Decision Support Systems 46 (2009) 562–575

Contents lists available at ScienceDirect

Decision Support Systems

journal homepage: www.elsevier.com/locate/dss

Communication flow orientation in business process modeling and its effect on redesign success: Results from a field study

Ned Kock [a,*], Jacques Verville [b,1], Azim Danesh-Pajou [c,2], Dorrie DeLuca [d,3]

[a] A.R. Sanchez Jr. School of Business, Texas A&M International University, 5201 University Boulevard, Laredo, TX, 78041, USA
[b] Faculty of Management, University of British Columbia – Okanagan, 3333 University Blvd, Kelowna, BC, Canada V1V 1V7
[c] John L. Grove College of Business, Shippensburg University, Grove Hall 237, Shippensburg, PA, 17257, USA
[d] College of Business, University of South Florida – Sarasota, 8350 N. Tamiami Trail C221, Sarasota, FL, 34243, USA

ARTICLE INFO

Article history:
Received 26 February 2008
Received in revised form 2 October 2008
Accepted 19 October 2008
Available online 31 October 2008

Keywords:
Business process modeling
Communication flow optimization
Business process redesign
Factor analysis
Structural equation modeling
Partial least squares
Data triangulation

ABSTRACT

Business process redesign has been intensely studied, particularly since the mid 1990s. One aspect that received little attention, however, is the relationship between business process modeling choices and redesign success. This research gap is addressed through a multi-methods study of 18 business process redesign projects conducted in 18 different organizations. A structural equation model is developed and tested based on data collected from those projects; the results are then triangulated with qualitative data. The structural equation model depicts relationships between the following broad perceptual constructs: communication flow orientation of a business process model, quality of a business process model, and business process redesign success. The communication flow orientation of a business process model is defined as the extent to which a model explicitly shows how communication interactions take place in a process. A model's perceived quality is defined as the degree to which the model presents the following perceptual sub-constructs: ease of generation, ease of understanding, completeness, and accuracy. The results of the study suggest that the degree of communication flow orientation of a business process model is significantly related to the model's perceived quality. Perceived model quality, in turn, is significantly related to perceived business process redesign success. Interestingly, a business process model's perceived completeness does not seem to be influenced by a model's communication flow orientation. The structural equation model accounted for 56% of the explained variance in the business process redesign success construct. The main implication of this study is that a focus on communication flows in business processes is an important ingredient in successful business process redesign projects.

1. Introduction

Business processes are sequences of interrelated activities that are carried out routinely in organizations. The tasks of preparing a cheeseburger at a fast-food restaurant, manufacturing a car part, and organizing a conference are all conducted through pre-defined business processes. Business process redesign involves analyzing one or more business processes, usually employing a modeling approach, and proposing changes in the processes. Those changes are then implemented, often with the use of information and communication technologies. If the changes lead to actual gains in quality and productivity that offset the costs of the changes, then the business process redesign project can be considered successful. If the changes do not lead to gains, then the redesign project is likely to be considered unsuccessful.

Many research efforts have been targeted at the understanding of business process redesign, particularly since the mid 1990s. During this time, a great deal of progress has been made in the clarification of the nature of business process redesign, and of how it can be successfully conducted in organizations. Problematic misconceptions about business process redesign have been revealed and discussed [19], and success factors associated with business process redesign initiatives have been identified [1,3,13,56].

The support role that information and communication technologies play in business process redesign ventures has been elucidated [20,21,58]. New approaches to assess business process redesign success have been proposed and validated [7,16]. Related change management techniques have been developed and tested [36,55]. Innovative automated tools to support business process redesign projects have been put forth [44], and new business process implementation approaches have been conceived [26].

In spite of the progress outlined above, there are still pending issues that remain to be understood. Research on certain topics often

* Corresponding author. Tel.: +1 956 326 2521; fax: +1 956 326 2494.
E-mail addresses: nedkock@tamiu.edu (N. Kock), Jacques.verville@ubc.ca (J. Verville), danesh@ship.edu (A. Danesh-Pajou), ddeluca@sar.usf.edu (D. DeLuca).
[1] Tel.: +1 250 807 9637.
[2] Tel.: +1 717 477 1674.
[3] Tel.: +1 941 359 4523.

0167-9236/$ – see front matter
doi:10.1016/j.dss.2008.10.002

follows particular directions, and leave gaps that prevent a full understanding of the topics [40,41]. This can be true even with a widely targeted topic such as business process redesign. One arguable gap that exemplifies this is in how business process modeling choices affect redesign success [33,38]. This is an important area of research because modeling decisions are likely to influence how business processes are looked at, and thus those decisions are also likely to influence what elements are targeted for redesign.

Competitive advantage may hinge on a choice of modeling contained in a business process management suite currently emerging in the marketplace [31]. Our study sheds light on the need for such an emerging standard where people, systems, information, and implementation are integrated for continuous incremental improvement efforts. Decisions regarding business modeling are ever more perplexing with a current marketplace of over 150 vendors; it is predicted that there will be significant churning of the market with only about 25 vendors surviving the next few years [31].

The above gap is addressed here through a study of 18 business process redesign groups, each having conducted a business process redesign project in a different organization. All organizations were located in Northeastern U.S. The study looks into whether a particular business process modeling orientation, namely an orientation that places emphasis on communication flow modeling, has any perceived impact on business process redesign success when compared with a "control" orientation. The control orientation places emphasis on activity flow modeling, and is assumed to present a significantly lower degree of communication flow orientation.

2. Research background and hypotheses

Models are somewhat similar to metaphors [34] in that they provide cognitive lenses through which many actual entities and situations are viewed. Business process models, like data models, present different levels of abstraction and emphasis on elements of what they are representing [10]. While data models represent the data organization structure of information systems, business process models represent the sets of interrelated activities that are usually automated using information systems. In this sense, business process models can be seen as instances of cognitive mapping tools [53].

The use of appropriate cognitive mapping tools has been shown to overcome cognitive and behavioral biases in information systems design and use (see, e.g., [54]). There is also evidence, although more limited, that this can also be the case in business process redesign. For example, it has been shown that the degree of communication flow orientation of business process models can help process redesign practitioners identify key problems in information-intensive processes [15]. It has been argued that business process models with a low degree of communication flow orientation cause a cognitive bias by "hiding" inefficiencies in the flow of information in business processes [38]. This can arguably be particularly problematic in modern information-intensive organizations.

The communication flow orientation of a business process model can be defined as the degree to which the model explicitly shows how communication interactions (e.g., conversations, form flows, memo exchanges) take place in a business process [38]. This includes both optimal and suboptimal communication exchanges. Examples of suboptimal communication exchanges are duplicated and redundant exchanges, as in a form that causes different workers to enter essentially the same information twice (e.g., someone's age and date of birth). The quality of a business process model is the degree to which the following attributes are present in the model: ease of generation, ease of understanding, completeness, and accuracy [15]. Table 1 summarizes these two key construct definitions, as well as that of business process redesign success, which is argued in this paper to be influenced by those key constructs.

Table 1
Communication flow orientation and quality of a business process model

Construct	Definition
Communication flow orientation of a business process model	The degree to which a model explicitly shows how communication interactions take place in a business process.
Quality of a business process model	The degree to which the model presents the following perceptual attributes: ease of generation, ease of understanding, completeness, and accuracy.
Business process redesign success	The degree to which the results of a business process redesign project is perceived to lead to an actual improvement of the targeted business process.

Note: A fundamental assumption tested through this study is that the communication flow orientation of a business process model positively affects its quality, which in turn positively affects the success of a business process redesign effort using the business process model in question.

Kock and Murphy [39] were arguably the first to study the relationship between the communication flow orientation and quality of business process models (see also [38]). Other studies have been conducted in the general area of requirements engineering [4] that address related topics. These include studies looking into how different approaches to requirements engineering lead to different degrees of information technology-enabled business process implementation success [5,14].

The main focus of requirements engineering research has been on the identification of elements that are used in information systems implementation, as opposed to business process redesign. Requirements engineering findings can be used for predictions associated with business process redesign. However, that should be done with some caution, and complemented with empirical findings of modeling research targeting business process redesign. This is a call for research that this study aims to address.

The action research study discussed by Kock and Murphy [39] was conducted at a defense contractor in the U.S. It arguably provides convincing empirical evidence that actual business process redesign groups perceive process models focusing on communication flow elements as being of higher quality than those focusing on activity flow elements. The specific models used by the participants in Kock and Murphy's [39] study built on two types of business process diagrams. The evidence in connection with business process redesign success provided by that study is not as convincing; one of the problems is that the study focuses on one single business process redesign project.

One of the types of diagrams used in Kock and Murphy's [39] study is the functional flowchart, a standard activity flow representation of business processes discussed in detail by Harrington [29] (see also [30]). The other type of diagram is the communication flow diagram, which is an adaptation of the standard data flow diagram (see, e.g., [22]) where communication flow inefficiencies are explicitly represented.

