, a mixed linear model is used to check the hypotheses and the post-tests. This approach combines fixed effects, which are controlled during the experiment, with random effects that result from taking a sample from a population (Seltman 2012). The main assumption of normally distributed residuals was analyzed by interpreting the Shapiro–Wilk test. In case the normality assumption was violated (i.e., $p = 0.042$ for H_{c1}, $p < 10^{-3}$ for H_{c2}, H_{p2}, and H_{p3}), a generalized mixed linear model was applied.

For each of the dependent variables, the results of each participant for both treatments were analyzed. The variable ‘treatment’ was added as the factor variable, while ‘gender’, ‘curriculum’, ‘MIS thesis’, ‘working experience’, ‘case’, and ‘order’ were used as covariates to perform the post-tests. Within the models, a random intercept accounts for random variability of individual participants in the dependent variables.

4.2.3 Hypotheses Tests

The experimental results confirm the hypotheses H_{c1}, H_{c2}, and H_{c3}. The use of the new BM viewpoint has a significant effect on both the effectiveness (+14.0 %, $p < 10^{-3}$) and the efficiency (−109s, $p < 10^{-3}$) of comprehension, compared to the existing VDML diagrams. This also results in a higher efficacy ($+0.000302 \frac{\%}{s}$, $p < 10^{-3}$) of comprehension for the new viewpoint.

Although the new BM viewpoint results in a slightly higher score for problem-solving effectiveness (+0.128pt, $p = 0.638$), the existing VDML diagrams are more efficient in this respect (−27s, $p = 0.202$). However, the results are not significant at a 0.05 level and confirm H_{p1} and H_{p2}. These opposite effects result in a non-significant effect ($p = 0.572$) of the developed viewpoint on the problem-solving efficacy, which supports H_{p3}.

4.2.4 Post-tests

The use of the healthcare case has an effect on the effectiveness of both comprehension (+6.37 %, $p = 0.058$) and problem-solving (+3.82 pt, $p < 10^{-3}$). The latter is expected as the problem-solving effectiveness score is measured as an absolute number. However, the effect on the internal validity is limited as both treatments are applied on this case example.

The learning effect appears for the efficiency of the comprehension (−306s, $p < 10^{-3}$) and problem-solving questions (−227s, $p < 10^{-3}$). Due to high significance, it also has an influence on the efficacy of comprehension ($+0.000368 \frac{\%}{s}$, $p < 10^{-3}$) and problem-solving ($+0.00122 \frac{pt}{s}$, $p < 10^{-3}$). This effect is controlled by counterbalancing treatments between groups (Sect. 4.1.4).

Gender and modeling experience that is measured by MIS courses in the curriculum of the participants, tend to have moderate significant effects on the efficiency of understanding (+70s for males, $p = 0.021$) and the effectiveness (+1.08pt for males, $p = 0.057$, +2.25pt for regular curriculum, $p = 0.009$) and efficiency of problem-solving (+44s for males, $p = 0.041$). However, as participants were randomly assigned to the experimental groups, the effect on the internal validity of the experiment is limited.

5 Discussion and Conclusion

This paper finishes the development of a focused BM representation. Previous research already identified the components of a BM (Roelens and Poels 2013b) and investigated whether relevant enterprise modeling languages capture these components (Roelens and Poels 2013a). This resulted in a set of VDML meta-model constructs that cover the complete BM. This paper develops and evaluates a new BM viewpoint that facilitates the understanding of the underlying BM knowledge.

The comprehension effectiveness, efficiency, and efficacy of the new BM viewpoint are significantly higher compared to the existing VDML diagrams. This confirms that the development of the new BM viewpoint, based on the design principles of cognitive effectiveness, has a positive effect on the understanding of the underlying BM components. The effectiveness, efficiency, and efficacy of problem-solving are not statistically different between the treatments, which supports comparable research (Parsons and Cole 2005; Burton-Jones et al. 2009). For this type of questions, the personality traits and modeling experience of participants, rather than the treatments, tend to have an impact on the deep level understanding of the problem domain.

The increased understanding of the underlying BM knowledge is useful in the context of value-based requirements engineering (Gordijn and Akkermans 2003). Indeed, the new viewpoint allows the documentation of business requirements in a form that facilitates analysis and communication, to better understand the purpose of IT systems in relation to these higher-level requirements (Nuseibeh and Easterbrook 2000). However, to assure a proper operationalization of requirements, organizational strategies [e.g., the unified business strategy meta-model represented by i* (Giannoulis et al. 2012)] should be further refined via business (e.g., our viewpoint represented by VDML) to process requirements (i.e., operational tasks, responsibilities, and business rules) and subsequent IS requirements (Gordijn and Akkermans 2003; Andersson et al. 2009).

In the experiment, the set of comprehension questions is answered by a homogeneous group of respondents. This is a threat for the external validity as stakeholders have various backgrounds in a real-life context. This limitation can be overcome by performing a case-study and a similar experiment with the actual stakeholders of a company. Such an experiment, which requires qualitative research methods as it is characterized by a smaller group of respondents, will eventually enable a practical evaluation of the developed viewpoint.

To realize IT support for BM representations, the new viewpoint can be used as the input for the development of a software tool, which should be extended as a proper decision support system to realize the alignment between the organizational strategy, BMs and processes (Veit et al. 2014).

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Appendix: Questionnaire

Comprehension Questions

1. Which processes are executed by the company? List these processes in the right order below.
2. The role who receives the value proposition with the most components if fulfilled by the following participant:

A. Community
B. Organization unit

3. The input resources of processes are provided by stores. List the input resources of the process that is connected with the most input stores.
4. List all unique value proposition components provided by the organization unit (s) within the business network.
5. Competences are the result of the coordination of resources during the processes of a company. List those capabilities (i.e., capability offers) of the hospital that are directly supported by a process (i.e., capability method).

Problem-solving Questions

1. Resources, which are held in Stores, can either be material, immaterial, or human. List those human resources, based on the provided diagrams.
2. The cost structure of a company is the result of acquiring resources, either bought from an external supplier or licensed from an external partner. Based on the provided diagrams, try to come up with cost elements that are economically relevant for the central organization unit.
3. The revenue streams of a company are acquired by a company in return for the provided value proposition. Based on the diagrams, try to come up with revenue streams that are economically relevant for the central organization unit.

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