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WORKING PAPER

Measuring User Beliefs and Attitudes towards Conceptual Models: A Factor and Structural Equation Model

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Abstract

This paper presents a tentative model of user beliefs and attitudes towards conceptual models applying the ideas of Theory of Reasoned Action (Fishbein and Ajzen, 1975) in a conceptual modeling context. We focus on users perceptions of conceptual model quality and investigate the relations between perceived semantic quality and perceived pragmatic quality measures. Given the growing awareness among researchers and practitioners about the importance of high-quality conceptual modeling, it is surprisingly that there are no formal measures to assess the perceived semantic quality of conceptual schemas. Therefore we address this need and present a robust and validated multi-item measurement instrument to evaluate the perceived semantic quality of conceptual schemas. We followed a rigorous empirical development process to ensure the validity and reliability of the proposed measurement instrument. Once this was accomplished, it was possible to empirically test the proposed user beliefs and attitudes model. The conducted experiment confirmed the proposed relations of the user beliefs and attitudes model. It was shown that perceived semantic quality had a direct effect on beliefs as perceived usefulness and perceived ease of use and also indirectly affects the attitudes of conceptual model users.

1. Introduction

Conceptual modeling (CM) plays an important role in (the success of) information systems development projects. The goal of CM is to enhance communication about the problem domain in order to get a common understanding of it (Gemino and Wand, 2003). The importance of high-quality conceptual models cannot be underestimated because they facilitate early detection and correction of errors in information systems development projects. Empirical studies show that more than half of the errors which occur during system development are due to requirements errors (Martin, 1989; Lauesen and Vinter, 2000; Enders and Rombach, 2003). Assuring the quality of conceptual models is therefore a necessary and worthwhile step for ensuring the quality of the final system. However, generally agreed formal/practical measures/methods for evaluating the quality of conceptual models still have to be developed (Moody, 2005). The current study addresses this need for reliable and valid measurement instruments to evaluate the quality of conceptual models. Furthermore, we also investigate the relations between different types of conceptual model quality by constructing and testing a model of users beliefs and attitudes towards the use of conceptual models.

Several frameworks for evaluating quality in CM have been proposed. Lindland et al.'s (1994) proposal articulates a systematic framework to help understanding what quality means in the CM context. Previous attempts merely resulted in lists of unstructured, imprecise and often overlapping quality properties (Moody and Shanks, 2003). Although alternative frameworks have been developed after Lindland et al.'s proposal (e.g., Kesh (1995), Schütte and Rotthowe (1998), Moody and Shanks (2003)), the Lindland et al. framework is the only one that has both a theoretical basis and empirical validation (see Moody et al. (2002; 2003)).

The theoretical basis for Lindland et al.'s framework is grounded in linguistics. According to Lindland et al. (1994) "modeling is essentially making statements in some language" (p. 42). Figure 1 depicts the main elements of the framework:

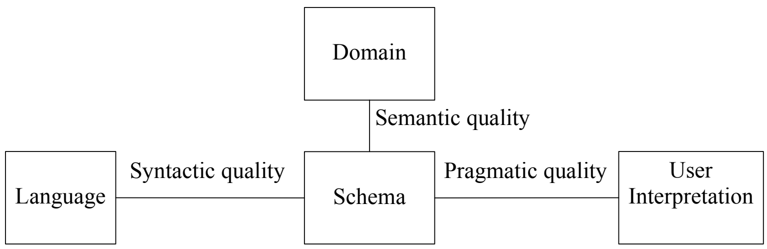


Figure 1: Lindland et al.'s (1994) framework for quality in conceptual modeling

The framework elements shown are:

- Language: all the statements that are allowed according to the syntax of the modeling language(s) used;
- Domain: all possible statements that would be relevant and correct for describing the problem domain;
- Schema: the set of statements actually made;
- User interpretation: the set of statements that schema users think the schema contains.

The framework distinguishes three types of model quality based on the correspondence between different sets of statements: Syntactic quality describes how well the schema follows the rules of the modeling language(s). Semantic quality describes how well the schema corresponds to the problem domain. Finally, pragmatic quality captures how well the schema is understood by its users.

The framework suggests that a systematic evaluation of quality would consider syntax, semantics and pragmatics. Recent survey research has shown that in practice, syntactic quality issues in CM seem to be well controlled (Poels et al., 2003). Therefore, the main evaluation effort would be directed towards semantic and pragmatic quality.

Several measures and instruments have been proposed for evaluating pragmatic quality or other schema features related to their use. Especially when comparing alternative conceptual modeling techniques or practices, resultant schemas have been compared with respect to how well users perform on comprehension tasks. Pragmatic quality measures used include task completion time (as an efficiency measure) and task accuracy (as an effectiveness measure) (Kim and March, 1995; Siau et al., 1997; Bodart et al., 2001; Burton-Jones and Weber, 2003; Parsons, 2003). Apart from performance-based measures, also user perceptions have been measured using 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, however, hard if not impossible to evaluate as it is impossible to know all statements that are relevant and correct for describing the problem domain (i.e., the real world). When evaluating semantic quality, we can only refer to our knowledge of the problem domain, which is obtained through observing the 'real' problem domain. Which filter is put upon reality by our observations possibly depends on many factors such as previously acquired domain knowledge and perceptual psychology effects. Krogstie et al. (1995) therefore extended the framework with a fourth quality type, namely perceived semantic quality, which is described as the correspondence between the set of statements that users think the schema contains and the set of statements that users think the schema should contain, based upon their knowledge of the problem domain (i.e., the Domain Knowledge element in Figure 2). Hence, perceived semantic quality can serve as an operational surrogate of semantic quality that should be easier to assess.