Fig. 1 shows examples of these two types of diagrams, together with basic diagramming symbols used. An example of communication flow inefficiency would be a synchronous information exchange, at business process execution time, between two individuals who participate in the execution of a business process. The representation of such a synchronous information exchange would violate standard data flow diagramming rules, but would be allowed in communication flow diagrams (for a more detailed discussion, see [38]).

Models focusing on communication and activity flow elements can be seen as representative of modeling approaches that are at different ends of a spectrum of communication flow orientation. At the core of these modeling approaches are diagrams. Modeling approaches also incorporate assumptions, guidelines and criteria that are different

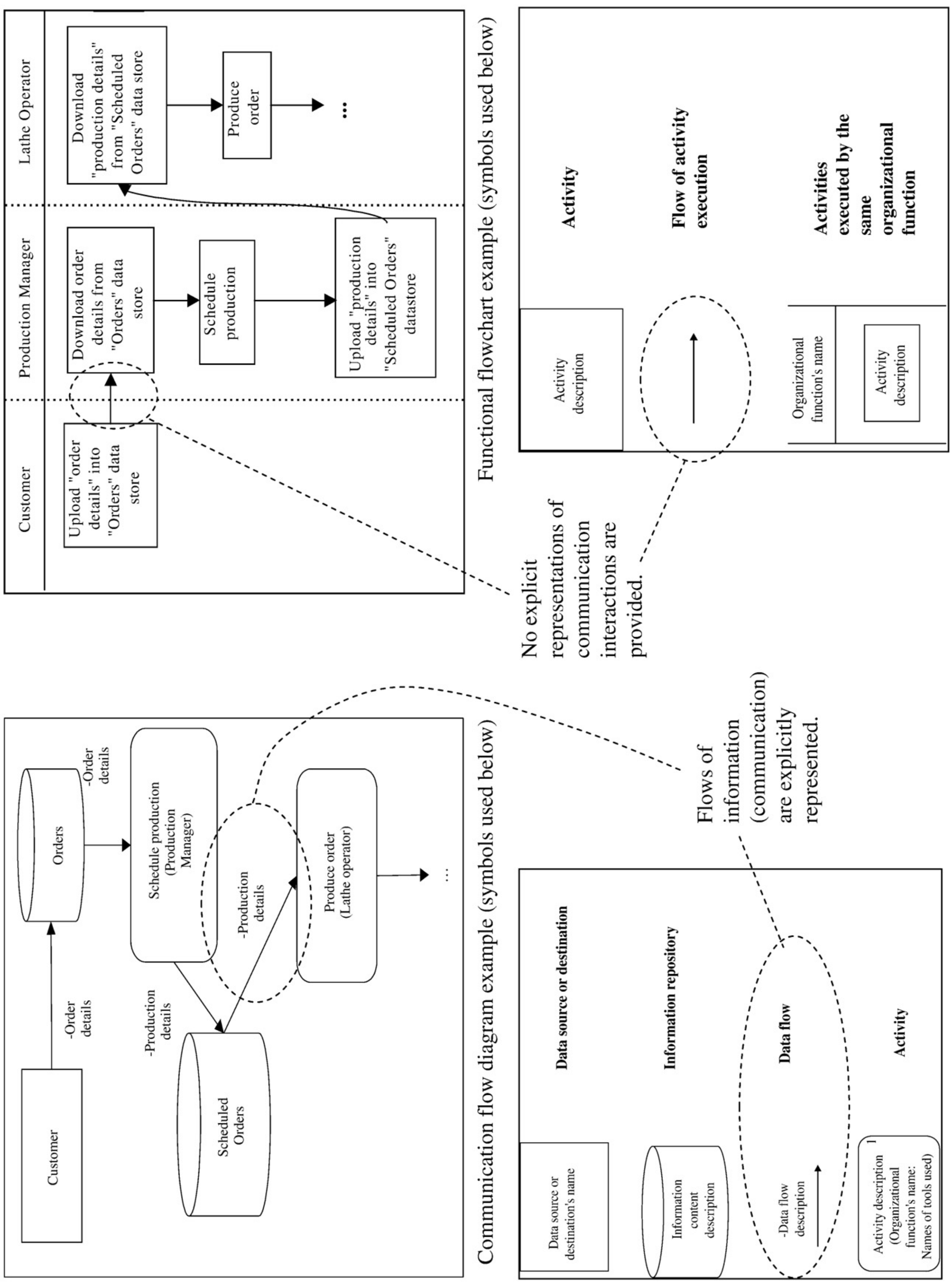

Fig. 1. Communication and activity flow diagram examples.

from but complementary to the diagrams. At the low end of the communication flow orientation spectrum are standard and functional flowcharts [29,30], since those types of diagrams provide a fairly limited view of how communication takes place in a business process. The arrows in standard and functional flowcharts do not indicate communication exchanges, as do the arrows in communication flow diagrams, but rather the chronological flow of activities in a business process.

Providing progressively more explicit and comprehensive views of communication flows in business processes are activity diagrams, use case diagrams, and communication diagrams; which are all part of the unified modeling language (UML). The unified modeling language [6,50] has been developed to allow business process modelers to represent processes in ways that facilitate their automation using object-oriented software development suites.

At the high end of the communication flow orientation spectrum are data flow diagrams, widely used in structured systems analysis and design approaches [20]; and communication flow diagrams, which are similar to data flow diagrams but differ from them in that they explicitly show communication flow inefficiencies that can in turn be targeted through business process redesign [38]. Representative examples of the diagrams just discussed are listed in Fig. 2, along with their approximate relative position on a line representing a continuum of communication flow orientation.

UML diagrams, including communication diagrams, are shown in Fig. 2 as having a lower degree of communication flow orientation than both data flow and communication flow diagrams. The reason for this is that UML diagrams are aimed at representing business processes with the goal of automation using object-oriented software development tools. Thus UML diagramming places emphasis on those business process elements that will lead to the definition of object classes, attributes, methods, inheritance mechanisms, and other object-oriented software development components [52].

Data flow and communication flow diagrams, on the other hand, place emphasis on how communication takes place among individuals involved in the execution of a business process, and are less dependent on information technology implementation strategies. Between the two, the one with the higher degree of communication flow orientation is the communication flow diagram. The reason here is that communication flow diagrams enable the representation of some communication inefficiencies that cannot be represented through data flow diagrams without violation of specific data flow diagramming rules. For example, two individuals may exchange information synchronously in a business process, which is arguably important to represent in a business process model so that communication inefficiencies are spotted and eliminated through business process redesign. Say, a sales representative always calls his manager on the phone to update a customer's contact information, instead of updating it asynchronously using a customer database management system. Data flow diagramming rules prevent that type of problematic communication interaction from being modeled.

Building on Kock and Murphy's [39] investigation, Danesh-Pajou [15] conducted an experimental study of a large number of individuals who completed a business process redesign task using business process modeling approaches presenting different degrees of communication flow orientation. The results of the study suggested a positive relationship between the communication flow orientation and the quality of a business process model, where quality can be assessed through the following perceptual attributes: ease of generation, ease of understanding, completeness, and accuracy. This leads to hypotheses H1–H4, each addressing one of the perceptual business process model quality attributes.

H1. A business process model with a higher communication flow orientation will be perceived as easier to generate than a model with a lower communication flow orientation.

H2. A business process model with a higher communication flow orientation will be perceived as easier to understand than a model with a lower communication flow orientation.

H3. A business process model with a higher communication flow orientation will be perceived as more complete than a model with a lower communication flow orientation.

H4. A business process model with a higher communication flow orientation will be perceived as more accurate than a model with a lower communication flow orientation.

Hypotheses H1–H4 allow for the focused testing of predictions based on Kock and Murphy's [39] and Danesh-Pajou [15] investigations under different, and perhaps more realistic, conditions than the conditions surrounding those investigations. (Danesh-Pajou [15] conducted an experiment with student subjects.) Hypotheses H1–H4 also provide the basis for the integration of the related effects on business process model quality with downstream mediating effects, ultimately leading to effects on business process redesign success.

Before proceeding toward the development of hypotheses associated with those downstream mediating effects, it is important to develop one additional hypothesis in connection with two of the business process model quality attributes discussed earlier. The attributes are ease of generation and ease of understanding, which Danesh-Pajou's [15] study suggests are highly correlated. This study result is intuitively appealing, since one would reasonably expect that a business process model that is easy to generate should also be easy to understand. Nevertheless, this result must be further tested, since there are examples from the modeling literature of elaborate and very difficult to generate models that are relatively easy to understand. One example would be critical path diagrams used in project management; see, e.g., [35]. This leads to hypothesis H5.

H5. A business process model that is perceived as easier to generate is also perceived as easier to understand than a model that is harder to generate.

Davenport [16] has been a strong advocate of the role of information technology (IT) as a driver of business process redesign (see, also, [17]). Along the same lines, Kock [37,38] has pointed out that a fundamental step in business process redesign projects is to develop a generic IT solution to implement the redesigned business process. Danesh-Pajou [15] and Kock [38] have put forth ideas based on empirical data suggesting that a business process model's ease of understanding, completeness and accuracy have a positive effect on the model's perceived usefulness in the development of a generic IT solution. Those ideas have not been directly tested in field empirical investigations before, and thus are formulated in a testable way through hypotheses H6–H8 below.

