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An Integrative Framework of the Factors Affecting Process Model Understanding: A Learning Perspective

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ABSTRACT

Process models are used by information professionals to convey semantics about the business operations in a real world domain intended to be supported by an information system. The understandability of these models is vital to them actually being used. After all, what is not understood cannot be acted upon. Yet until now, understandability has primarily been defined as an intrinsic quality of the models themselves. Moreover, those studies that looked at understandability from a user perspective have mainly conceptualized users through rather arbitrary sets of variables. In this paper we advance an integrative framework to understand the role of the user in the process of understanding process models. Building on cognitive psychology, goal-setting theory and multimedia learning theory, we identify three stages of learning required to realize model understanding, these being Presage, Process, and Product. We define eight relevant user characteristics in the Presage stage of learning, three knowledge construction variables in the Process stage and three potential learning outcomes in the Product stage. To illustrate the benefits of the framework, we review existing process modeling work to identify where our framework can complement and extend existing studies.

Keywords (Required)

Process modeling, User Characteristics, Learning, Empirical Research.

INTRODUCTION

Information systems (IS) analysts and designers need to have an understanding about the domain in which the system is meant to operate, and the functions it has to perform (Maes and Poels 2007). Over recent years, analysts have started to specify these domains using graphing models articulating the processes that are run by an organization, in order to assess or build information systems that are “process-aware.” And indeed, the exercise of ‘process modeling’ has emerged as a primary reason to engage in conceptual modeling (Davies et al. 2006). It is now considered a key instrument for the analysis and design of process-aware information systems, service-oriented architectures, and web services alike (Recker et al. 2009).

Business process models play an important role for the documentation of organizational processes and for the specification of information systems requirements. These models are specified using graphical modeling languages such as BPMN (BPMI.org and OMG 2006), which provide sets of graphical constructs, together with rules for how to combine these constructs, to express graphically relevant aspects of business processes. These aspects include the tasks that have to be performed, the actors that are involved in the execution of these tasks, relevant data, and, notably, the control flow logic that describes the logical and temporal order in which tasks are to be performed.

One key objective of process modeling in information systems projects is to reach a common understanding of how a business works at current (as-is modeling) or in the future (to-be modeling) (Burton-Jones and Meso 2008). Consistently, practitioners have identified process improvement, communication and process understanding as the three most important process modeling benefits (Indulska et al. 2009). A prerequisite for realizing understanding and communication, however, is that process models are understood by their audience, making *model understandability* an important topic for research relevant to all potential uses of process models (Aguirre-Urreta and Marakas 2008). Due to model understandability having mostly been decoupled from user understanding, our aim is to close the gap by looking into the *soft understandability* of process models and aid analysts in developing an understanding of (current and future) business domains.

Specifically, we are interested in ascertaining what makes an *understandable process model*, defined as a process model that is readily and intuitively understood by all types of stakeholders that aspire to use a process model in their work. Prior studies in this vein of research have examined how characteristics of the process model itself affect its understandability. Our motivation is to complement this stream of work and examine to which extent and how characteristics of the end user working with the model affect the development of model understanding. Our research focus is motivated by the observation that understanding a process model is, by nature, a cognitive process and therefore dependent on the skills, attitudes and other characteristics of the person engaging in the understanding process (Moody 2009). We state the following research questions:

R1) How can *process* and *product* of process model understanding be conceptualized?

R2) Which factors relating to the user involved in the process are important to process model understanding?

We proceed as follows: First, we review prior research on process model understandability. Then, we review understandability as a cognitive learning process, and outline an integrative framework drawing attention to important factors alongside three stages of this learning process. Then, we apply this framework to review prior work on process modeling, and discuss how our framework can contribute to these studies. We conclude this paper by providing a discussion of contributions and limitations.

THEORETICAL BACKGROUND

Process Modeling

Process models typically include graphical depictions of at least the activities, events/states, and control flow logic that constitute a business process. Additionally, process models may also include information regarding the involved data, organizational/IT resources and potentially other artifacts such as external stakeholders and performance metrics to name just a few. In considering how to create business process models that are conducive and readily understandable to model users, many scholars argue that the type of language to be used for process modeling is an important decision to make (Rosemann et al. 2006). This is because different modeling languages emphasize different aspects of process domains, for instance activity sequencing, resource allocations, information flows, or organizational responsibilities (Soffer and Wand 2007).