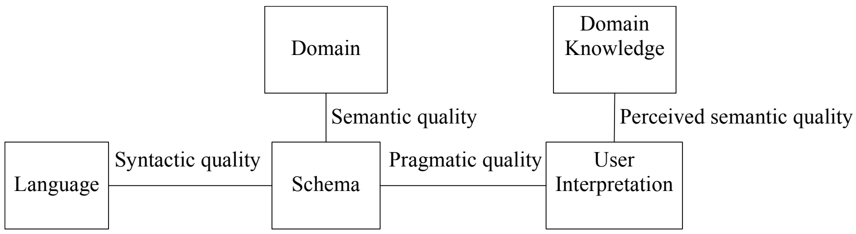


Figure 2: The Lindland/Krogstie (1995) extended framework for quality in conceptual modeling

Nevertheless, user perceptions of semantic quality have been less investigated than perceptions related to schema pragmatics. Dunn and Grabski (2000) conducted an experiment investigating the perceived semantic quality (which they called 'perceived semantic expressiveness') of conceptual schemas of accounting systems.[2] It was shown that business students have a more favorable perception of semantic quality when the conceptual schema is based on the Resource-Event-Agent accounting data model (McCarthy, 1982) than on the classic Debit-Credit-Account model. Other studies have quantified the degree of semantic quality with respect to a reference theory (as a substitute for problem domain knowledge). Examples include studies employing as evaluation instruments ontological analysis (Shanks et al., 2003), meta-model analysis (Halpin, 2004), and comparison against reference models (Patig, 2004). These approaches ignore the user beliefs of how well the schema helps understanding the underlying reality. It is our position that, even if a generally agreed reference theory 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 will result from using high-quality models during systems development. Therefore an empirical approach that recognizes possible differences in user perceptions is needed to complement more theoretically-oriented evaluation studies.

Dunn and Grabski (2000) measured perceived semantic quality using a single-item measurement instrument. In general, the use of a multi-item instrument is preferred because of its ability to diminish measurement error resulting from the specificity of individual items (Churchill, 1979). A first goal of this paper is therefore to present the development of a new

[2] Other terms used for perceived semantic quality include perceived semantic expressiveness (Dunn and Grabski, 2000), representation fidelity (Parsons and Cole, 2003), representation faithfulness (Wand and Weber, 2002) and semantic representativeness (Debreceny and Bowen, 2004).

multi-item measurement instrument for perceived semantic quality. Given the call of Topi and Ramesh (2002) to focus more on human factors in CM research and the lack of instruments to measure user perceptions of semantic quality, CM researchers urgently need such a measure. Once a valid and reliable instrument is obtained, the perceived semantic quality of schemas resulting from the use of alternative conceptual modeling techniques can be measured and compared.

A second goal of the paper is to propose and test a model of user beliefs and attitudes towards the use of conceptual schemas. 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 having a good perceived semantic quality measure is even more important, as it could be used for the quality assurance and improvement of conceptual schemas.

The next section of this paper presents the development of a user beliefs and attitudes model for use in the CM context. The initial model proposed in that section acts as the research framework for the rest of the paper. In section three we describe the methodology followed to develop a perceived semantic quality measure. We also present the design of an experiment that aimed at validating the measure as well as validating the initially proposed model. The data analysis is presented in a fourth section. Finally, in section five, the paper concludes by discussing the results of the experiments, identifying lessons learned and outlining future research.

2. Research framework

A theoretical basis for developing a user beliefs and attitudes model with respect to quality of conceptual schemas can be found in Fishbein and Ajzen's (1975) theory of reasoned action (TRA) (Figure 3). TRA suggests that a person's behavior is determined by behavioral intention which, in turn, is influenced by a person's attitude. A person's attitude towards a concept can be defined as "a person's general feeling of favorableness or unfavorableness for the concept" (Fishbein and Ajzen, 1975, p.6). An attitude can thus be seen as a person's overall evaluation of the concept under study. According to the TRA, external stimuli will influence a person's attitude indirectly by influencing his or her salient beliefs about performing a specific behavior.