H6. A business process model that is perceived as easier to understand is also perceived as more useful in the development of a generic IT solution than a model that is harder to understand.

H7. A business process model that is perceived as more complete is also perceived as more useful in the development of a generic IT solution than a model that is less complete.

H8. A business process model that is perceived as more accurate is also perceived as more useful in the development of a generic IT solution than a model that is less accurate.

Danesh-Pajou [15] and Kock [38] also have put forth ideas based on various empirical studies, employing experimental [15] and field research [38] methods, suggesting that some of the attributes that define a business process model's quality are related to business process redesign success. More specifically, their studies suggest that a business process model's ease of understanding, completeness and

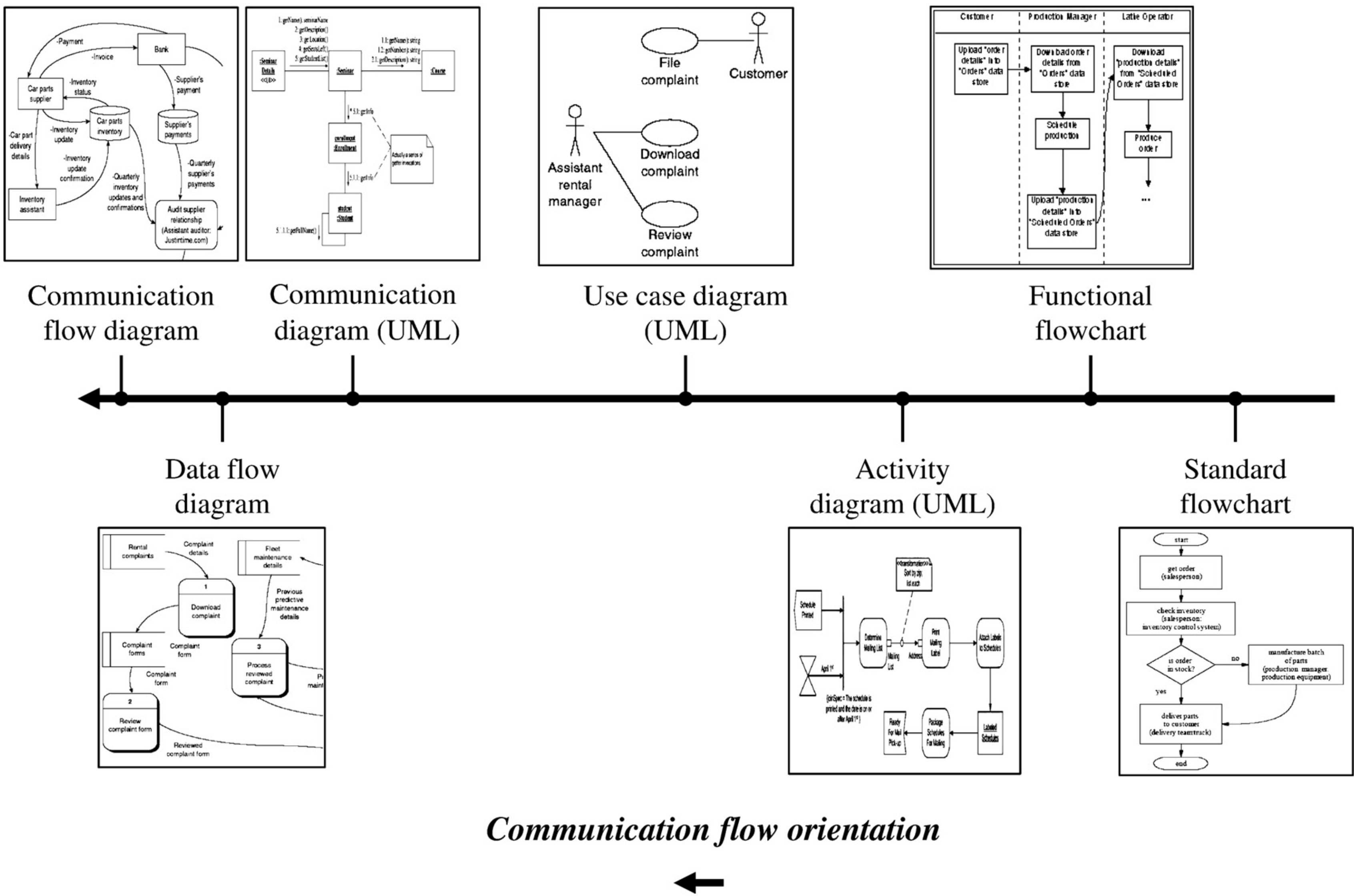

Fig. 2. Communication flow orientation of different business process diagrams.

accuracy are likely to have a positive effect on the success of the business process redesign project employing the business process model. Hypotheses H9–H11, enunciated below, formulate those predictions in an empirically testable manner.

H9. A business process model that is perceived as easier to understand is also perceived as enabling a greater degree of redesign success than a model that is harder to understand.

H10. A business process model that is perceived as more complete is also perceived as enabling a greater degree of redesign success than a model that is less complete.

H11. A business process model that is perceived as more accurate is also perceived as enabling a greater degree of redesign success than a model that is less accurate.

One additional hypothesis is necessary to account for the conceptual arguments and related empirical findings that IT implementation is an important determinant of business process redesign success [15,16,17,38]. The hypothesis should provide the basis for testing the prediction that the usefulness of a business process model in the development of a generic IT solution is likely to also affect business process redesign success. The reason is that the generic IT solution is likely to be used as a basis for the implementation of a redesigned business process. If the business process model does not provide a solid basis for the generation of a generic IT solution, then one would expect that the implementation of the redesigned business process will not be done properly. As a result, the business process redesign success, as perceived by close observers, will also suffer. This line of reasoning is formalized through hypothesis H12.

H12. A business process model that is perceived as more useful in the development of a generic IT solution is also perceived as enabling a greater degree of redesign success than a model that is less useful in the development of a generic IT solution.

Predicted causal links in a structural model can be used to represent a set of hypotheses [42]. This is done in Fig. 3, where each of the hypotheses above is depicted as a causal link that represents a relationship between a pair of variables. All of the depicted links are assumed to refer to a positive relationship. That is, an increase in the variable that is pointing at the other variable is predicted to be associated with an increase in the latter variable. For example, the link between "Communication flow orientation" and "Ease of generation", which refers to hypothesis H1, means that a higher communication flow orientation of a business process model is predicted to be associated with a higher ease of generation of the model.

The diagrammatic depiction of the hypotheses in Fig. 3 is useful in the understanding of the hypotheses individually, and particularly in the understanding of how the hypotheses are related to each other. It also has another important use, related to the statistical analyses of the data with the goal of testing the hypotheses. When the data analysis method employed is co-variance-based or variance-based structural equation modeling [51], the structural model depicting the hypotheses is likely to be homologous to the one built as a basis for the statistical analyses. This was the case in this study. We employed a variance-based technique for structural equation modeling based on the partial least squares (PLS) technique [11,12,25].

3. Research method

A researcher provided business process redesign training and facilitation to the members of 18 business process redesign groups. The training sessions covered a number of standard as well as emerging issues [18,28,29,30,32,38]. The groups that were facilitated by the researcher comprised members of a research center housed in a large public university located in Northeastern U.S., as well as

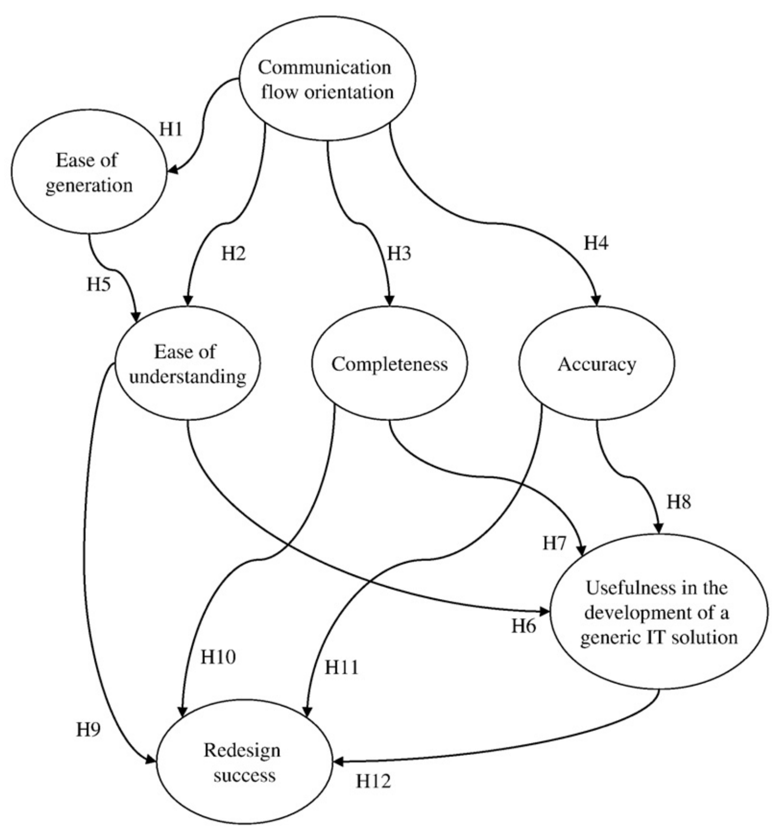

Fig. 3. Structural equation model depicting the hypotheses.

