2005

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ABSTRACT

Human factors research in conceptual modeling is scarce. Recently, quality assurance frameworks, methods and tools for conceptual schemas have received increased research attention, but the perception of quality by schema users has largely been ignored in this stream of research. This paper proposes a tentative model of user beliefs and attitudes towards the quality of conceptual schemas. The proposed model is original in the sense that it includes both perceived semantic quality and perceived pragmatic quality measures. The paper also presents a new measurement instrument for the perceived semantic quality of conceptual schemas. This instrument was used in a classroom experiment that tested the proposed user beliefs and attitudes model. It was shown that the perceived semantic quality of a schema is directly related to its perceived usefulness and perceived ease of use and indirectly to the user satisfaction with the schema.

Keywords

Conceptual schema, quality evaluation, user perceptions, measurement model, structural model.

INTRODUCTION

Conceptual modeling (CM) plays an important role in (the success of) information systems development (ISD) projects. The goal of CM is to enhance the communication about the problem domain. The importance of high-quality conceptual schemas cannot be underestimated because they facilitate early detection and correction of errors in ISD projects.

Lindland, Sindre and Sølvberg (1994) presented a framework based on semiotics theory that helps understanding what quality means in the CM context. This framework suggests that a systematic evaluation of quality would consider a schema's syntax (how well does the schema adhere to the rules of the modeling language?), semantics (how well does the schema reflect the reality modeled?) and pragmatics (how well is the schema understood and used?).

Several measures and instruments have been proposed for evaluating schema pragmatics. For instance, when comparing alternative CM techniques or practices, resultant schemas have been compared with respect to how well they are understood by users. In experimental settings, measures used for comparison include comprehension task accuracy and completion time (Kim and March, 1995; Parsons, 2003; Siau, Wand and Benbasat, 1997). In addition, user perceptions of schema pragmatics have been measured with instruments for ease of use, usefulness and user information satisfaction (Burton-Jones and Weber, 1999; Gemino and Wand, 2005).

The semantic quality of a schema is more difficult to evaluate as it is hard (and some would argue even impossible) to know, externalize and agree upon reality. When evaluating semantic quality, we can only refer to our perception of reality, which is obtained through observing the 'real' focal domain of our modeling efforts. However, user perceptions of a conceptual schema's semantic quality have been less investigated than perceptions related to schema pragmatics. Most studies have quantified the degree of semantic quality with respect to some reference theory or modeling benchmark (Gemino and Wand, 2003), as a substitute for the 'real' domain. These studies ignore the user beliefs of how well the schema helps understanding the underlying reality. Even if a generally agreed modeling benchmark could be established, it is still the user's perception of semantic quality, rather than a theoretically verified quality, that will largely determine whether benefits result from using a high-quality conceptual schema during the ISD project. Therefore an empirical approach that recognizes possible differences in user perceptions is needed to complement more theoretically-oriented evaluation studies.

The goal of the paper is to propose and test a model of user beliefs and attitudes towards the use of a conceptual schema. The theoretical basis for this model is the Theory of Reasoned Action (TRA) (Fishbein and Ajzen, 1975). Via this model we investigate whether the user perception of semantic quality is related to perceptions of ease of use and usefulness, as well as to the general attitude towards the use of a conceptual schema as expressed by the user's satisfaction with the schema. Previous research has suggested that higher perceived semantic quality may result in benefits such as higher user satisfaction and increased usage (Dunn and Grabski, 2000), but has not empirically demonstrated these effects. If a model can be established that demonstrates such benefits, then measuring perceived semantic quality becomes even more

important, as such measurements could feed the quality assurance and improvement process.

RESEARCH MODEL

TRA has been, and continues to be, one of the most influential theories in social psychology. It has been applied and proven successful to explain and predict people's behavior in several domains, among which the MIS discipline. The Technology Acceptance Model (TAM) (Davis, Bagozzi and Warshaw, 1989), which explains why users accept or reject an information technology, was based on TRA. The intention to use an information technology was hypothesized and empirically proven to be a function of two pervasive beliefs: perceived ease of use and perceived usefulness. Perceived ease of use (PEOU) is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p.320). Perceived usefulness (PU) is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p.320). Moody (2002) further adapted the TAM for evaluating ISD methods. The resulting model, called Method Adoption Model (MAM), recognizes that for a method to be adopted in practice, users perceptions of efficiency (i.e., ease of use) and effectiveness (i.e., usefulness) of the method play an important role.