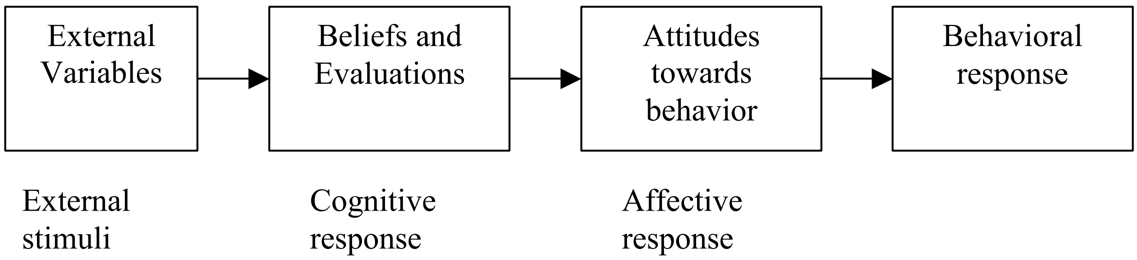


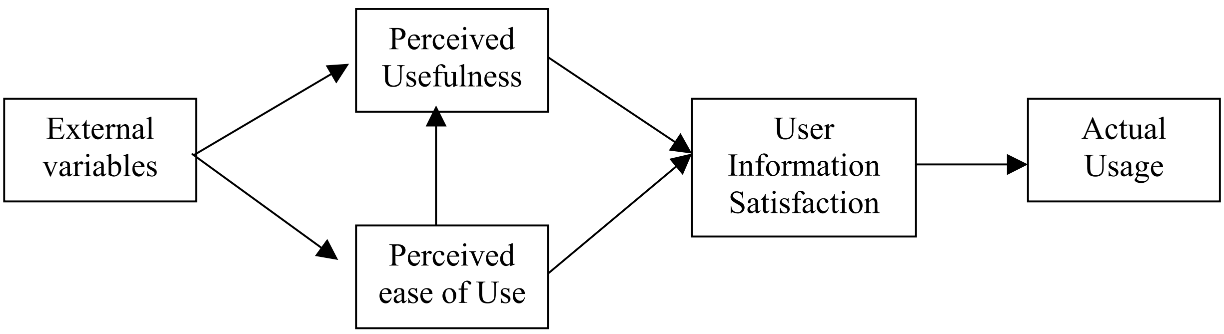
Figure 3: Theory of Reasoned Action (Fishbein & Ajzen, 1975)

When applying TRA to CM, the concept about which beliefs and attitudes are formed is the use of a conceptual schema. The extent to which a schema will be used for its purpose (*behavioral response*) is affected by the users' assessment of how well the schema serves its stated purpose (*attitudes 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 w.r.t. this purpose (*beliefs and evaluations*). They will perceive the semantic quality of the schema (i.e. how valid and complete is it with respect to the problem domain, as perceived?) as well as its pragmatic quality (i.e. 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 (other) modeling languages, etc.

Although related, there is a distinction between attitudes and beliefs which is important for the development of our model. Beliefs are sets of information-based ideas, regardless of whether that information is accurate or inaccurate. Belief does not necessarily include an evaluation, although it may. It represents the cognitive response of the believer to the presented external stimuli (Petty & Cacioppo, 1981). Hence, beliefs can be described as "thinking of things" while attitudes represent the feeling or affective responses to the external stimuli.

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 IS discipline. The Technology Acceptance Model (TAM) developed by Davis (1986) to explain why users accept or reject information technology was based on TRA. The intention to use an information technology, which determines whether one will actually use the technology, was hypothesized and empirically proven to be a function of two beliefs: perceived ease of use and perceived usefulness. Furthermore ease of use also indirectly affects attitude/usage through its effect on 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 (2001) further adapted the TAM for evaluating IS design methods. The resulting model, called Method Evaluation Model (MEM), recognizes that for a method to be adopted in practice, users perceptions of efficiency and effectiveness of the method play an important role. Moody (2001; p.126) even suggests that the actual efficiency and effectiveness of using a method are only “second order determinants of people’s intentions to use a particular method”.

Applying the ideas expressed in TRA and the TRA-based evaluation models TAM (for information technologies in general) and MEM (for IS design methods in particular), we propose a user beliefs and attitudes model for CM as shown in Figure 4. This model proposes that external stimuli like interacting with a conceptual schema only influence behavior indirectly through changes in a person’s beliefs (PU and PEOU) and attitudes. Comparing with the TAM and MEM the Intention To Use construct was replaced by the User Information Satisfaction (UIS) construct. The intention to use a schema is perhaps less relevant than it is for IS design methods or information technologies in general, which are meant to be repeatedly used for different applications. A general attitude towards the use of a conceptual schema can be measured in terms of how satisfied users are with the schema with respect to its purpose. This attitude construct is consistent with the original definition of the general affective response to external stimuli as in the TRA.



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.[3] Of course, user perceptions of ease of use and usefulness may be affected by other factors than perceived semantic quality (e.g. the aesthetic value of a conceptual schema as determined by diagram layout (Wand and Weber, 2002)). What we wish to investigate is the extent to which perceived semantic quality affects these variables.

As a first and tentative model (Figure 5), we hypothesize that perceived semantic quality has a direct impact on PEOU and PU, and that it indirectly impacts UIS. The relationships between PEOU, PU, and UIS are based on the MEM and TAM (replacing ITU with UIS).

