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Communicating Ideas in Computer-supported Modeling Tasks: a Case Study with BPMN

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Communicating Ideas in Computer-supported Modeling Tasks: a Case Study with BPMN

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Abstract. The communication role of models in Software Engineering is widely acknowledged. Models tell model readers what model writers propose. Computer-supported modeling (CSMod) traditionally concentrates on helping users build models with various kinds of notations (and annotations). Although such focus on 'representation' is obviously important for the overall 'communication' goal, some design features in CSMod tools may be yet unexplored. This paper presents a study with the use of ARIS EXPRESS in modeling tasks with a business process modeling notation. We report on how we combined various methods to analyze the way in which this tool supports 'communication through models'. Our findings articulate semiotic and cognitive aspects of notations with evidence provided by study participants during tasks and interviews. Our contribution lies not only in the findings, and how CSMod design can evolve in relatively unexplored ways, but also in our methodology, which we believe can be used in similar contexts.

Keywords: Semiotic engineering methods, computer-supported modeling, Cognitive dimensions of notations; discourse analysis; inspection method; communication; modeling notation, BPMN.

Resumo. O papel comunicativo de modelos na Engenharia de Software é amplamente conhecido. Modelos dizem aos leitores destes modelos o que os elaboradores destes propõem. Modelagem apoiada por computador (CSMod) tradicionalmente se concentra em ajudar os usuários na construção de modelos utilizando diversos tipos de notações (e anotações). Apesar do foco em ‘representação’ ser obviamente importante para o objetivo da comunicação global, algumas funcionalidade de modelagem em ferramentas CSMod podem ser ainda inexploradas. Este artigo apresente um estudo utilizando o ARIS EXPRESS na tarefa de modelagem com uma notação de modelagem de processos de negócio. Nós reportamos como combinamos vários métodos para analisar forma como esta ferramenta suporta "comunicação através de modelos". Nossos achados articulam aspectos semióticos e cognitivos da notação com evidências fornecidas por participantes de estudos durante execução de tarefas e entrevistas. Nossa contribuição não está apenas nos resultados, e em como a modelagem apoiada por ferramentas CSMod pode evoluir de formas relativamente inexploradas, mas também em nossa metodologia, que acreditamos que pode ser usada em contextos similares.

Palavras-chave: Métodos da Engenharia Semiótica, Modelagem apoiadas por computador, Dimensões cognitivas da notação, análise de discurso, método de inspeção, comunicação, notações de modelagem, BPMN.

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1 INTRODUCTION

The use of models as an abstraction or representation of some object, entity, event, and so on is mandatory in various disciplines, including Computer Science. In software development professional practice, one of the main roles of models is to express a common ground, that is, shared basic understanding of the essence of the modeled object, entity, event, or other. Common ground is needed because software development is typically a group undertaking, where different people are responsible for completing different parts of the overall goal. Therefore, models play a crucial communication role in the process, carrying shared meanings across space (from one team member to the other) and time (from one development phase to the other).

Many modeling languages have been proposed and evolved in decades. The most popular of them is UML (the Unified Modeling Language [OMG, 2011a]), which - as its name suggests - brings together a number of more or less independently proposed modeling languages. It aims to support systems architects, software engineers and software developers throughout analysis, design and implementation stages. Computer modeling tools have been built and evolved to increase the ease, speed, notational standardization and quality of modeling tasks. As a result, today serious software development is normally carried out with the aid of computer-supported modeling (CSMod) tools.

Although CSMod tools have been extensively analyzed from a software engineering perspective [Gruhn et al, 2009] [Moody , 2009] [Tortora , 2011], they haven't been as often analyzed from an HCI perspective. In particular, to the best of our knowledge, there haven't been studies about the 'communicability' of models produced with CSMod tools. Why is this important? Because the ultimate purpose of models in the context of software development activities is to 'communicate' meanings and to 'signify' common ground. An interesting aspect of this sort of investigation is whether we can or cannot (should or should not) isolate the model from the tool that creates it. If we do, we must engage into a discussion about the tool-independent representational stance of a model. For example, we must agree that a hand-made use case diagram as the one shown in Figure 1a is (or is not) the same thing as its corresponding computer-generated version in Figure 1b.

We will however defer this discussion in favor of another one which we believe is also intriguing and revealing: can (or should) CSMod tools such as the one that produces the diagram in Figure 1b boost the communicative power of the model they produce? Although we are tempted to answer 'yes', thinking for example about how huge class models can be walked through with the help of sophisticated visualization techniques, on second thought there may be more to the communicability of computer-generated models than visualizations.