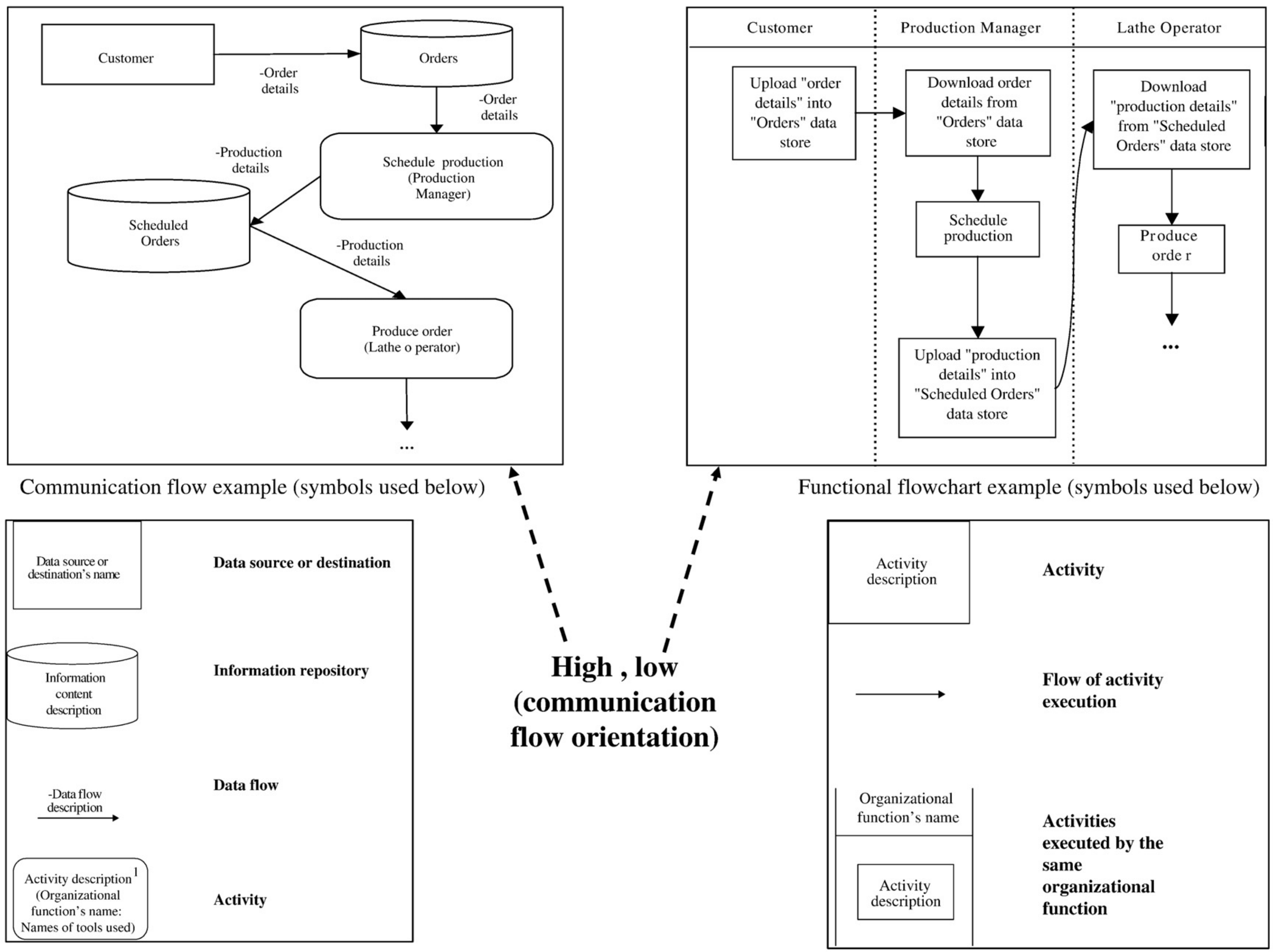

Fig. 4. High and low communication flow orientation diagrams used.

employees and management from several organizations based in Northeastern U.S.

Each business process redesign group targeted a process at a different organization; that is, 18 different organizations were involved in this study. Each group conducted its work independently from the other groups. The facilitation provided by the researcher was solely methodological, in the sense that no specific process redesign suggestions were offered as part of the facilitation conducted by the researcher. The facilitation was also "methodologically neutral" so as not to bias the perceptions of the subjects about the business process modeling approaches used.

Seventy-eight individuals who had participated as business process redesign group members completed a survey approximately 2 weeks after the conclusion of their business process redesign projects. Both quantitative and qualitative data were collected through these surveys. All of the respondents used two modeling approaches, with high and low communication flow orientation, in their business process redesign group projects.

The business process modeling approach with high communication flow orientation was centered on the use of communication flow diagrams [38]. The modeling approach with low communication flow orientation was centered on the use of functional flowcharts [29,30]. All of the business process redesign groups generated both types of diagrams of the processes they targeted for redesign. Both diagrams and respective symbols are shown in Fig. 4. The diagrams generated by the participants were much more detailed and complex than the schematic representations shown in Fig. 4. The level of detail and complexity was roughly the same for both types of diagrams generated by the participants.

The respondents answered questions related to both approaches, which makes the research design employ repeated measures design [49], also known as within-subjects design, with a total sample size of 156. One important aspect of this research study is that the unit of analysis was the individual member of the business process redesign group, not the group itself or the organization to which the group belonged. Thus the possible group correlation effect was controlled for in the quantitative data analysis; each group belonged to a different organization. Approximately 63% of the respondents were males. Their ages ranged from 19 to 60, with a mean age of approximately 31. Their work experience ranged from 1 to 30 years, with a mean of approximately 9 years.

Most of the variables used in this study were perception-based. Whenever perception-based variables are used in inferential studies, measurement errors can bias the results [27,49]. One effective technique often employed to minimize the impact of such measurement errors on results is to measure each variable based on multiple indicators. This technique also allows for validity and reliability tests in connection with the measurement model used [47]. Each set of related indicators is designed, often in the form of related question-statements, to "load on" (or correlate with) what is referred to as a latent variable [24]. This technique is used with a variety of multivariate statistical analysis methods, and is particularly well aligned with the statistical analysis method known as structural equation modeling [42], which was employed in this study for the analysis of the quantitative data.

The measurement model used in this study included six latent variables related to participants' perceptions associated with two business process modeling approaches. These latent variables were: ease of generation (easgen), ease of understanding (easund), completeness (comple), accuracy (accura), usefulness in the development of a generic IT solution (genits), and redesign success (success). The measurement of a latent variable is based on a set of indicators, which often store answers from a study's participants to a set of related question-statements that are numeric and based on a Likert-type scale [46]. The question-statements used to measure each of the six latent variables in this study are listed in the Appendix A.

In addition to the above-mentioned variables, several other variables were included in the analysis as control variables. The control variables included in the analysis were: gender, age, work experience, and group correlation (the latter as a dummy variable). The inclusion of control variables in a model is an approach commonly utilized when certain predicted effects may be affected by other extraneous effects, and when the nature of that influence is not known in advance.

4. Validation of the quantitative data collection instrument

Validity and reliability tests of the measurement model in connection with the latent variables must be conducted before a structural equation modeling analysis can be effectively utilized for the assessment of a set of hypotheses [42]. Among the most common validity tests are those in connection with the assessment of the convergent and discriminant validity of a measurement model. Convergent validity tests are aimed at verifying whether answers from different individuals to question-statements are sufficiently correlated with the respective latent variables. Conversely, discriminant validity tests are aimed at checking whether answers from different individuals to question-statements are either lightly correlated or not correlated at all with other latent variables.

Reliability tests have a similar but somewhat different purpose than validity tests. They are aimed at verifying whether answers from different individuals to question statements associated with each latent variable are sufficiently correlated among themselves [49]. Not only do validity and reliability tests allow for the assessment of the quality of a measurement model, but also for the verification that the individuals responding to question-statements understood and answered the question-statements reasonably carefully; as opposed to answering them in a hurry, or in a mindless way.

The assessment of convergent validity is usually conducted based on loadings calculated through a non-confirmatory factor analysis. Reliability assessment usually builds on the calculation of reliability coefficients, of which the most widely used is arguably Conbrach's alpha [24,45].