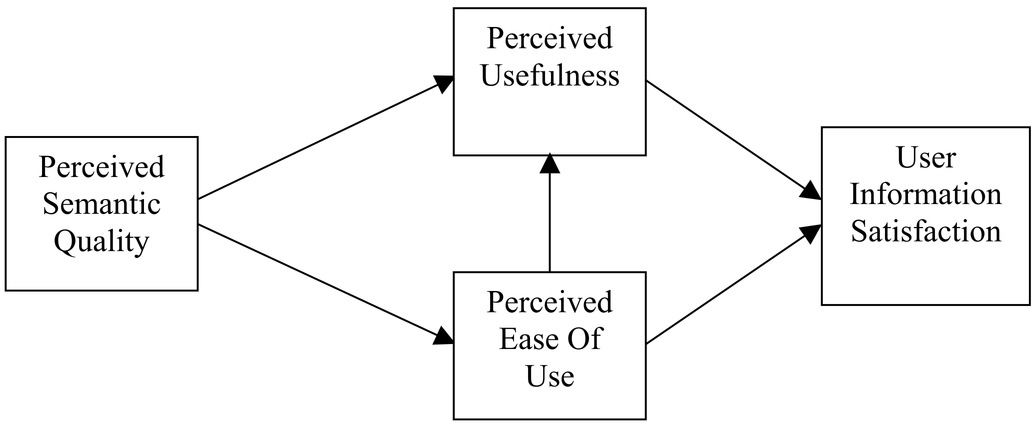


Figure 5: Proposed research model

3. PSQ measure development

In this section we present the development of our PSQ measure. The general methodological steps followed in measure development are illustrated in Figure 6.

We started by examining the literature related to quality in CM to discern relevant items to consider for our instrument. The result of this item generation step is presented in subsection 3.1. The following step was to pre-test the initial measurement instrument in a small sample to assess its reliability and validity. The pre-test made it possible to refine the measurement instrument. The design of this pre-test and the analysis of the obtained data as well as the subsequent refinement of the measure are presented in subsection 3.2. The final step in the measure development process was a confirmatory factor analysis (CFA). The design of this

[3] This is true even when the actual semantic quality of the schema is assured. When two conceptual schemas A and B are informationally equivalent, external variables such as differences in the user's familiarity with the modeling languages used, might still cause differences in perceived semantic quality. As noted before, beliefs can be based on inaccurate information.

confirmatory analysis is described in subsection 3.3. The analysis and results of the CFA will be discussed in the next section.

Item Generation

Step 1 – Literature Review and Scale Creation

- Examine literature for existing scales
- Assess applicability of existing scales and revise if appropriate
- Develop new items as necessary based on conceptual definition/ theoretical framework

Item Refinement

Step 2 – Pre-Test

- Test scale and items using convenience sample
- Calculate reliability and validity scores and modify scales as necessary
- Purify measurement instrument

Confirmatory Analysis

Step 3 – Confirmatory Factor Analysis (CFA)

- Perform CFA on initial measurement model using representative sample
- Examine overall fit and inspect item-level fit for multi- dimensionality
- Assess reliability and validity of measurement model
- Remove "problem" indicators, if any from measurement model

Figure 6: Methodological steps in the measure development process
(based on Froehle and Roth (2004))

3.1. Item generation

Prior to developing measurements items for a PSQ measure, we searched the literature for existing scales. We identified only one measure, used in the previously mentioned experiment of Dunn and Grabski (2000), consisting of a single 7-point Likert scale with the following assertion: "The documentation I received provided me with a realistic representation of the accounting information flows of the business" (p. 83). Dunn and Grabski do not explain how they created and validated their PSQ measure, nor do they mention any problems encountered with their measurement instrument. However, compared to a single-item instrument such as used by Dunn and Grabski, "the goal of the multi-item approach is to reduce any extraneous effects of individual items, allowing idiosyncrasies to be cancelled out by other items in order to yield a more pure indicant of the conceptual variable" (Davis, 1989, p. 324). In this context, it can be questioned whether Dunn and Grabski's formulation 'realistic representation' has been identically understood by all study participants and whether it captures all facets of semantic quality.

The item used by Dunn and Grabski is a useful starting point. To propose additional measurement items we used a number of well-known quality properties for conceptual schemas that were mapped by Lindland et al (1994) onto their semantic quality construct, based on a literature survey. Table 1 shows the quality properties considered, their definition (taken from Lindland et al. (1994)), and the corresponding item statement in our proposed PSQ instrument. The wording of the item statements was adapted to the pre-test where the instrument was applied to two entity-relationship representations of the same business process (see section 3.2). The style of the item statements was varied in order to avoid monotonous responses.

Table 1: Items of the initially proposed PSQ instrument

Item name	Quality property	Definition	Item statement
Correct	Correctness	All statements in the schema are *correct* and relevant to the problem domain	The conceptual schema represents the business process correctly
Relevant	Correctness	All statements in the schema are correct and *relevant* to the problem domain	The conceptual schema shows only relevant entities, relationships and structural constraints
Complete	Completeness	The schema contains all statements about the problem domain that are correct and relevant	The conceptual schema gives a complete representation of the business process
Adequate	Completeness	The schema contains all statements about the problem domain that are correct and relevant	Entities, relationships or structural constraints must be added to adequately represent the business process
Minimal	Minimality	The schema does not contain statements that overconstrain the problem domain	None of the entities, relationships and structural constraints in the conceptual schema can be removed
Consistent	Consistency	The schema does not contain contradictory statements	The conceptual schema contains inconsistencies
Realistic	*Single-item measurement instrument for perceived semantic expressiveness of Dunn and Grabski (2000)*		The conceptual schema is not a realistic representation of the business process

The correctness property was split into two items as it also incorporates the notion of relevance. The dual concept of correctness is completeness, which is equally important in determining the correspondence between schema and problem domain. Hence, we decided to create also two items for the completeness property (i.e., the 'complete' and 'adequate' items).