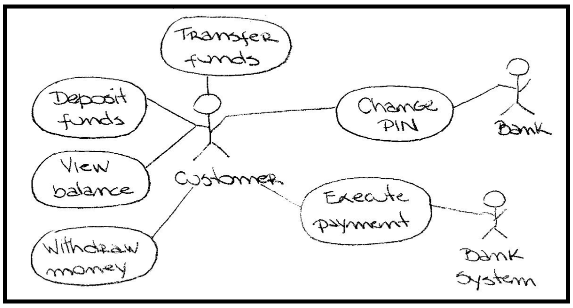


Figure 1-a. Hand-made Use case diagram

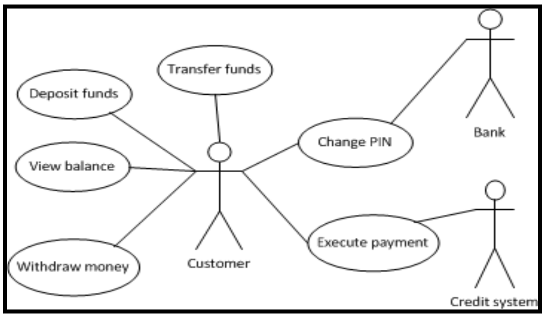


Figure 1-b. Use case diagram built with CSMod tool

This paper reports on research based on Semiotic Engineering [De Souza , 2005], a theory of HCI which focuses on how well producers of software artifacts communicate their intent to their consumers through user interface signs and patterns of interaction. In particular, we are interested in tracing the effects of CSMod tool design on the models that are built with it. In other words, we want to understand how CSMod tools support the ultimate goal of model building, namely: 'communication through models'. Such an investigation will deal not only with how modeling notations respond to the expressive needs of model builders, but also on how the context of communication - where at least two interlocutors are necessarily involved, a sender and a receiver of the communication message - is communicated and made available to the model builder, so that he can explore how his message can be received by other software development team members, across space and time.

We have done a qualitative in-depth study of a small-size modeling case using ARIS EXPRESS [AG Software , 2012], a free business process modeling tool. The study had two major phases. In the first one we carried out an inspection of ARIS EXPRESS using SIM, the Semiotic Inspection Method [De Souza et al, 2009], along with a cognitive analysis of notations it displays, using CDN, the Cognitive Dimensions of Notations Framework [Blackwell et al, 2003]. The second phase served as an internal triangulation in our method. It consisted of an empirical experiment with four participants, who had previous professional experience in business process modeling. In this experiment we registered and analyzed the participants' modeling activity with ARIS EXPRESS and then interviewed them about their thoughts in relation with the task they had been asked to perform.

Our findings suggest that CSMod design can evolve in relatively unexplored directions, helping users (modelers) to gain greater awareness of the 'communication through models' process. This is the main contribution of this paper. However, we believe that the methodology that we have used - which has been tested before in a totally different context - has yielded valuable results and can, therefore, be considered an additional contribution of this paper.

The next four sections present and discuss our research in detail. We begin with a brief description of BPMN, the Business Process Modeling Notation [OMG, 2011b] and ARIS EXPRESS. Then we outline the methodology we used: a two-phased analysis starting with semiotic and cognitive inspections followed by an empirical qualitative study which provides material for internal triangulation. Next we present our findings in each phase and our conclusion about what they mean when compared to each other. In the last section we conclude the paper and point at some of the implications of this work and the opportunities for future work.

2 BPMN and ARIS EXPRESS

We used the BPMN modeling language and ARIS EXPRESS in our experiments. Together they support the modeling of business models, which constitute the starting point for software development and a means of communication between business stakeholders and software development professionals. Based on these models, they define the scope and context where technological support is meant to be applied. [Gruhn et al, 2009] [Zhao et al, 2012]

The Business Process Model and Notation (BPMN) is said to be readily understandable by all business players, from business analysts that create the initial drafts of the processes, to technical developers that are responsible for implementing the technology that will perform those processes. [OMG, 2011a] BPMN has been the object of several studies aiming to investigate its capability and suitability to represent business context through modeling as well as exploring its capability to communicate and visualize business context. [Wohed et al, 2006] [Zhao et al, 2012] Because of this research history and for being an established standard business process notation, we decided to use BPMN in our attempt to investigate jointly the cognitive and semiotic power CSMod tools in building communicative models.