From an ontological perspective (Rosemann and Green 2002), a process model can be identified as a *thing* with *properties*. Past research has attempted to define understandability as an *intrinsic property* of a process model (e.g., Vanderfeesten et al. 2008). This means that understandability has been looked at as a function of the design of the process model itself, or the grammar used to articulate the model. Metrics proposed or used include the notions of complexity, adequacy, learnability, usability, modularity, and others (e.g., Cardoso et al. 2006; Mendling et al. 2007; Reijers and Mendling 2008).

To complement this body of knowledge, we posit that process model understandability should be seen as an *emergent* property rather than an *intrinsic* one. Accordingly, it should be expressed in terms of the relation between human and performance rather than as a static property of the model itself. And indeed, prior research in other modeling domains (e.g.,Batra and Davis 1992; Shanks 1997) shows that different types of modelers engaged in conceptual modeling processes, and used conceptual modeling outcomes (i.e., the models) in noticeably different ways. Similarly, Khatri et al. (2006) showed empirically that users with different levels of method and domain knowledge performed tasks on the basis of model quite differently. Recently, Recker (2010) confirmed that individual differences also manifested in different usage behavior of process modeling grammar users. On the basis of these findings, we thus contend that process model understandability is dependent not only on properties intrinsic to the model itself but also on properties of the user working with the model, and properties that emerge in the process of working with a process model. Accordingly, in the following we offer some theoretical arguments that inform an understanding of process model understandability as a property emerging in the process of a human user applying a process model in a work-related task.

Process Model Understandability as a Learning Process

Clearly, the usefulness of any process modeling effort should be evaluated based on the ability of the outcome (the process model) to represent, communicate, and develop understanding of the domain depicted (Gemino and Wand 2003). The benefits generated by such process models all (in)directly revolve around knowledge, e.g., externalization of tacit knowledge to improve model completeness, anchoring of redesigned task specifications at an operational level (zur Muehlen and Ho 2008) or increased compliancy to regulatory mandates due to transparency in mutual expectations (Indulska et al. 2009). Since acquiring knowledge requires its integration with existing mental models, the construction of understanding from process models inherently requires users to utilize their existing knowledge and prior experience. Our contention is therefore that theories from cognitive psychology about how humans develop understanding from presented information are important in improving our comprehension about process model understandability.

Following previous work on the understandability of graphical and textual information (Mayer 1989) we therefore advance that model understanding should be seen as a learning process, in which model viewers actively organize and integrate model *information content* that is *presented using a certain process modeling approach* with their own *previous experience*, to *construct new knowledge* as an outcome of this learning process. And indeed, conceptualizing model understanding as a learning process has yielded some useful insights in the area of data modeling (Masri et al. 2008) and object modeling (Burton-Jones and Meso 2006), thereby increasing our confidence that similar patterns will emerge in the context of process modeling. Still, while previous application of Mayer's (1989) theory of learning to conceptual modeling processes and outcomes examined different *content presentation formats* (e.g., different modeling grammars), or different *contents* (e.g., different model versions), our interest in this study is to extend these conceptualizations to consider important *user characteristics* and the role these characteristics play in the learning process leading to understanding generated from a process model. Consequently, we advance an extended framework in the following.

AN INTEGRATIVE FRAMEWORK

The proposed framework comprises three stages of presage, process and product (see Figure 1). In the next subsections, we will discuss these stages, the concepts they include and their relations in more detail.