The property of minimality is subsumed by correctness (Lindland et al., 1994). As it might be a sub-dimension of correctness, we decided to retain it in the measurement instrument, but create only one item for it. Lindland et al. further show that the property of consistency is subsumed by both correctness and completeness. As it is, however, one of the most common quality properties and it is recommended to have an overinclusive item pool when developing new measurement instruments (Loevinger, 1957), we decided to create also a separate item for this property.

Finally, the 'realistic' item was the one used by Dunn and Grabski (2000) in their single-item measurement instrument, though we adapted the wording of the item statement in order to use it in the pre-test. The realism property seems to capture the essence of semantic quality, meaning a good fit between schema and problem domain. It surely incorporates the notion of correctness, as a schema with incorrect or irrelevant statements would not be considered 'realistic'. But if a schema is not complete, then it can hardly be seen as 'realistic' either, so completeness is also a facet of realism. As it is common to include in a measurement instrument an "overall" (Davis, 1989, p. 325) item for the construct, we decided to retain Dunn and Grabski's 'realistic' item.

We reckoned that these seven items cover more or less the content domain of our construct. Although they are not the result of an exhaustive and systematic review of the literature, their explicit linkage with the linguistic-based frameworks for understanding quality with respect to conceptual schemas provides reasonable assurance that our PSQ measure has content validity.

It is interesting to note that a set of four quality properties for conceptual schemas that Shanks et al. (2003) recently derived from the Bunge-Wand-Weber ontology-based representation model, representing different kinds of ontological deficiencies, confirms the quality properties underlying our PSQ measurement instrument. In Table 2 we show how we map the schema properties that Shanks et al. (2003) require for having a faithful representation of a domain onto the four quality properties that we used to generate items.

Table 2: Quality properties related to (perceived) semantic expressiveness

Shanks et al. (2003)		Quality properties underlying our PSQ measurement instrument
Accuracy	The schema should accurately represent the semantics of the problem domain as perceived by the focal stakeholders.	Correctness
Completeness	The schema should completely represent the semantics of the problem domain as perceived by the focal stakeholders.	Completeness
Conflict-free	The semantics represented in different parts of the schema should not contradict one another.	Consistency
No-redundancy	The schema should not contain redundant semantics.	Minimality

3.2. Item Refinement

Once our initial set of items for the PSQ instrument was specified, we conducted a pre-test, employing a convenience sample of 42 graduate business students who participated in a controlled experiment. The experiment required participants to comprehend a number of business process models (in entity-relationship diagram format) for an example commercial company. After completing their tasks, participants received a questionnaire which included the PSQ items. For each item statement a 7-point Likert scale with response options ranging from 'strongly disagree' to 'strongly agree' was offered.

This questionnaire also contained the items of two other perception-based measures (for PEOU and UIS). It is important to include marker variables or concepts to which the construct under study (PSQ) is expected to relate and from which it must be differentiated (Clark and Watson, 1995). Since all items in the questionnaire capture user perceptions of the schema, we wished to verify whether the PSQ items measure another construct than what is measured by the PEOU and UIS items. If it is hypothesized that PSQ has an impact on UIS and PEOU, then it is essential to have different measures for these constructs.

PEOU was measured using five 7-point Likert items adapted from Davis (1989). The item statements used are shown in Table 3. The measurement instrument for user information satisfaction (UIS) was adapted from Seddon and Yip (1992). The four items of this measure were stated as questions that required an answer on a 7-point Likert scale. The item questions and their anchor points are listed in Table 4. Both measures have been used before for the evaluation of conceptual schemas (see e.g. Burton-Jones and Weber, 1999; Dunn and Grabski, 2001; Gemino and Wand, 2005).

Table 3: Items of the PEOU instrument

Item code	Item statement
PEOU_1	I found the conceptual schema cumbersome (confusing) to use
PEOU_2	Using the conceptual schema required a lot of mental effort
PEOU_3	The conceptual schema was clear and understandable to me
PEOU_4	Overall, I found the conceptual schema easy to use
PEOU_5	Using the conceptual schema was frustrating

Table 4: Items of the UIS instrument

Item code	Item question	Anchor 1	Anchor 7
UIS_1	How adequately do you believe the conceptual schema meets the information needs that you were asked to support?	Adequate	inadequate
UIS_2	How efficient is the conceptual schema for providing the information you needed?	Efficient	inefficient
UIS_3	How effective is the conceptual schema for providing the information you needed?	Effective	ineffective
UIS_4	Overall how satisfied are you with the conceptual schema for providing the information you needed?	Dissatisfied	satisfied

Given the small sample size in this pre-test an inter-item correlation analysis was used to assess the validity of the PSQ measurement instrument. The "relevant" item did not survive the Campbell- Fiske test [4] for validity and thereby will need refinement. Other possible validity problems were indicated for the minimal and consistent items, that showed some significant correlations with items intended to measure the PEOU and UIS constructs. The reliability of the PSQ measure was assessed using Cronbach's alpha. The reliability of the initial instrument (with seven items) was only 0.71, which is barely above the value of 0.70 that is usually required for measurement instruments to be deemed reliable (Nunally, 1978). The removal of the 'relevant' or the "consistent" item did not increase reliability, while cutting the 'minimal' item led to an increase in reliability (to 0.74).