ARIS EXPRESS [AG Software , 2012] is a free modeling tool that offers a small subset of features from the professional ARIS Platform products that are recognized by the industry as a leading tool for business process management (BPM)[1]. ARIS EXPRESS focuses on supporting business process modeling activities done by beginners and occasional users.

It provides the users with a set of model types, and one of them is based on BPMN. ARIS EXPRESS was chosen for the experiments because it was a modeling tool known by the participants, which allowed us to focus on how the tool supports business modeling activities, rather than on other issues having to do with novice user interaction with new software. Even though this did not guarantee that usability issues would not get in the way of focused investigation, it could at least substantially decrease the possibility that this be the case. Another relevant motivating factor for using ARIS Express is precisely the fact that it is meant for beginners and occasional users. We assume that this is the kind of user profile that requires most guidance and support for achieving their tasks, which brings about a privileged context for examining our research question: how does this tool support 'communication through models'?

3 SEMIOTIC-COGNITIVE COMBINED METHODOLOGY

We used a combined semiotic-cognitive methodology because it allows us to analyze a very heterogeneous, yet tightly related, collection of data. Evidence collected for this research was registered in audio recordings of interviews and verbal protocols produced by participants of empirical test sessions, the various versions models used in test tasks, and the researcher's annotations made throughout the experiments. Another important piece of evidence was the ARIS Express interface itself, which in this research is considered a key piece of empirical evidence of the CSMod tool design intent communicated to the users via software.

1 http://www.softwareag.com/corporate/products/bis/recognition/default.asp

The collection of such heterogeneous data is related to Semiotic Engineering perspective that governs our research. In it, whatever happens in human-computer interaction is the result of a computer-mediated intentionally designed communication of design rationale, that is: what a system does, why, how, what for, where, when, as well as to whom it has been designed.

This designer-user communication through the system interface can be viewed from two angles. One is the emission of the communication, that is, how the designer encodes what he has to say to the users. The other is the reception of this communication, that is, how the users perceive, interpret and react to the designer's communication. In the present research we focused our investigation on BPMN modeling supported by ARIS EXPRESS. The specific tasks we used to collect evidence were the interpretation and modification of business process models.

The whole set of collected data allowed us to investigate aspects of both the emission and the reception of the designer-user computer-mediated communication. For instance, in interview and verbal protocol data we could search for evidence of how the designers' message was received by users. Likewise, in registered model states and manipulations data we could search for evidence of how the mediated designer-user conversation was articulated in a real context of use. This hybrid set of data was analyzed using a combination of three methods: Semiotic Engineering concepts and inspection method (SIM) [De Souza et al, 2009]; the Cognitive Dimensions of Notations (CDN) framework [Blackwell et al, 2003] [Green et al, 1998]; and discourse analysis (DA) [Gee, 2005].

The method we used is a two-phased analysis with a final diagnose phase, as shown in Figure 2. All three phases were performed by the same researcher, as described below.

3.1 SIM and CDN analysis

The first phase of the method is carried out to give the researchers an in-depth understanding of ARIS EXPRESS as used for modeling business processes with BPMN. ARIS EXPRESS also supports other modeling notations, but the focus of this research lies solely on BPMN. Henceforth, when we refer to "ARIS EXPRESS" we are only talking about this specific portion of the tool.

The Semiotic Inspection Method (SIM) helps us to identify the various sign systems and notations with which ARIS EXPRESS' designers structure and communicate their entire design vision to users. This method allows us to characterize how interface designers organize and structure various signs (like words, images, layout, widgets, animations, screen patterns and sequences, etc.) to communicate to the users their interactive message, which we can paraphrase as this:

"Here is my understanding of who you are, what I've learned you want or need to do, in which preferred ways, and why. This is the system that I have therefore designed for you, and this is the way you can or should use it in order to fulfill a range of purposes that fall within this vision."

In this message the first person "I" refers to the designer (or the person who represents the design team), whereas the "you" refers to the user (or targeted user community). In accordance with Semiotic Engineering [De Souza , 2005], this method frames human-computer interaction as a special case of computer-mediated human (designer-user) communication and analyzes how this communication is emitted, that is, sent from designers to users.

While SIM framed communication in the context of computer-supported modeling (i. e. taking into consideration the fact that the model is produced under the influence of CSMod tool features), we used CDN [Blackwell et al, 2003] to inspect cognitive dimensions of BPMN with ARIS EXPRESS notations (i. e. we also studied the cognitive characteristics of representations with which users have to deal, given that modeling is in essence an intellectual task).