Loadings obtained from a non-confirmatory factor analysis are shown in Table 2 in the columns labeled "easgen", "easund", "accura", "comple", "genits", and "success". In this non-confirmatory factor analysis the extraction method used was principal components, and the rotation method was varimax [23,57]. Shown in shaded cells are the loadings expected to be conceptually associated with the respective latent variables. In the column labeled "alpha" are shown the Conbrach's alpha coefficients calculated for each of the latent constructs.

Whenever factor loadings associated with indicators for all respective latent variables are .5 or above the convergent validity of a measurement model is generally considered to be acceptable [27]. For this study, the sets of factor loadings associated with each of the latent variables are shown in the shaded cells in Table 2. They range from .68 to .89, which indicates that the measurement model used in this study has acceptable convergent validity.

The reliability of a latent variable-based measurement model is generally considered to be acceptable if the Cronbach's alpha coefficients calculated for each latent variable are .7 or above [24,45]. As shown in Table 2, the Cronbach's alpha coefficients obtained for this study ranged from .81 to .93, suggesting that the measurement model presents acceptable reliability.

Shown in Table 3 are Pearson's bivariate correlation coefficients calculated for each pair of latent variables. Coefficients followed by "*"are significant at the .05 level in a two-tailed correlation test; coefficients followed by "**" are significant at the .01 level. Also shown in Table 3 are the average variances extracted for each of the latent variables, on the diagonal and within parentheses. The two bottom rows of Table 3 contain the means and standard deviations calculated for each latent variable, respectively.

Table 2
Factor loadings and Cronbach's alpha coefficients

	easgen	easund	accura	comple	genits	success	alpha
easgen1	.82	.08	.26	.17	.03	.08	.90
easgen2	.89	.06	.06	.12	−.07	.04	
easgen3	.87	.26	.05	.03	.04	.10	
easgen4	.78	.33	.08	−.03	.11	.20	
easund1	.30	.68	.15	.22	.18	.28	.81
easund2	.27	.72	.24	−.02	.27	.19	
easund3	.19	.83	.17	−.03	.16	.01	
accura1	.19	.27	.80	.14	.11	.28	.84
accura2	.20	.22	.86	.12	.19	.07	
comple1	.13	−.04	.11	.78	.09	−.16	.81
comple2	−.04	.04	.10	.72	.02	.24	
comple3	.14	.06	.00	.83	−.06	.20	
comple4	.03	.04	.02	.83	.02	−.15	
genits1	.02	.17	.10	.02	.86	.22	.87
genits2	.05	.06	.16	.05	.85	.10	
genits3	−.07	.22	−.02	.08	.84	.17	
genits4	.04	.08	.07	−.07	.68	.31	
success1	.21	.13	.17	.07	.42	.77	.93
success2	.21	.18	.14	.08	.45	.76	
success3	.12	.17	.17	−.02	.51	.71	

Notes:
easgen = ease of generation.
easund = ease of understanding.
comple = completeness.
accura = accuracy.
genits = usefulness in the development of a generic IT solution.
success = redesign success.
alpha = Cronbach's alpha coefficient.

A measurement model containing latent variables is generally considered to have acceptable discriminant validity if the square root of the average variance extracted for each latent variable is higher than any of the bivariate correlations involving the latent variables in question [24]. An even more conservative discriminant validity assessment, which was used here, would involve comparing the average variances extracted (as opposed to their square roots) with the bivariate correlations. As can be inferred from Table 3, our measurement model passes this more conservative assessment. All average variances extracted are higher than the correlations shown below them or to their left.

The discussion above can be summarized as suggesting that the latent-based measurement model employed appears to present good validity and reliability. This leads to confidence about the interpretation of the results of a structural equation modeling analysis employing the latent variables and testing the hypothesized effects depicted as links in the structural model.

5. Summary of quantitative analysis results

Fig. 5 shows the results of a structural equation modeling analysis aimed at testing the hypothesized effects among the latent variables. Full arrows represent statistically significant effects, and dotted arrows represent non-significant effects. The β coefficients for each link are shown near the full arrows, and refer to the path coefficients (standardized partial regression coefficients) associated with statistically significant effects. For the dotted arrows, the letters "NS" (not significant) are shown in place of the β coefficients. Either the symbol "*" or "**" follows each of the β coefficients, and indicate effect significance levels of .05 and .01, respectively. Several R^2 coefficients are shown under each of the endogenous latent variables. These are variables that are indicated as being affected by, or dependent on, other variables in the structural model. The R^2 coefficients display the percentage of explained variance in connection with each of the variables provided by the model.

Fig. 5 suggests that a communication flow orientation has a significant and positive relationship with ease of generation (β= 135, P<.05); that is, the model with a higher communication flow orientation seemed generally easier to generate. Communication flow orientation seems to also be significantly and positively related with ease of understanding (β= .269, P<.01) and accuracy (β=.244, P<.01); although it does not seem to be significantly related with completeness.

Ease of generation seems to have a significant and positive relationship with ease of understanding (β=.503, P<.01). Ease of understanding, in turn, appears to have significant and positive relationships with redesign success (β=.178, P<.05) and usefulness in the development of a generic IT solution (β= .363, P<.01). Accuracy appears to also have a significant and positive relationship with redesign success (β=.180, P<.01), but does not appear to be related with usefulness in the development of a generic IT solution.

Completeness does not seem to be related with either redesign success or usefulness in the development of a generic IT solution. The latter variable, i.e., usefulness in the development of a generic IT solution, seems to have a significant and positive relationship with redesign success (β=.538, P<.01). None of the control variables included in the analysis was found to have a significant relationship with redesign success.

6. Summary of qualitative analysis results

The qualitative data for this analysis was obtained from a questionnaire in which the participants were asked about positive and negative aspects related to the business process modeling approach employed. To analyze the qualitative data, two techniques were employed. The first technique involved "pattern matching" [43] across the data. The data was then classified according to the patterns that had emerged. Subsequently, the data was categorized according to emerging patterns, and the patterns were then calculated as percentages.

Content analysis was the second qualitative analysis technique used. Content analysis is defined as a "catch-all term covering a variety of techniques for making inference from text data" [8, p. 179]. There

Table 3
Pearson correlations, AVEs, means, and standard deviations

	easgen	easund	accura	comple	genits	success
easgen	(.77)					
easund	.52**	(.73)				
accura	.41**	.55**	(.87)			
comple	.18*	.15	.24**	(.53)		
genits	.12	.43**	.33**	.07	(.73)	
success	.35**	.51**	.47**	.12	.68**	(.88)
Mean	5.01	5.02	4.43	3.63	4.75	5.11
SD	1.04	1.02	1.17	1.14	1.08	1.18

Notes:
easgen = ease of generation.
easund = ease of understanding.
comple = completeness.
accura = accuracy.
genits = usefulness in the development of a generic IT solution.
success = redesign success.
Correlation coefficients shown are Pearson bivariate correlations.
* = correlation significant at the .05 level.
** = correlation significant at the .01 level.
Average variances extracted (AVEs) are shown on diagonal.
SD = standard deviation.

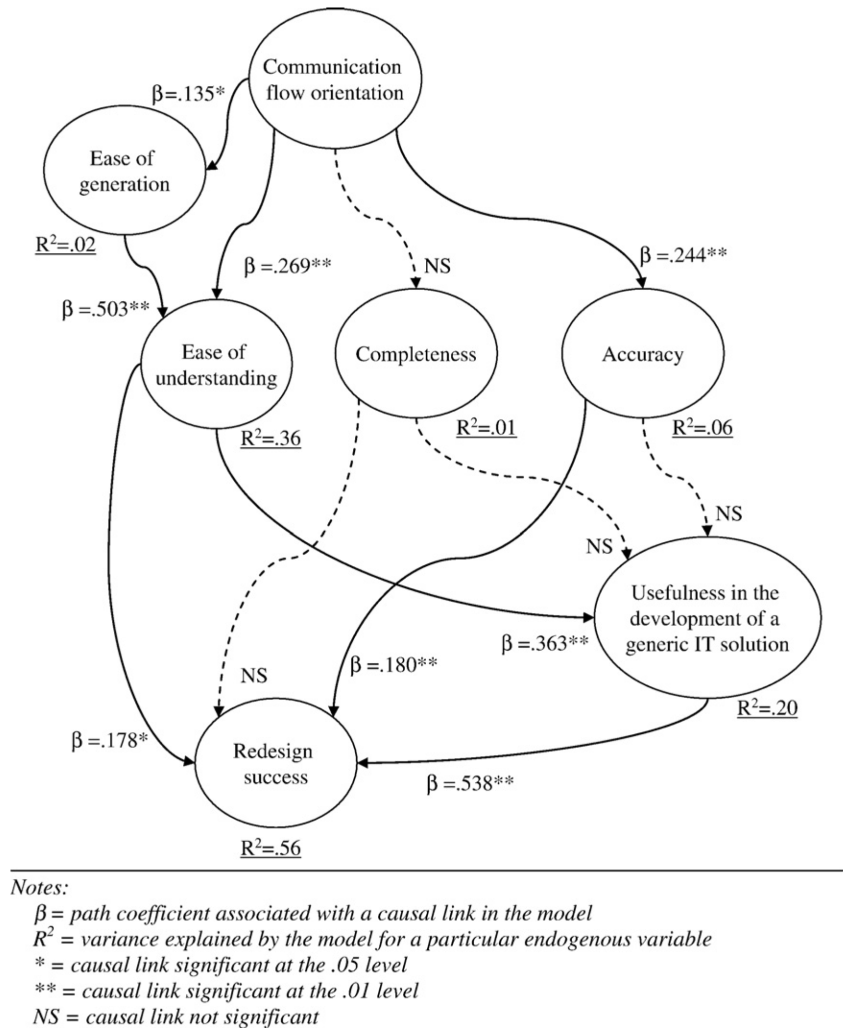

Fig. 5. Structural equation model and estimated parameters.

are two different types of content analysis: manifest content analysis; and latent content analysis [59]. In categorizing and coding items, the degree of inference (high or low) determines whether the data is manifest or latent [48].