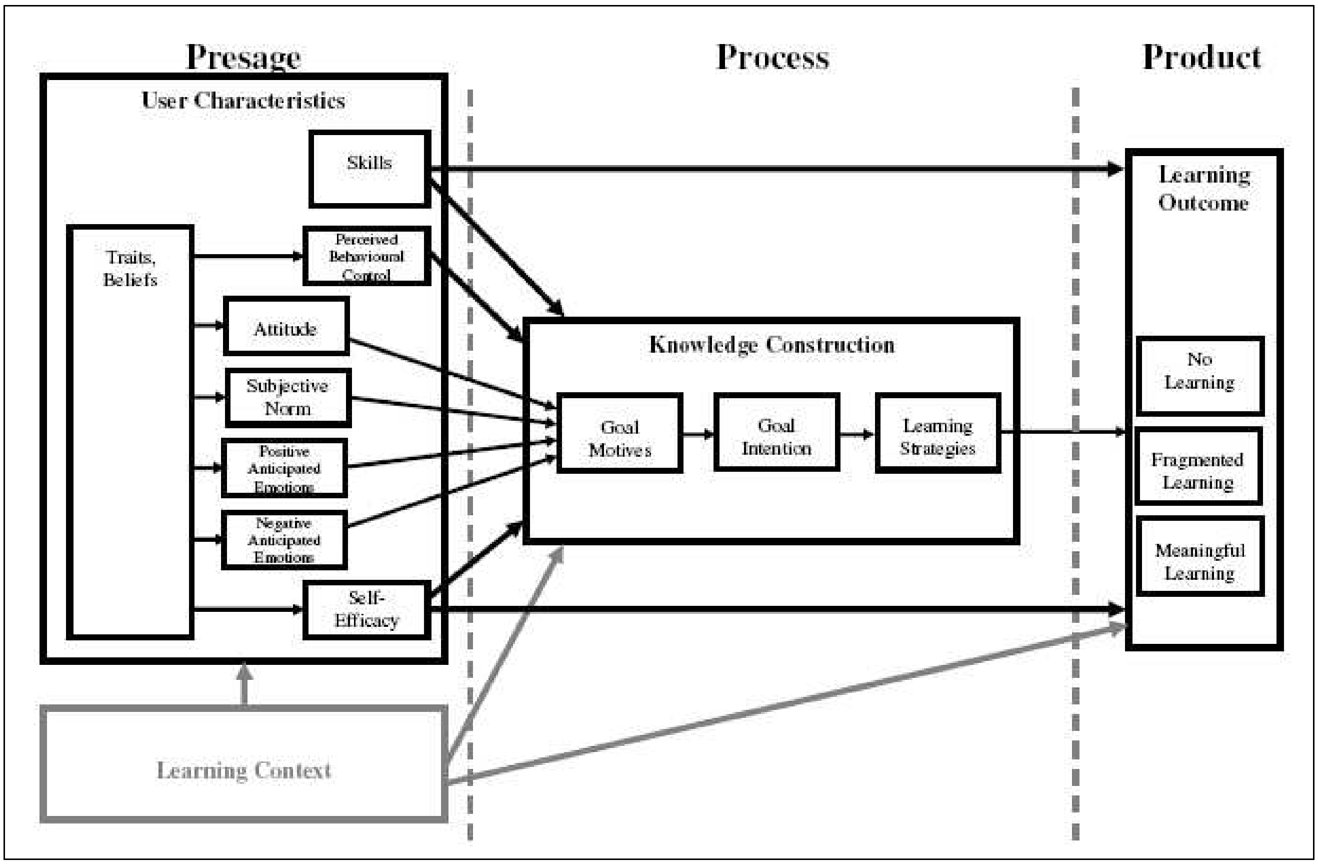

Figure 1. Three-Stage Framework of Process Model Understanding as Learning Process

Presage

The presage stage of the learning process describes what already exists prior to the process of attempting to understand a process model (Biggs 1987). *User characteristics* and a *learning context* can be identified at this stage. Before identifying different user characteristics, it needs to be acknowledged that the three stages of learning are interdependent. Users adapt to the learning task at hand and form some of their characteristics in anticipation of the learning process, e.g., self-confidence. Similarly, users are also influenced by the learning context which could be beneficial or detrimental to learning success, e.g. consider the effect of time pressure versus visual aids. Although the concept of context is therefore essential when conceptualizing the learning process, it is less relevant to this discussion strictly focusing on user characteristics. The effect of the learning context is therefore acknowledged in Figure 1, but will typically be absent from an application of the model in an empirical study.