These findings motivated us to revise and refine the initial measurement instrument to further enhance its validity and reliability. The 'problematic' items were rewritten taken into account the definitions of the four quality properties for conceptual schemas of Shanks et al. (2003). In the 'consistent' item statement "inconsistencies" was replaced by "no

[4] Campbell and Fiske (1959) state that an item is considered valid when its convergent validity is higher than its lack of discriminant validity, meaning that the item is more closely associated with the other items of the measure it belongs to, than with the items of other measures.

contradictions". The "minimal" item was reformulated in line with the no-redundancy property defined by Shanks et al. (2003). Other minor changes were made to the "relevant" and "adequate" items. Furthermore, all items were refined using more general item statements to increase the external validity of our measurement instrument. The item statements as they were initially formulated assume the entity-relationship model as the representation format. We believe that our instrument can be used in any study on the quality of conceptual models. The item statements of the refined PSQ measurement instrument as well as the underlying quality properties are shown in table 5.

Table 5: Items of refined PSQ instrument

Item name	Quality property	Definition	Item statement
Correct (PSQ 1)	Correctness	All statements in the representation are *correct* and relevant to the Problem	The conceptual schema represents the business process correctly
Relevant (PSQ 6)	Correctness	All statements in the representation are correct and *relevant* to the Problem	All the elements in the conceptual schema are **relevant** for the representation of the business process
Complete (PSQ 7)	Completeness	The representation contains all statements about the domain that are correct and relevant	The conceptual schema gives a complete representation of the business process
Adequate (PSQ 5)	Completeness	The representation contains all statements about the domain that are correct and relevant	Elements must be added to **faithfully** represent the business process
Minimal (PSQ 4)	Minimality	The representation does not contain statements that overconstrain the Domain	The conceptual schema contains **redundant** elements.
Consistent (PSQ 3)	Consistency	The representation does not contain contradictory statements	The conceptual schema contains **contradicting** elements
Realistic (PSQ 2)	*Single-item measurement instrument for perceived semantic expressiveness of Dunn and Grabski (2000)*		The conceptual schema is a realistic representation of the business process

3.3. Confirmatory analysis

The final step in our systematic approach toward pre-testing, refining and validating our PSQ measure was a confirmatory analysis. The objective of this confirmative phase was to retest the reliability and validity of the refined PSQ measure using a different and larger set of participants. Using a larger sample will result in a more precise and stable factor solution and will allow us to reach a certain level of statistical power and increase the accuracy of our findings.

The design of the experiment conducted for this confirmatory analysis was similar to that of the pre-test. The experimental participants were 211 business students enrolled in an IS course. As part of this course they were introduced to and trained in the use of conceptual modeling techniques. In the experiment, participants received again an entity-relationship schema of an example business process and had to answer a number of questions assessing their understanding of this process (based on the information conveyed by the schema). Two distinct representations of a same business process were used in the experiment, representing a spread in SQ (high-low). The schema of inferior SQ had some shortcomings as opposed to the schema of high SQ with respect to the SQ properties (e.g. incompleteness, incorrectness, irrelevancy, redundancy, inconsistency).

The two schemas were equally distributed amongst the participants; each participant thus received a single schema. The experimental objects further included the same domain description for the two schemas and some comprehension questions that had to be answered. These questions comprise cardinality knowledge questions, validation questions and information retrieval questions, meaning that to answer the questions interaction between model comprehension and previously acquired knowledge was necessary. The main purpose of the questions was for the participants to get an understanding of the schema and see possible shortcomings.

After completing the comprehension task, participants received the questionnaire which included the refined PSQ items and also the items of the perception-based variables PEOU, UIS, and PU. The measure for UIS was the same as used in the pre-test. The PEOU measure was slightly adapted using the statements of the perceived ease of interpretation instrument of Gemino and Wand (2005). Contrary to the pre-test, we also included a measure for PU based on Moody's (2001) PU measure for the MEM. The item statements used can be found in table 6. For each item statement a 7-point Likert scale with response options ranging from 'strongly disagree' to 'strongly agree' was offered.

Table 6: Items of the PU instrument

Item code	Item statement
PU_1	Overall, I think the conceptual schema would be an improvement to a textual description of the business process of X..
PU_2	Overall, I found the conceptual schema useful for understanding the processes modeled.
PU_3	Overall, I think the conceptual schema improves my performance when understanding the processes modeled.

4. Results confirmatory analysis

Partial Least Squares (PLS) was chosen as the statistical analysis method for this study.[5] PLS allows testing the psychometric properties of the instruments used to measure a unobservable variable (i.e. measurement model), as well as estimating hypothesized structural models of relationships among multiple model variables (Chin, 1998). Although PLS estimates both factor loadings and structural paths simultaneously we follow a two-step approach (Anderson and Gerbing, 1988; Hulland, 1999) in evaluating PLS models. 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. The program used for these analyses was SmartPLS version 1.01 developed by the Institute of Operations Management and Organization of the University of Hamburg (Germany).