In qualitative data analysis, data items that are physically present are called manifest data. These types of data are considered to have a low degree of inference. In this study, words such as "visualize", "view", "time" and "understanding" are examples of manifest data that were found in the data. As for latent content, according to [48], the researcher 'interprets' what has been stated in order to extract it. Latent content is considered to have a high degree of inference.

An example of latent content from the data concerning the high communication flow orientation approach (positive), with reference to the model, is the term "graphical representation". In their statements regarding the positive aspects, and their relative explanations for their views, the participants did not mention the word "model". Using latent content analysis enables the researcher to infer what is being stated from the responses that have the same general meaning.

Using the aforementioned techniques in an iterative way, the responses were grouped according to six categories, which are the same as the latent variables used in the quantitative data analysis: ease of generation, ease of understanding, completeness, accuracy, usefulness in the development of a generic IT solution, and redesign success. These categories were then partitioned according to four main groups: "Positive – High communication flow orientation", "Negative – High communication flow orientation", "Positive – Low communication flow orientation", and "Negative – Low communication flow orientation". The "Positive" and "Negative" qualifiers in the category headings refer to positive and negative statements made by the participants in the study.

The results of the qualitative data analysis are summarized in Table 4. The first section presents the positive and negative aspects in connection with the high communication flow orientation approach to business process modeling. The second section presents the positive and negative aspects in connection with the low communication flow orientation approach. The quote segments provided under each category serve to illustrate examples of statements found in the qualitative data.

As it can be seen from Table 4, the vast majority of the positive and negative comments provided in connection with each business process modeling approach were related with business process model quality issues – ease of generation, ease of understanding, completeness, and accuracy.

If one looks at the top and bottom parts of Table 4, a comparison suggests that participant perceptions varied more in terms of negative than positive characteristics in connection with low and high communication flow orientation of the business process models utilized. High communication flow orientation seems to have been particularly associated with ease of generation problems, when compared with low communication flow orientation. Low communication flow orientation, in turn, seems to have been particularly associated with accuracy problems.

Table 4
Perceived positive and negative aspects of the modeling approaches

Positive – High communication flow orientation	Negative – High communication flow orientation
(24%) Ease of generation	(21%) Ease of generation
(41%) Ease of understanding	(10%) Ease of understanding
(2%) Completeness	(39%) Completeness
(12%) Accuracy	(12%) Accuracy
(8%) Usefulness in the devel. of a gen. IT solution	(8%) Usefulness in the devel. of a gen. IT solution
(13%) Redesign success	(10%) Redesign success
Positive – Low communication flow orientation	**Negative – Low communication flow orientation**
(31%) Ease of generation	(5%) Ease of generation
(38%) Ease of understanding	(17%) Ease of understanding
(4%) Completeness	(30%) Completeness
(9%) Accuracy	(34%) Accuracy
(5%) Usefulness in the devel. of a gen. IT solution	(4%) Usefulness in the devel. of a gen. IT solution
(13%) Redesign success	(10%) Redesign success

Comparing the left and right parts of Table 4, it seems that both high and low communication flow orientation models of business processes were perceived as being somewhat incomplete representations. Nevertheless, both types of representations seem to have elicited significantly more positive than negative perceptions in connection with ease of understanding.

7. Discussion

The results of the quantitative and qualitative analyses are generally consistent with one another. They provide general support for the prediction that a high degree of communication flow orientation of a business process model will be associated with increased business process model quality. When taken as a whole, those results also provide general support for the prediction that increases in business process model quality will be associated with increases in the success of business process redesign efforts. In other words, business process model quality acts as a mediating construct between communication flow orientation and business process redesign success. Not all of the hypotheses were supported though. Fig. 5 indicates whether or not each of the hypotheses was supported by the data.

Particularly noteworthy among the findings from the data analyses is the irrelevant role that one of the business process model quality attributes, namely completeness, played in the structural equation model comprising the hypotheses. This is indicated in Table 5 by the lack of support found for hypotheses H3, H7 and H10. Apparently completeness was not influenced by a model's communication flow orientation, nor did it influence the model's usefulness in the development of a generic IT solution or business process redesign success.

The above finding is of particular interest because it may suggest that trying to develop very detailed representations of business processes, as a basis for their redesign, may not always be such a good idea. The inclusion of many details in a business process representation may be motivated by a modeler's attempt to ensure model completeness, based on the assumption that a high level of completeness will contribute to the success of a business process redesign project. The results of this study suggest that this preoccupation is less warranted than many modelers may believe. One of the possible reasons for this is that too detailed representations of business processes may lead to information overload, where only a certain level of detail will actually be absorbed by those involved in the redesign of a business process.

Business process models with greater communication flow orientation were perceived to be more accurate than models with a lower communication flow orientation. The accuracy also had a positive influence on both the development of a generic IT solution and a greater redesign success. Accuracy has been attributed to the quality and suitability of information to meet the user's requirements for the intended purpose; inaccurate or misleading information could result in difficulties, which may result in failure to focus properly on the actual problems and inefficiencies [2,9,15].

Also noteworthy is the large percentage of explained variance provided by the structural equation model in connection with the main dependent construct of the model, namely business process redesign. The results of the analysis suggest that 56% of the variance in that construct is explained by the model. When we look at the mediating effects that make up the “middle” of the model, it appears that a business process model's ease of understanding is one of the most relevant constructs in defining business process redesign success. The reason for this is the high percentage of explained variance associated with this mediating construct (36%) and its significant direct and indirect effects on business process redesign success. This construct is one of the component constructs (or composite attributes) of the broader construct referred to here as business process model quality.

Like the vast majority of research studies, this study has important limitations that must be recognized, of which two are particularly noteworthy. The first noteworthy limitation is the relatively small number of business process redesign projects used in the data collection. The second is the limited degree of variation in its main independent variable, namely the communication flow orientation of the business process representations employed in the redesign projects. Since only two types of diagrams were contrasted, that

Table 5
Summary of hypotheses-testing results

Hypothesis	Supported?
H1: A business process model with a higher communication flow orientation will be perceived as easier to generate than a model with a lower communication flow orientation.	Yes
H2: A business process model with a higher communication flow orientation will be perceived as easier to understand than a model with a lower communication flow orientation.	Yes
H3: A business process model with a higher communication flow orientation will be perceived as more complete than a model with a lower communication flow orientation.	No
H4: A business process model with a higher communication flow orientation will be perceived as more accurate than a model with a lower communication flow orientation.	Yes
H5: A business process model that is perceived as easier to generate is also perceived as easier to understand than a model that is harder to generate.	Yes
H6: A business process model that is perceived as easier to understand is also perceived as more useful in the development of a generic IT solution than a model that is harder to understand.	Yes
H7: A business process model that is perceived as more complete is also perceived as more useful in the development of a generic IT solution than a model that is less complete.	No
H8: A business process model that is perceived as more accurate is also perceived as more useful in the development of a generic IT solution than a model that is less accurate.	No
H9: A business process model that is perceived as easier to understand is also perceived as enabling a greater degree of redesign success than a model that is harder to understand.	Yes
H10: A business process model that is perceived as more complete is also perceived as enabling a greater degree of redesign success than a model that is less complete.	No
H11: A business process model that is perceived as more accurate is also perceived as enabling a greater degree of redesign success than a model that is less accurate.	Yes
H12: A business process model that is perceived as more useful in the development of a generic IT solution is also perceived as enabling a greater degree of redesign success than a model that is less useful in the development of a generic IT solution.	Yes

independent variable assumed only two values in this analysis. One way in which these two limitations can be addressed in the future is through a survey study of a large number of business process redesign projects in a large number of organizations. In this type of study one would also expect a larger amount of variation in the communication flow orientation of the business process representations employed. The challenge will be to ensure that different participants understand in the same way what is meant by communication flow orientation. Treating communication flow orientation as a latent construct can address this challenge, where this construct will be measured through multiple indicators. This will enable the measurement instrument's various tests of validity and reliability to be performed with this construct as part of the mix.