Identifying user characteristics starts with the identification of clusters. By dissecting some of the most accepted frameworks in goal-setting and behavioral theory (Fishbein and Ajzen 1975; Ajzen 1991; Perugini and Bagozzi 2001), roughly four main clusters can be identified relevant to categorize user attributes. These clusters are: *latent* cluster, *intrinsic motivational* cluster, *extrinsic motivational* cluster, and *competence* cluster. The latent cluster (in-) directly affects the other three and mainly comprises constructs of personality, which are labeled traits and beliefs and are depicted on the left side of the presage stage in Figure 1. The other three clusters pertain to wanting, specified to both one's affection and one's perception of affection from the learning context depicted as the six attributes right next to traits and beliefs, and to capability, expressed in skills and depicted in the upper right corner of the presage stage. The most important characteristics in each of these four clusters are discussed in the next subsections.

Traits & Beliefs refer to the personality of the learner and the preconceptions that the learner brings to the learning process (Fishbein 2000). These attributes inherently shape the way users look at process models like looking through a tainted pair of goggles. The importance of these less mutable characteristics thus lies in the fact that they help explain differences in user perception, a concept that has enjoyed extensive attention in IS research throughout the years. Examples of the effect of traits and beliefs are culturally defined connotations of colors or icons used in process models and the effect of personality traits, such as openness and neuroticism, on exploring new modeling tools (McElroy et al. 2007).

Intrinsic motivational attributes represent the evaluation of potential outcomes of the learning process in terms of favorableness, emotions and confidence. As weighing possible gains against potential losses is an important aspect of decision making, affective attributes help explain a user's willingness to engage in process model learning and consecutive user-model interaction. *Attitude* refers to one's feelings towards learning from process models in terms of favorableness (Fishbein 2000). It therefore portraits intrinsic willingness to learn and relates to concepts such as anticipated acceptance and perceived value of the modeling formalism (Topi and Ramesh 2002). *Anticipated emotions* refer to the perceived emotional consequences of success or failure (Perugini and Conner 2000), i.e. the affective gains or losses. An example is anticipated dissatisfaction or frustration motivating a user to abstain from inspecting a process model that is perceived to be complex. *Self-efficacy* relates to confidence and entails an evaluation of the sufficiency of a user's capabilities. Having been related to both anxiety reduction (Compeau and Higgins 1995) and overconfidence (Wang and Chiew 2010), self-efficacy remains a very elusive yet potent construct. Based on these findings and in accordance with behavioral theory (Fishbein 2000), self-efficacy is attributed both an indirect and direct effect on learning outcome, as shown in Figure 1.

Extrinsic motivational attributes represent the user's perception of affection from the learning context in terms of social approval and external control. An example is that the information in process models may impact an organization in multiple ways, not only intentionally elaborating on processes but possibly also having unintended negative side-effects. When a process modeling initiative lacks perceived deliberation with some actors, negative sentiment amongst them might incline third party users to behave accordingly. *Subjective Norm* represents the perception of social appeal including both the perception of others' behavior as well as the perceived attitude of others towards one's own behavior. Desire to belong and fear of rejection are very basic emotions when choosing intended behavior, exemplified by a scenario in which widespread resistance to change causes change ready employees to be pressured into attaining a lower level of to-be model understanding. *Perceived Behavioral Control (PBC)* refers to the perception of the ability to utilize opportunities and resources in the environment. An example of PBC playing a role is a perceived high barrier to enrolling in BPM training sessions potentially resulting in inferior understanding of process models.

Skills express a user's proficiency in specific aspects of learning from process models and are regarded a result of experience which refers to the frequency with which the user has enacted process models in the past (Perugini and Conner 2000). Experience relates to mastery by being a measure of habit and leads to the development of *Knowledge* and *Abilities*. In accordance with process model quality literature (Lindland et al. 1994) the latter two can be divided into syntactic, semantic and pragmatic knowledge and abilities. Conjoined all the former attributes are theorized to be enablers of understanding process models as well as important dimensions in the concept of Expertise. The latter having been associated with decision making (Davis and Hufnagel 2007) and model understanding (Topi and Ramesh 2002). As such, skills consider a wide array of concepts and do not only determine a user's behavior in the learning process stage but also directly relate to the possible learning outcomes.

Process

The process stage of the learning model describes how knowledge is constructed to reach a learning outcome, i.e. how a user enacts a model to reach a desired level of understanding about the business processes depicted. In existing IS literature, a predominantly static view has been taken on the relation between user characteristics and understanding, implying absence of factors mediating or moderating the relation between the two and thereby diminishing the importance of the process stage. In line with Hungerford et al. (2004) this paper explicitly recognizes the role played by the processing method of learning employed in knowledge creation.