4.1 Measurement model:

The measurement model consists of the relationships between the constructs (PSQ, PEOU, PU, UIS) 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.

First, individual item reliabilities were assessed by examining the factor loadings of all items on their respective constructs. Following the recommendation of Hair et al. (1987) only items with factor loadings of at least 0.50 are considered very significant and were retained in our final measurement model. This lead to the removal of three items from the initial

[5] The sample size for a PLS study should be equal to the larger of the following: 1) ten times the scale with the largest number of formative indicators or (2) 10 times the largest number of structural paths directed at particular construct in the structural model (Chin, 1998). These conditions are satisfied in our study since we received 187 usable questionnaires in the confirmatory experiment.

measurement instrument due to low loadings (PSQ3, PSQ4, PSQ5 with respective loadings of 0.458, 0.337 and 0.340). Two of these items namely “consistent” (PSQ3) and “minimal” (PSQ4) were also problematic in the pre-test and as such do not seem to measure PSQ. Interestingly, the three items that have to be removed are the negatively keyed items from our PSQ measurement instrument. Although it is generally recommended to include both standard (positive) and reversed-scored (negative) items to control for response biases, research has shown the presence of item wording effects on the obtained factor structures (Schriesheim and Eisenbach, 1995). This finding questions the relevance of reversing the wording of some items of the PSQ measurement instrument and should be investigated further in future research. All other items demonstrate a good level of reliability. The results of the final measurement model after excluding PSQ3, PSQ4 and PSQ5 are presented in Table 7.

Next, the convergent validity of the different constructs was examined by computing the composite reliabilities (ICR), using the internal consistency measure developed by Fornell and Larcker (1981) which is similar to Cronbach’s alpha. In this study composite reliability of every construct in the final measurement model was higher than 0.7, the suggested value by Fornell and Larcker (1981) for measures to be deemed reliable (see also Table 7).

Table 7: assessment of construct measures (measurement model)

Variable / Items	Final loading	Composite reliability	Average Variance extracted
PSQ1	0.753	0.789	0.492
PSQ2	0.866		
PSQ3r			
PSQ4r			
PSQ5r			
PSQ6	0.582		
PSQ7	0.559		
PEOU1	0.802	0.834	0.560
PEOU2r	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
UIS2r	0.820		
UIS3	0.872		
UIS4	0.872		

Note: r indicates items that were reversed coded.

In addition to item loadings and ICR, another indication of convergent validity was made by investigating the average extracted variances of the constructs (AVE). AVE is the average variance shared between a construct and its items. Fornell and Larcker (1981) stated that 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 were above 0.5 except for PSQ (0.49) (Table 7). It is true that 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.

Finally, to complete the psychometric assessment of our final measurement model discriminant validity was examined by means of analyzing cross-loadings and average variance extracted (AVE). Discriminant validity refers to the extent to which items of a given construct differ from measures of other constructs in the same model. A cross-loading check indicated that all items loaded higher on the construct they were supposed to measure than on any other construct. Second, besides the cross-loading check, the AVE was used for discriminant validity assessment as suggested by Fornell and Larcker (1981). 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 8. Diagonal elements, which should be larger than any other corresponding row or column elements, 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. Most of the correlations were far below the square root of AVEs. Consequently, discriminant validity was supported and confidence was gained that all constructs in the model were indeed measuring different concepts.

Table 8: discriminant validity of constructs (correlation matrix and square roots of AVE)

	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

Hence, after passing all these assessments, the strength of the used measurement instruments was proven as all measurement instruments achieved acceptable levels of reliability and validity. Now that confidence was gained with respect to the measurement model, we could turn our attention to the evaluation and interpretation of the structural model.

4.2 Structural model

The structural model was tested to assess the hypothesized relationships in the proposed research model (see Figure 5). 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 asses the statistical significance of the path estimates. Figure 7 presents the structural path diagram with the path coefficients indicating the direct effect on the endogenous[6] constructs and the total variance explained in the endogenous constructs. An examination of these results reveals that the variance explained in the endogenous constructs (PEOU, PU and UIS) ranges from 0.13 to 0.41 and that all of the paths were statistically at least significant at the 0.05 level.