8. Conclusion

One of the arguable gaps in the empirical research literature on business process redesign is related to how business process modeling choices affect business process redesign success. This study is one of the first to address this research gap through an analysis of field data. It investigated the degree of communication flow orientation of a business process modeling approach, and its impact on perceived business process modeling quality elements. The modeling quality elements considered were a model's ease of generation, ease of understanding, completeness and accuracy. The study also investigated the effect of those business process modeling quality elements on business process redesign success.

The degree of communication flow orientation of a business process model was found to be significantly and positively related to the perceived ease of generation, ease of understanding, and accuracy of the model. However, no relationship was found between the degree of communication flow orientation of a business process model and its perceived completeness. As expected, the perceived ease of generation of a model was found to be significantly and positively related to the ease of understanding of the model. Also, the perceived ease of understanding of a model was found to be significantly and positively related to the model's perceived usefulness in the development of a generic IT solution to implement the redesigned process.

Perceived ease of understanding, accuracy, and usefulness in the development of a generic IT solution of a business process model were all found to be significantly and positively related to the degree of business process redesign success. The perceived completeness of a business process model, however, did not seem to be related to redesign success. Finally, the three perceptual constructs ease of understanding, accuracy, and usefulness in the development of a generic IT solution of a business process model seem to strongly influence business process redesign success. Those three constructs accounted for 56% of the explained variance in the business process redesign success construct.

The results summarized above are relevant for practitioners for several reasons. One such reason comes from the widespread use of business process redesign in organizations of all shapes and sizes. Arguably hundreds of thousands of business process redesign projects likely take place annually in most developed countries (and in many developing ones). Literally thousands of such projects are conducted annually in large individual organizations such as large retailers (e.g., Wall Mart and Carrefour) and large government branches (e.g., European Commission and U.S. Department of Defense).

Each of those projects involves costs, especially if the new redesigned processes are fully implemented. The benefits of business process redesign should outweigh the costs. Those business process redesign initiatives are needed to allow organizations, large and small, to cope with changes in economic conditions, competition, and the emergence of new disruptive technologies.

Findings such as the ones from this study speak to the strong influence that communication flow orientation of business process models is likely to have on business process model quality, which in turn seems to strongly influence business process redesign success. If an organization is large enough to conduct many business process redesign projects on a regular basis, its return on investment in business process redesign may be largely affected (from a hard cash, bottom-line perspective) by the decision to place emphasis on business process modeling approaches with a high degree of communication flow orientation.

Large organizations often institute internal approaches for business process redesign; some organizations, such as General Electric, are well known for that. Given the above discussion, it seems to makes sense for senior executives to become personally involved in the setting of the general direction that such internal approaches for business process redesign should take. One of the components of such direction should be a high communication flow orientation in business process modeling. As modeling choices become embedded in the emerging and volatile business process management suite market, the choice becomes a critical investment.

While research in process redesign permeates many fields, the findings in this study should also help information system developers and designers to acknowledge and better align information systems design with business process techniques. Utilizing communication flow methodologies in the analysis stage should significantly help in the design and development processes.

Why should a high communication flow orientation be so important for business process redesign success? The answer to this question is deceptively simple. Business processes have been gradually but drastically transformed over the last 100 years or so [37,38,60,61]. In the early 1900s, most business processes, as well as those who executed them, were dedicated to the handling and production of tangible items (e.g., car parts). Today, most business processes and workers process data. Those processes involve intense communication, and so it is no surprise that most of the problems to be addressed by business process redesign will be communication flow problems. The findings of this study are likely a reflection of that.

Appendix A

The question-statements associated with each of the indicators of the latent variables used in this study are listed below. The same question-statements were used for both high and low communication flow orientation approaches. Answers were provided on a Likert-type scale ranging from 1 (Very strongly disagree) to 7 (Very strongly agree). The indicators noted as “reversed” were reversed prior to their use in the data analysis.

Ease of generation

- easgen1: It is easy to conceptualize a process using this approach.
- easgen2: It is easy to create a process model using this approach.
- easgen3: This approach for process modeling is easy to use.
- easgen4 (reversed): It is difficult to use this process modeling approach.

Ease of understanding

- easund1: Graphical representations of processes using this approach are clear.
- easund2: This process modeling approach leads to graphical models that are easy to understand.
- easund3 (reversed): Process models generated using this approach are difficult to understand.

Accuracy

- accura1: This process modeling approach leads to accurate process representations.

- accura2: Models created using this approach are correct representations of a process.

Completeness

- comple1: Graphical process models created using this approach are complete.
- comple2: Process representations using this approach are very detailed.
- comple3: This modeling approach leads to full, rather than partial, process representations.
- comple4 (reversed): Process models generated using this approach are incomplete.

Usefulness in the development of a generic IT solution

- genits1: This process modeling approach is useful in the development of a generic IT solution to automate the redesigned process.
- genits2: Creating a generic IT solution to enable the redesigned process is easy based on this process modeling approach.
- genits3: Graphical process representations using this approach facilitate the generation of a generic IT solution to automate the redesigned process.
- genits4 (reversed): Process models generated using this approach are useless in the development of a generic IT solution to automate the redesigned process.

Redesign success

- success1: Using this process modeling approach is likely to contribute to the success of a process redesign project.
- success2: Success chances are improved if this process modeling approach is used.
- success3: Using the graphical process representations in this approach is likely to make process redesign projects more successful.