Existing process modeling literature that did elaborate on knowledge creation suggests application of cognitive metrics related to artifact complexity. Examples are chunking and tracing (Cardoso et al. 2006), based on the division between short- and long-term memory. Regardless of their accuracy, no empirical evidence yet exists, do such concepts fall short of providing an overview of the process stage. One of the earliest (and only) studies in the IS domain that does conceptualize a learning process is the one by Mandviwalla and Hovav (1998), applying Business Process Redesign to learning theory. In accordance with general learning theory (e.g., Locke 1991) they include motivation and activity in the process stage accompanied by a continuous loop of understanding and feedback or commitment. Building on this conceptualization, motivation, defined as motives and goals, and activity, defined as strategy, are included assuming that attaining a learning outcome implies commitment (Perugini and Conner 2000). These concepts are further elaborated on in the next subsections.

Motivation translates into Motives referring to reasons for movement and action (Eccles and Wigfield 2003). Motives thereby explain what compels a user to define a desired learning outcome in width and depth of knowledge. Motivation can therefore be compared to a frame of reference for task requirements because they guide the user in defining the type and complexity of the learning task. For example, compare a motive to learn all there is to learn about modeling to a motive to qualify according to the employer's demands. Because motives do not necessarily take feasibility into account, they are highly affective in nature.

Goals can be defined as "thoughts about desired (or undesired) states or outcomes that one would like to achieve (or avoid)" (Ford 1992). This implies anticipated states and outcomes can be compared to one another, equaling a goal to the outcome of an expectation-value analysis. In contrast to motivation, goals therefore introduce the concept of feasibility to the process stage and indicate a user's perception of the task requirements. An example is the role of opportunity costs when the goal to study a process model in depth is undone by high alternative workload or when the goal to stay away from a Business Process Redesign initiative is impeded by mandatory attendance (Kember et al. 2004). Because of this notion of feasibility, goals serve as a bridge between motivation and activity.

Strategy refers to attempting to adapt and change cognition by choosing and following up on a learning method (Pintrich 2004). It therefore comprises both method selection and method execution. The latter could be monitored by for example applying such methods as diagram reviewing (Hungerford et al. 2004) or chunking and tracing (Cardoso et al. 2006). Examples of method selection are choosing to translate the model into possible scenarios or choosing to learn the objects in the model by rote.

Product

In the product stage of our framework, we consider the outcome of the understanding process, viz., the learning outcome. We use the Cognitive Theory of Multimedia Learning (CTML) by Mayer (2001) to explain how individuals viewing explanative material (such as a process model) develop an understanding of the content being presented to them. We chose CTML for several reasons. First, it focuses on words and graphics, which in fact are elements in any process model (the graphical constructs and their textual labels). Second, it provides principles for the design of effective content presentations in the form of textual and/or graphical descriptions (i.e., a model) that can be tested empirically. Third, there is an established track record of experimental studies in conceptual modeling that has successfully used CTML to establish empirically observable differences in studies of process, object or data modeling (Gemino and Wand 2005; Masri et al. 2008).

CTML suggests three outcomes are possible when presenting explanative material in the form of models: (1) *no learning*, (2) *fragmented learning* and (3) *meaningful learning*. These outcomes are primarily based on measures of two variables that Mayer (2001) labels *retention* and *transfer*. Retention is defined as the comprehension of material being presented. Transfer is the ability to use knowledge gained from the material and apply it to problem-solving questions not directly answerable from the material at hand. For example, if presented with an explanation of how a car's braking system works, a retention question might be "What are the components of a braking system?", but a transfer question could be "What could be done to make brakes more reliable?" No learning occurs where retention and transfer are low. Fragmented learning occurs where retention is high but transfer is low. Such result indicates material has been received but has not been well integrated with prior knowledge. This suggests memorization rather than meaningful learning has occurred. Finally, meaningful learning occurs when both retention and transfer are high. High transfer scores indicate information has been integrated into long-term knowledge and a deep level of understanding of the presented material has been achieved. This means that the process model is both comprehended and can be acted upon, hence equaling model understanding.