When formulating our CM quality perspective in terms of TRA, the concept about which beliefs and attitudes are formed is the use of a conceptual schema. The extent to which users intend to use a schema (*behavioral intention*) is affected, amongst others, by the users' assessment of how well the schema serves its stated purpose (*attitude towards behavior*). If this purpose is to develop a common and agreed upon understanding of the problem domain, then users will evaluate the quality of the schema with respect to this purpose (*beliefs and evaluations*). They will perceive the semantic quality of the schema (how valid and complete is it with respect to the problem domain, as perceived?) and its pragmatic quality (how well do they understand what is modeled and how easy is it to acquire this understanding?). These perceptions can be influenced by *external variables* like a particular task they have accomplished using the schema, their experience and familiarity with the modeling language used, etc.

Similar to the TRA-based evaluation models TAM and MAM, we propose a user beliefs and attitudes model for CM in which external stimuli like interacting with a conceptual schema influence behavior indirectly through changes in a person's beliefs and attitudes. As in the TAM and MAM, the perceived ease of use (PEOU) and perceived usefulness (PU) constructs are used to capture a person's beliefs about the use of a conceptual schema. We further propose that a general attitude towards the use of a conceptual schema is measured in terms of how satisfied users are with the schema with respect to its purpose. To this end the User Information Satisfaction (UIS) construct is introduced.

Apart from perceiving the pragmatics of a conceptual schema, users also form a perception of its semantic quality. It is plausible that this perception affects the user perception of ease of use and usefulness. If users believe that the schema is invalid and/or incorrect with respect to the problem domain, they are likely to develop a less favorable perception of the ease of use and usefulness of the schema. Of course, user perceptions of ease of use and usefulness may be affected by other factors than perceived semantic quality. What we wish to investigate is the extent to which perceived semantic quality affects these variables.

As a first and tentative model (Figure 1), we hypothesize that perceived semantic quality (PSQ) has a direct impact on PEOU and PU, and that it indirectly impacts UIS. The hypothesized relationship between PEOU and PU is taken from the TAM and MAM.

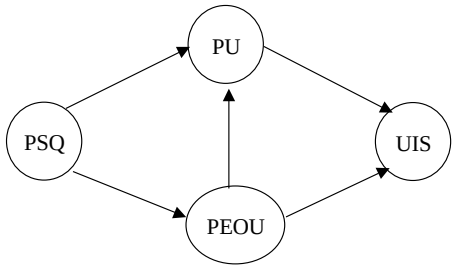


Figure 1. Research Model

METHOD

To test the research model, a measure is needed for each construct. For measuring PEOU, PU and UIS, Burton-Jones and Weber (1999), Dunn and Grabski (2001), Gemino and Wand (2005), and Moody (2002) have proposed multi-item instruments for use in a CM context (Table 1). These proposals are based on the original measures for these constructs, as in (Davis, 1989; Seddon and Yip, 1992), and their reliability and validity has been repeatedly demonstrated. Conversely, research on the perception of a schema's semantic quality is rare. Dunn and Grabski (2000) present an experiment investigating the perceived semantic quality of conceptual schemas of accounting systems. Perceived semantic quality was measured using a single-item measurement instrument. However, no details on the measure's reliability and validity are presented. Therefore, a multi-item instrument for measuring PSQ had to be developed before the research model could be tested.

Item	Statement/Question
PEOU1	It was easy for me to understand what the conceptual schema was trying to model.
PEOU2	Using the conceptual schema was often frustrating.
PEOU3	Overall, the conceptual schema was easy to use.
PEOU4	Learning how to read the conceptual schema was easy.
PU1	Overall, I think the conceptual schema would be an improvement to a textual description of the business process.
PU2	Overall, I found the conceptual schema useful for understanding the process modeled.
PU3	Overall, I think the conceptual schema improves my performance when understanding the process modeled.
UIS1	How adequately do you believe the conceptual schema meets the information needs that you were asked to support?
UIS2	How efficient is the conceptual schema for providing the information you needed?
UIS3	How effective is the conceptual schema for providing the information you needed?
UIS4	Overall how satisfied are you with the conceptual schema for providing the information you needed?