References

[1] R. Archer, P. Bowker, BPR consulting: An evaluation of the methods employed, Business Process Re-Engineering & Management 1 (2) (1995) 28–46.
[2] S. Barnes, R. Vidgen, Measuring web site quality improvements: A case study of the forum on strategic management knowledge exchange, Industrial Management & Data Systems 103 (5) (2004) 297–309.
[3] B.J. Bashein, M.L. Markus, Preconditions for BPR success, Information Systems Management 11 (2) (1994) 7–13.
[4] J.M. Bhat, M. Gupta, S.N. Murthy, Overcoming requirements engineering challenges: Lessons from offshore outsourcing, IEEE Software 23 (5) (2006) 38–44.
[5] S.J. Bleistein, K. Cox, J. Verner, Validating strategic alignment of organizational IT requirements using goal modeling and problem diagrams, The Journal of Systems and Software 79 (3) (2006) 362–378.
[6] G. Booch, I. Jacobson, J. Rumbaugh, The Unified Modeling Language User Guide, Addison-Wesley, New York, NY, 1998.
[7] A. Börjesson, L. Mathiassen, Successful process implementation, IEEE Software 21 (4) (2004) 36–45.
[8] J.S. Boyle, Style of ethnography, in: J.M. Morse (Ed.), Critical Issues in Qualitative Research Methods, Sage, Thousand Oaks, CA, 1994, pp. 159–185.
[9] C. Cappiello, C. Francalanci, B. Pernici, Time-related factors of data quality in multichannel information systems, Journal of Management Information Systems 20 (3) (2003) 71–91.
[10] H.C. Chan, K.K. Wei, K.L. Siau, User-database interface: The effect of abstraction levels on query performance, MIS Quarterly 17 (4) (1993) 441–465.
[11] W.W. Chin, Issues and opinion on structural equation modeling, MIS Quarterly 22 (1) (1998) vii–xvi.
[12] W.W. Chin, B.L. Marcolin, P.R. Newsted, A partial least squares latent variable modeling approach for measuring interaction effects: Results from a Monte Carlo simulation study and voice mail emotion/adoption study, in: J.I. DeGross, S. Jarvenpaa, A. Srinivasan (Eds.), Proceedings of the 17th International Conference on Information Systems, The Association for Computing Machinery, New York, NY, 1996, pp. 21–41.
[13] E.K. Clemons, M.E. Thatcher, M.C. Row, Identifying sources of reengineering failures: A study of the behavioral factors contributing to reengineering risks, Journal of Management Information Systems, 12 (2) (1995) 9–36.
[14] D. Damian, J. Chisan, An empirical study of the complex relationships between requirements engineering processes and other processes that lead to payoffs in productivity, quality, and risk management, IEEE Transactions on Software Engineering, 32 (7) (2006) 433–453.
[15] A. Danesh-Pajou, IT-Enabled Process Redesign: Using Communication Flow Optimization Theory in an Information Intensive Environment, Doctoral Dissertation, Temple University, Philadelphia, PA, 2005.
[16] T.H. Davenport, Process Innovation: Reengineering Work through Information Technology, Harvard Business Press, Boston, MA, 1993.
[17] T.H. Davenport, J.G. Harris, S. Cantrell, Enterprise systems and ongoing process change, Business Process Management Journal, 10 (1) (2004) 16–27.
[18] T.H. Davenport, J.E. Short, The new industrial engineering: Information technology and business process redesign, Sloan Management Review, 31 (4) (1990) 11–27.
[19] T.H. Davenport, D.B. Stoddard, Reengineering: Business change of mythic proportions?, MIS Quarterly, 18 (2) (1994) 121–127.
[20] D. DeLuca, Business Process Improvement Using Asynchronous e-Collaboration: Testing the Compensatory Adaptation Model, Doctoral Dissertation, Temple University Philadelphia, PA, 2003.
[21] D. DeLuca, S. Gasson, N. Kock, Adaptations that virtual teams make so that complex tasks can be performed using simple e-collaboration technologies, International Journal of e-Collaboration, 2 (3) (2006) 64–90.
[22] A.R. Dennis, B.H. Wixom, Systems Analysis and Design: An Applied Approach, John Wiley & Sons, New York, NY, 2000.
[23] A.S.C. Ehremberg, G.J. Goodhart, Factor Analysis: Limitations and Alternatives, Marketing Science Institute, Cambridge, MA, 1976.
[24] C. Fornell, D.F. Larcker, Evaluating structural equation models with unobservable variables and measurement error, Journal of marketing research, 18 (1) (1981) 39–50.
[25] D. Gefen, D.W. Straub, M.-C. Boudreau, Structural equation modeling and regression: Guidelines for research practice, Communications of the AIS, 4 (7) (2000) 1–76.
[26] V. Grover, S.R. Jeong, W.J. Kettinger, J.T.C. Teng, Evaluating structural equation models with unobservable variables and measurement error, Journal of Management Information Systems, 12 (1) (1995) 109–144.
[27] J.F. Hair, R.E. Anderson, R.L. Tatham, Multivariate Data Analysis, Macmillan, New York, NY, 1987.
[28] M. Hammer, Don't automate, obliterate, Harvard Business Review, 68 (4) (1990) 104–114.
[29] J.H. Harrington, Business Process Improvement, McGraw-Hill, New York, NY, 1991.
[30] J.H. Harrington, E.K.C. Esseling, H. Van Nimwegen, Business Process Improvement Workbook: Documentation, Analysis, Design, and Management of Business Process Improvement, McGraw-Hill, New York, NY, 1998.
[31] J.B. Hill, J. Sinur, Magic Quadrant for Business Process Management Suites, Gartner, Inc., New York, NY, 2006.
[32] V.D. Hunt, Process Mapping: How to Reengineer your Business Processes, John Wiley & Sons, New York, NY, 1996.
[33] G. Katzenstein, F.J. Lerch, Beneath the surface of organizational processes: A social representation framework for business process redesign, ACM Transactions on Information Systems, 18 (4) (2000) 383–422.
[34] J.E. Kendall, K.E. Kendall, Metaphors and methodologies: Living beyond the systems machine, MIS Quarterly, 17 (2) (1993) 149–172.
[35] H. Kerzner, Project Management: A Systems Approach to Planning, Scheduling, and Controlling, Wiley, New York, NY, 2005.
[36] W.J. Kettinger, V. Grover, Toward a theory of business change management, Journal of Management Information Systems, 12 (1) (1995) 9–30.
[37] N. Kock, Business Process Improvement through e-Collaboration: Knowledge Sharing through the Use of Virtual Groups, Idea Group Publishing, Hershey, PA, 2005.
[38] N. Kock, Systems Analysis and Design Fundamentals: A Business Process Redesign Approach, Sage Publications, Thousand Oaks, CA, 2006.
[39] N. Kock, F. Murphy, Redesigning Acquisition Processes: A New Methodology Based on the Flow of Knowledge and Information, Defense Acquisition University Press, Fort Belvoir, VA, 2001.
[40] T. Kuhn, The Structure of Scientific Revolutions, University of Chicago Press, Chicago, IL, 1962.
[41] T. Kuhn, The Structure of Scientific Revolutions, third ed. University of Chicago Press, Chicago, IL, 1996.
[42] R.B. Kline, Principles and Practice of Structural Equation Modeling, The Guilford Press, New York, NY, 1998.
[43] H.B. Miles, A.M. Huberman, Qualitative Data Analysis: An Expanded Source Book Sage, Thousand Oaks, CA, 1994.
[44] M.E. Nissen, Redesigning reengineering through measurement-driven inference, MIS Quarterly, 22 (4) (1998) 509–534.
[45] J.C. Nunnaly, Psychometric Theory McGraw-Hill, New York, NY, 1978.
[46] J.C. Nunnally, I.H. Bernstein, Psychometric theory, McGraw-Hill, New York, NY, 1994.
[47] A.C. Rencher, Multivariate Statistical Inference and Applications, John Wiley & Sons, New York, NY, 1998.
[48] C. Robson, Real World Research: A Resource for Social Scientists and Practitioner-Researchers, Blackwell, Oxford, UK, 1993.
[49] R. Rosenthal, R.L. Rosnow, Essentials of Behavioral Research: Methods and Data Analysis, McGraw-Hill, Boston, MA, 1991.
[50] J. Rumbaugh, I. Jacobson, G. Booch, The Unified Modeling Language Reference Manual, Addison-Wesley, New York, NY, 1998.
[51] R.E. Schumacker, R.G. Lomax, A Beginner's Guide to Structural Equation Modeling, Lawrence Erlbaum, Mahwah, NJ, 1996.
[52] K. Siau, L. Lee, Are use case and class diagrams complementary in requirements analysis? An experimental study on use case and class diagrams in UML, Requirements Engineering, 9 (4) (2004) 229–238.
[53] K. Siau, X. Tan, Use of cognitive mapping techniques in information systems, Information Management, 19 (3) (2006) 18–21.

[54] K. Siau, X. Tan, Cognitive mapping techniques for user-database interaction, IEEE Transactions on Professional Communication, 49 (2) (2006) 96–108.
[55] D.B. Stoddard, S.L. Jarvenpaa, Business process redesign: Tactics for managing radical change, Journal of Management Information Systems, 12 (1) (1995) 81–107.
[56] J.T.C. Teng, R.J. Seung, V. Grover, Profiling successful reengineering projects, Communications of the ACM, 41 (6) (1998) 96–102.
[57] B. Thompson, Exploratory and Confirmatory Factor Analysis: Understanding Concepts and Applications, American Psychological Association, Washington, DC, 2004.
[58] N. Venkatraman, IT-enabled business transformation: From automation to business scope redefinition, Sloan Management Review, 35 (2) (1994) 73–87.
[59] H.S. Wilson, The craft of qualitative analysis, in: H.S. Wilson (Ed.), Research in Nursing, Addison Wesley, Menlo Park, CA, 1989, pp. 394–428.
[60] J.-H. Wu, H.-S. Doong, C.-C. Lee, T.-C. Hsia, T.-P. Liang, A methodology for designing form-based decision support systems, Decision Support Systems, 36 (3) (2004) 313–335.
[61] L.-C. Wu, C.-S. Ong, Y.-W. Hsu, Knowledge-based organization evaluation, Decision Support Systems, 45 (3) (2008) 541–549.

Ned Kock is Professor of Information Systems in the A.R. Sanchez Jr. School of Business, Texas A&M International University. He holds degrees in electronics engineering (B.E.E.), computer science (M.S.), and management information systems (Ph.D.). Ned has authored and edited several books, including the bestselling *Systems Analysis and Design Fundamentals: A Business Process Redesign Approach*. Ned has published his research in a number of high-impact journals including *Communications of the ACM*, *Decision Support Systems*, *European Journal of Information Systems*, *Human Resource Management*, *IEEE Transactions (various)*, *Information & Management*, *MIS Quarterly*, and *Organization Science*. He is the Founding Editor-in-Chief of the *International Journal of e-Collaboration*, Associate Editor of the *Journal of Systems and Information Technology*, and Associate Editor for Information Systems of the journal *IEEE Transactions on Professional Communication*. His research interests include business process improvement, action research, ethical and legal issues in technology research and management, human evolution theories, and e-collaboration.

Jacques Verville is an Associate Professor of Information Technology & Operations Management in the Faculty of Management at the Okanagan campus of the University of British Columbia. He holds degrees in Linguistics (BA), International Relations (MA), Information Resource Management (MSc) and a PhD in Organizational Information Systems. Jacques has published in a number of journal including *IEEE Transactions on Professional Communication; Long Range Planning; Decision Sciences Journal of Innovation in Education; Industrial Marketing Management; International Journal of Technology Management; International Journal of Enterprise Information Systems*. Dr. Verville is co-author of *Acquiring Enterprise Software: Beating the Vendors at their Own Game*.

Azim Danesh is Associate Professor of Management Information Systems at Shippensburg University of Pennsylvania. He holds a Ph.D. in Computer and Information Sciences from Temple University. In addition, he has over 18 years experience in the computer industry as a software engineer, database designer, and consultant. His research interests include process redesign, electronic commerce, and database development. He holds an MS in Computer Science, an MS in Information Systems, and a BS in Mechanical Engineering Technology.

Dorrie DeLuca is Visiting Assistant Professor of MIS at the University of South Florida, College of Business. Her Ph.D. is from Temple University. She brings a varied background of industry experience to her action research on socio-technical aspects of facilitating organizational change using e-collaboration. She has published in *Journal of the AIS*, *Information, Technology & People*, *Journal of Global Information Technology Management*, and the *Communications of the AIS*. She has published in and is on the editorial review board at the *International Journal of e-Collaboration*.

Decision Support Systems