One key objective of using process modeling, therefore, should be to enable meaningful learning about the depicted business domain, i.e., to be able to develop retention skills as well as transfer skills. Given that a process model is in its essence a graphical description of real-world business domains intended to be supported by an information system, meaningful learning should enable a viewer to *comprehend the business domain* that is depicted in the process model, and t*o reason faithfully and appropriately about associated problems*. And indeed, in process modeling practice, analysts are often required to firstly comprehend the model itself and retain the information it conveys about a process domain (retention), and to apply this knowledge in the generation of deeper understanding to solve process-related problems (transfer) such as case processing, exception handling or implementations of process changes. Table 1 illustrates the different outcomes of process model understanding.

Outcome	**Cognitive description**	**Performance**	
		Retention	**Transfer**
No learning about domain	No understanding of process	Poor	Poor
Fragmented learning about domain	Surface understanding of process, incorporated into working memory only	Good	Poor
Meaningful learning about domain	Deep understanding of process integrated into long-term memory and combined with existing knowledge	Good	Good

Table 1. Different understandability outcomes. Adapted from (Mayer 2001)

APPLICATION OF THE FRAMEWORK

To illustrate the usefulness of the framework, we now explain how it can be applied using an example case. Then, we identify existing studies on process modeling that can be complemented using our framework.

Turning to an illustrative application, based on our definition of model understandability as an emergent property, we can use the framework to assess user-model interaction and use its outcome as input for both non-functional process model improvement (Chung and Sampaio do Prado Leite 2009) and (future) user training. This procedure is illustrated by providing two scenarios where model understanding is low and our framework is used to make recommendations for improving model understandability:

- Users showed to dominantly experience high negative anticipated emotions, suggesting users associate the model with non-favorability. In this case, our framework suggests that an appropriate *secondary notation* (Schrepfer et al. 2009) should be used to create a more positive connotation and users should be deliberated with evaluating their learning process in terms of the positive and negative impressions associated with working with the model.
- Users showed to mainly use an intuitive learning style, suggesting users are so-called divergers. In this case, our framework suggests that *model abstraction* is required and users should be instructed using analogies, e.g., by means of worked examples (Bostrom et al. 1990) or appropriate metaphors (Hirschheim and Newman 1991).

Although lacking a formal inference procedure, the examples do indicatively illustrate two very different conclusions that can be drawn to improve the emergent understandability of process models, showing the utility of our framework.

Turning to an assessment of existing studies on process modeling, to illustrate the utility of the framework within the process modeling domain, we reviewed all articles published from 1999-2009 in the three journals typically listed as the “top journals” in the IS field (Information Systems Research, Journal of Management Information Systems, and MIS Quarterly) to identify opportunities for completion. We contend that other journals also publish process modeling research, yet, we argue that our journal sample provides a useful snapshot of the research that has been published in this area recently. We do not claim this sample to be representative of all process modeling research but instead merely suggest it to be an adequate sample to illustrate the application of our framework.

In the selected time frame, 1,082 articles were published in this sample of journals. Of these articles, we identified 18 candidate articles that focused on process modeling. We identified those papers through a full-text search for the keywords “process model”, “workflow model”, “process map” and “process diagram”, and carefully inspecting each result returned by the search engine. We eliminated papers that used the search terms for concepts irrelevant to this research (such as using the term “process model” to describe a longitudinal theoretical research model).

In doing our literature analysis, we carefully inspected each paper, to classify the reported use of process modeling into one or several stages of a process model lifecycle: Models are (1) created and can be (2) modified. As long they exist, the can be used for (3) interpretation (by humans), for (4) analysis (with quantitative techniques) or (5) enactment (by workflow technology). In principle, there are more use scenarios imaginable but they are not applicable for this sample. We expect that papers that deal with the interpretation of process models are most likely to benefit from our work. Next, for each paper we identified whether, and to what extent our framework could meaningfully extend or complement the reported work. Last, we provide a rationale and clarification of how such complementary work could be carried out. Table 2 gives the results from our analysis.