Table 1. PEOU, PU and UIS Measurement Items

To develop a PSQ measure we started by examining the literature related to quality in CM to discern relevant items to consider for our instrument. The following step was to pre-test the initial measurement instrument to assess its reliability and validity. The pre-test made it possible to purify the measurement instrument and to enhance its psychometric properties. The item generation and refinement steps in the measure development process are presented in (Poels, Maes, Gailly and Paemeleire, 2005). The items of the resulting PSQ measurement instrument are shown in Table 2.

To test the research model, a classroom experiment was conducted. The participants were 211 business students enrolled in a MIS course. As part of this course they were introduced to and trained in the use of CM techniques, in particular entity-relationship (ER) modeling. In the experiment, participants received an ER diagram of an example business process. The experimental materials further included a domain description for the diagram and a series of comprehension questions that assessed their understanding of the process, as modeled in the diagram. The main purpose of the questions was for the participants to get an understanding of the diagram and see possible shortcomings by comparing it with the domain description. After completing the comprehension task, participants received a questionnaire with the PSQ, PEOU, PU, and UIS items.

Item	Statement
PSQ1	The conceptual schema represents the business process correctly.
PSQ2	The conceptual schema is a realistic representation of the business process.
PSQ3	The conceptual schema contains contradicting elements.
PSQ4	The conceptual schema contains redundant elements.
PSQ5	Elements must be added to faithfully represent the business process.
PSQ6	All the elements in the conceptual schema are relevant for the representation of the business process.
PSQ7	The conceptual schema gives a complete representation of the business process.

Table 2. PSQ measurement items

RESULTS

Partial Least Squares (PLS) was chosen as the statistical analysis method for this study. A two-step approach in evaluating PLS models was followed. First, the measurement model is evaluated in order to assess the validity and reliability of the used measurement instruments. Afterwards, the structural model of relationships between the constructs is tested.

Measurement Model

The measurement model consists of the relationships between the constructs and the observed items used to measure them. The adequacy of the measurement model is assessed by examining the individual-item reliabilities and evaluating the convergent and discriminant validity of the measures.

Individual-item reliabilities were assessed by examining the factor loadings of the items on their respective constructs. Only items with factor loadings of at least 0.50 were considered significant and were retained in the measurement model. This led to the removal of three items (PSQ3, PSQ4, PSQ5 with respective loadings of 0.458, 0.337 and 0.340). All other items demonstrate a good level of reliability. The measurement model after excluding PSQ3, PSQ4 and PSQ5 is presented in Table 3.

The convergent validity of the different constructs was examined by computing the composite reliabilities (ICR). In this study the composite reliability of every construct in the final measurement model was higher than 0.7, the suggested value for measures to be deemed reliable (see Table 3).

Item	Loading	ICR	AVE
PSQ1	0.753	0.789	0.492
PSQ2	0.866		
PSQ6	0.582		
PSQ7	0.559		
PEOU1	0.802	0.834	0.560
PEOU2	0.688		
PEOU3	0.845		
PEOU4	0.639		
PU1	0.750	0.866	0.684
PU2	0.879		
PU3	0.847		
UIS1	0.721	0.894	0.679
UIS2	0.820		
UIS3	0.872		
UIS4	0.872		

Table 3. Assessment of the Measurement Model

Another indication of convergent validity was made by investigating the average variance extracted of the constructs (AVE). AVE is the average variance shared between a construct and its items. AVE should be higher than 0.5, meaning that at least 50 percent of measurement variance is captured by the construct. The AVE of all the constructs in the final measurement model was above 0.5 except for PSQ (0.49) (see Table 3). This might indicate a problem of convergent validity of the PSQ measure but on the other hand the individual-item reliabilities and ICR were indicative of acceptable convergent validity.