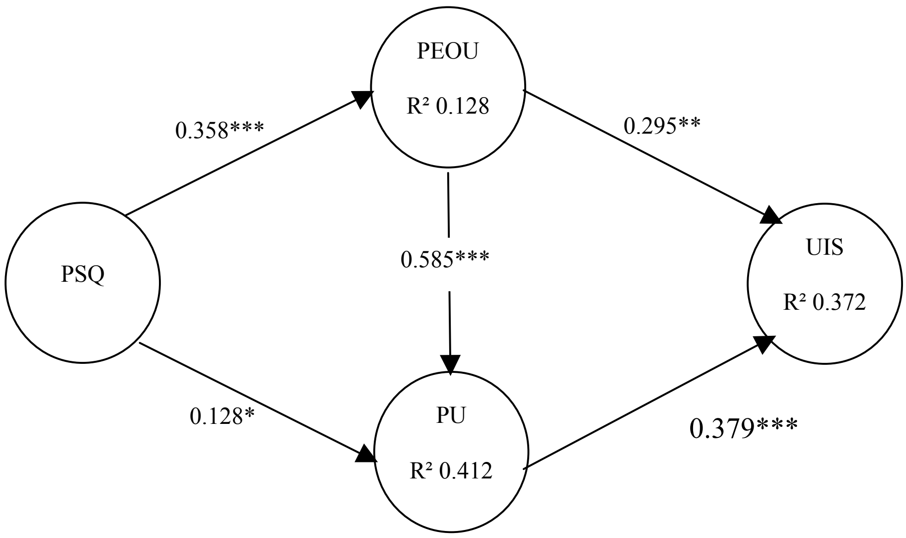


Figure 7: Results research model
* indicates significant paths : ***P< 0.001 ** P < 0.01 *P < 0.05

The results indicate that PSQ, as was hypothesized, had a significant direct effect on PEOU ($\beta = 0.36$, $p<0.001$) and this single exogenous variable accounted for 13% of the variance of PEOU. We also found support for the relation between PSQ and PU ($\beta = 0.13$, $p<0.05$) although the direct effect of PSQ was smaller and less significant than with PEOU. More importantly in explaining PU seems PEOU since there was a highly significant and strong

[6] Variables that only exert an "effect" on other variables are called exogenous variables, while those that receive an "effect" from others are called endogenous variables (Chin, 1998).

effect of PEOU on PU ($\beta = 0.59$, $p<0.001$). Together PSQ and PEOU explained 41% of the variance of the PU variable. Finally, we could as in previous research also confirm the direct effects of PEOU on UIS ($\beta = 0.30$, $p<0.01$) and of PU on UIS ($\beta = 0.38$, $p<0.001$) which were more or less of equal importance. These two variables were able to explain 38% of the variance of the UIS variable.

5. Discussion and conclusions

Given the importance of conceptual modeling in IS development projects, there is a growing research interest in the quality of conceptual modeling. However, formal measures to assess the quality of conceptual schemas are lacking. This paper addresses the need for psychometrically sound measurement instruments that researchers and practitioners can use with confidence when evaluating the perceived semantic quality of conceptual schemas. We focus on semantic quality because of its importance and the limited attention devoted to it in previous empirical research.

Following a rigorously defined systematic process, we developed a reliable and valid measurement instrument for assessing the perceived semantic quality (PSQ) of conceptual schemas. The presented measure is the first validated multi-item measurement for measuring PSQ. The measure is theoretically grounded on the Lindland et al. (1994) framework for evaluating the quality of conceptual schemas. Based on a pre-test and a confirmatory analysis of the measurement model, the final instrument containing four items ("correct", "relevant", "complete" and "realistic") seems to capture the content domain of semantic quality. Interestingly, the first three items represent the core dimensions in the definition of semantic quality as defined by Lindland et al. (1994). The 'realistic' item assesses an overall impression of a schema's semantic quality. The other three items ("consistent", "minimal" and "adequate") in our original measurement instrument were stated to be subsumed by these core dimensions and the result of our confirmatory analysis confirms this. Therefore, these item statements were removed from the final instrument.

Although evidence was gained about the reliability and validity of our PSQ measure, further research is necessary to establish the external validity of our PSQ measure. Both the pre-test and confirmatory study were class-room experiments employing students as participants, small-scale business process models (in entity-relationship format) as study objects, and relatively simple tasks to be performed. Future research might take the form of field studies where the PSQ measure is tested in a different setting.

The development of our PSQ measurement instrument has some important theoretical and practical contributions. Having a PSQ measure will allow to evaluate and compare the semantic expressiveness of alternative models (via the schemes they produce), as perceived by their users. The measure can also serve in studies on the mechanisms that lead to increased perceptions of semantic quality as well as any benefits that result. Such studies will provide insight in how to develop even better models and how to instantiate the models such that users will profit most from the advantages of using a semantically expressive model. The PSQ measure can also be used as a quality assurance instrument to assess user perceptions of alternative candidate conceptual schemas and to identify areas of satisfaction/dissatisfaction.

Another benefit of having a suitable instrument to assess perceived semantic quality is the possibility of investigating the relationships between different quality types of conceptual schemas. As a second research objective this study proposed and tested a structural equation model examining the relationships between semantic and pragmatic quality. Applying the ideas of TRA in a conceptual modeling context we proposed a tentative user beliefs and attitudes model in which PSQ is incorporated. We demonstrated that perceived ease of use is related to perceived usefulness, and that both these variables are related to user information satisfaction. Furthermore, we showed an impact of perceived semantic quality on perceived usefulness and perceived ease of use.

Although the hypothesized relationships in the proposed model were validated, the interpretation of the results obtained should be treated with care. It is possible that the relation between PSQ and perceptions related to the pragmatics of schema use (PEOU and PU) 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 presented schema. Further research is required to explore the relationship between these different types of quality further. Future research might also include other variables of interest (like 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.

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