Paper	**Lifecycle Stage**	**Potential Contribution of Framework**
(Dennis et al. 1999)	Creation	yes
(Kakola and Koota 1999)	Interpretation	yes
(Davamanirajan et al. 2006)	Analysis	no
(Bieber et al. 2002)	Creation, Modification, Interpretation, Enactment	yes
(Zhao et al. 2001)	Enactment	no
(Kumar et al. 2002)	Enactment	no
(Sierhuis et al. 2003)	Analysis	yes
(Reijers et al. 2003)	Analysis	no
(Raghu et al. 2004)	Creation, Analysis	yes
(Krishnan et al. 2005)	Creation	no
(Wand and Weber 2002)	Creation, Interpretation	yes
(Basu and Blanning 2000)	Analysis	yes
(Basu and Kumar 2002)	Enactment	no
(Basu and Blanning 2003)	Modification, Analysis, Enactment	no
(Sun et al. 2006)	Enactment, Analysis	no
(van der Aalst and Kumar 2003)	Creation, Analysis, Enactment	no
(Sircar et al. 2001)	Creation	yes
(Broadbent and Weill 1999)	Modification	yes

Table 2. Results from Literature Analysis

Since it is not possible within the constraints of a conference paper to motivate the viability of our framework to be used for building on and extending the work in the analyzed papers, we will only consider two cases in more detail here.

The first of these is (Kakola and Koota 1999). Because of its emphasis on the interpretation stage of a process model's lifecycle, a connection with our proposed framework is to be expected. And indeed, the point of the paper is that by using IT systems – that build on process models of good practices – the practices themselves become invisible and cannot be reflected upon. Process models are therefore explicitly proposed to "become inseparable components of the agents' working and learning environment". Based on indirect evidence that similar formalisms can be easily understood, the authors propose a new formalism to capture valuable work practices, the so-called Knowledge Creation Nets. Our framework would provide a proper angle for an evaluation of the effectiveness of this formalism to support the learning objectives.

The second case we use is (Raghu et al. 2004). As can be seen from our classification of this paper in Table 2 its focus does not relate to the interpretation stage of process models. Rather, an agent-centric extension to activity-centric process modeling is proposed to capture economic incentives of agents to perform in processes. The extended approach is tested using a computational analytical simulation in which different incentives, information availability and resource allocation decisions are contrasted with performance (in a sales process). The key phenomenon of interest in this paper is the performance in the process under various incentive, decision and information conditions but not whether or not human actors can faithfully interpret the agent- and activity-centric process model. We would argue that our framework could meaningfully complement the work to investigate not only task performance but also process understanding. This would be of interest to the decision-makers associated with the process. Also, it would provide an interesting opportunity to study interaction effects between the new modeling approach, how people can learn from these models, and how such learning improvements produce better or worse task performance.

In summary, from the 18 papers we analyzed we see opportunities for 9 of these to make a meaningful connection with the framework that is proposed in this paper. For papers that emphasize the interpretation stage of the process model lifecycle this comes as no surprise. Yet, our analysis also points at opportunities to complement process modeling research work with a focus on the other stages. We consider this insight as a clear and hopeful indication for the usefulness of our work.

CONCLUSIONS AND OUTLOOK

In this paper, we outlined an integrative framework to understand the role of the user in the process of understanding process models. Our research has made a contribution to existing process modeling literature in the areas of process model quality and understandability. By proposing a framework to explain the *process* and the *product* of understanding, and by considering important user characteristics on model understanding performance, a user's perspective on understandability has been proposed. To date, user considerations have received considerably less attention in process modeling research compared to the prevalent model-centered perspective.

Furthermore, our framework offers an extended model of relevant user characteristics. Past endeavors taking a user-centered perspective have mostly researched a rather one-sided set of characteristics (e.g., modeling experience, or gender) and have mostly researched user characteristics in isolation, i.e. the impact of only one or two user characteristics were investigated, if any. By taking an integrative perspective, the relative impact of various characteristics can be determined. Not only will this expand the body of knowledge on the user-performance relation, it will also offer a way to synthesize process modeling research in search of a unified framework.

Moving forward, we have started data collection to empirically test some of the predictions offered by our theoretical framework through a cross-sectional survey research, which is traditionally a typical method for testing models in IS (Straub et al. 2004). The population of interest for this study includes analysts and designers with knowledge of process modeling. Due to the space constraints for conference papers, details of the empirical study are not reported in this paper but will be given in the paper presentation.

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