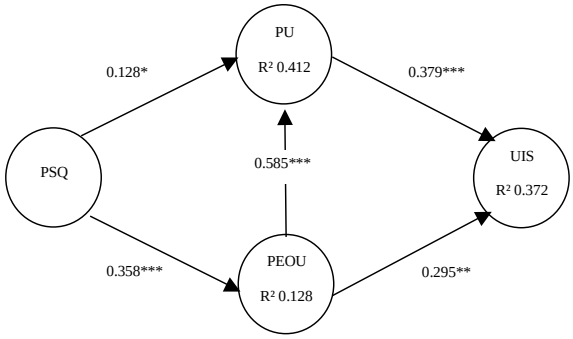
	PEOU	PSQ	UIS	PU
PEOU	0.748			
PSQ	0.358	0.701		
UIS	0.534	0.493	0.824	
PU	0.631	0.338	0.565	0.827

Table 4. Discriminant Validity

Discriminant validity was examined by analyzing cross-loadings. A cross-loading check indicated that all items loaded higher on the construct they were supposed to measure than on any other construct. Further, the AVE was also used for discriminant validity assessment. This test compares the correlation between any two constructs with the root-squared AVE of these two constructs. The test requires that the correlation be smaller than the average of the two root-squared AVEs, meaning that the variance shared between any two constructs is less than the AVE by the constructs. The results of this discriminant validity analysis are displayed in Table 4. Diagonal elements, which should be larger than any other corresponding row or column element, show the square root of the AVE, whereas the off-diagonal elements show the construct correlations. In this study, there was no correlation between any two latent constructs larger than or even equal to the square root AVE of these two constructs. Consequently, discriminant validity was supported and confidence was gained that all constructs in the model were indeed measuring different concepts.

Structural Model

The structural model was tested to assess the hypothesized relationships in the proposed research model. Variance explained (R^2) and the sign and significance of path coefficients are used to evaluate the structural model. A bootstrapping method with 100 resamples was used to assess the statistical significance of the path estimates. Figure 2 presents the structural path diagram. All of the paths tested were statistically significant.



* indicates significant paths: ***P< 0.001 ** P < 0.01 *P < 0.05

Figure 2. Structural Model

The results indicate that PSQ had a significant direct effect on PEOU ($\beta = 0.36$, $p<0.001$) and that this single exogenous variable accounted for 13% of the variance in PEOU. We also found support for the relation between PSQ and PU ($\beta = 0.13$, $p<0.05$) although the direct effect of PSQ on PU was smaller and less significant than with PEOU. More important in explaining PU seems PEOU since there was a highly significant and strong effect of PEOU on PU ($\beta = 0.59$, $p<0.001$). Together PSQ and PEOU explained 41% of the variance in PU. Finally, the direct effects of PEOU on UIS ($\beta = 0.30$, $p<0.01$) and PU on UIS ($\beta = 0.38$, $p<0.001$) were confirmed. These two variables were able to explain 38% of the variance in UIS.

CONCLUSIONS

Applying the ideas of TRA, TAM and MAM in a CM context we proposed a user beliefs and attitudes model that incorporates semantic and pragmatic quality constructs. We demonstrated relationships between the following variables of schema pragmatics: ease of use is related to usefulness, and both these variables are related to user information satisfaction. Furthermore, we demonstrated relationships between perceived semantic

quality on the one hand and perceived usefulness and ease of use on the other hand.

We call our model 'tentative' as the research ideas and results presented are preliminary. First, a better theoretical basis for the model must be found as our tentative model fits only partially with the TAM and MAM. In particular, the replacement of the intention to use construct by a user satisfaction construct is not supported by TRA. We are currently investigating alternative theoretical bases for our model, drawing from the IS success and user satisfaction literature.

Second, although the hypothesized relationships in the proposed model were validated, the interpretation of the results should be treated with care. It is possible that the relation between perceived semantic quality and the other variables is reciprocal. In other words, perceptions of ease of use and usefulness may perhaps also change a user's perception of the semantic quality of the schema. Further research is required to explore the relationship between these different types of quality further. Clearly, a better theoretical basis is needed to guide this research.

We also realize that further research is necessary to improve our perceived semantic quality measure. Our study employed students as participants, small-scale business process schemas (in ER diagram format) as study objects, and had a relatively simple task to be performed. Future research might take the form of field studies where the robustness of the measure is tested with respect to the population of conceptual schema users.

Further research might also include other variables of interest (like theoretically established notions of semantic quality, performance-based variables of user comprehension and other model-usage factors). This should eventually contribute to the establishment of a comprehensive model for the assessment of the overall quality of conceptual schemas.

ACKNOWLEDGMENTS

We thank the anonymous reviewers of the HCI/MIS 2005 Workshop for their useful comments and suggestions.

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