Both methods were articulated in a principled way. Whenever the semiotic method indicated the presence of a communicability issue in the designer-user communication, we invoked CDN to inspect the sub-range of signs (i. e. the "notations" that constitute the object of CDN inspection) implicated in it. In other words, for every semiotic issue identified during SIM execution, a cognitive analysis of the notations associated with it was performed using CDN.

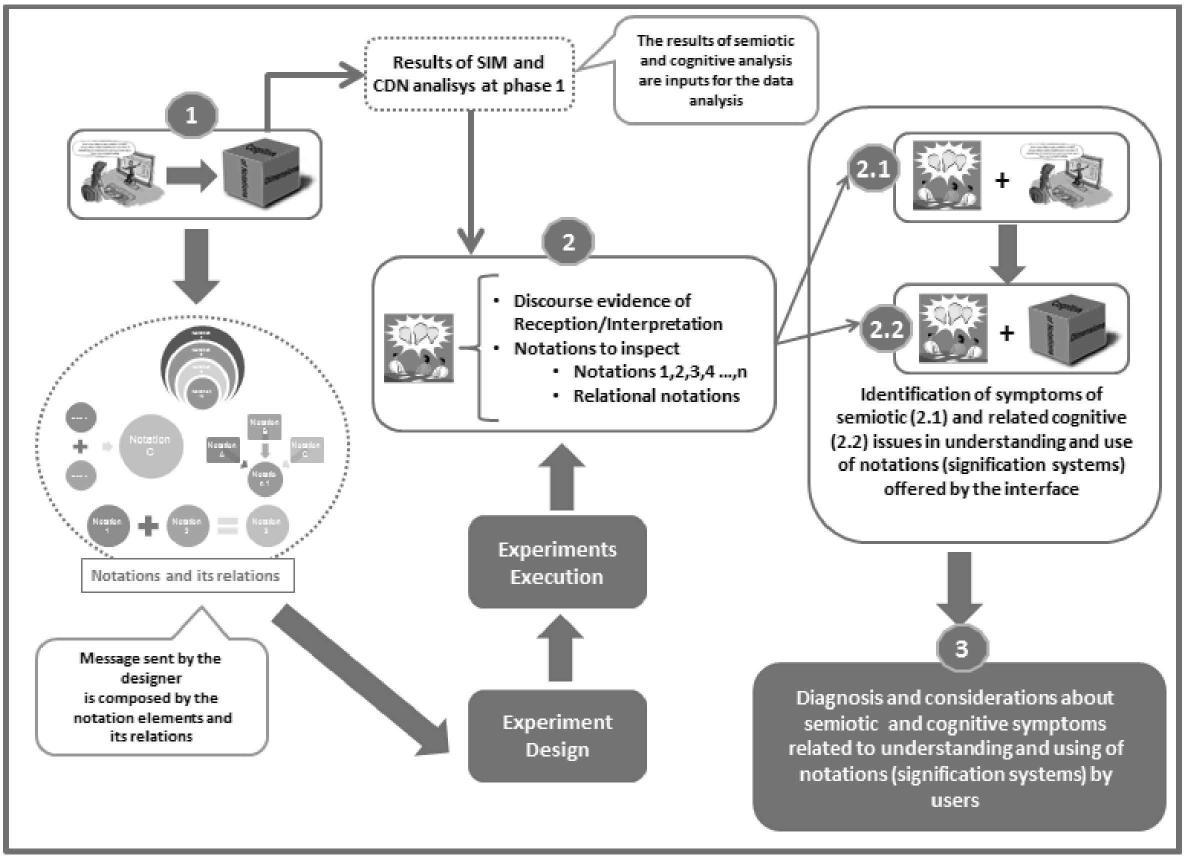


Figure 2. Semiotic-Cognitive combined methodology

CDN proposes a set of design principles for creating or evaluating notations, user interfaces and programming languages used with information artifacts [Green et al, 1998]. In practice, it provides a common vocabulary for discussing many cognitive factors of such representation systems. The aim of the CDN framework is to improve the quality of discussions and decisions in design and evaluation activity [Blackwell et al, 2003]. There are fourteen dimensions in the CDN framework, which we will not explain for lack of space and because this is not the purpose of this paper. However, for sake of quick illustration, we will briefly present two of the cognitive dimensions proposed by CDN: hidden dependencies and premature commitment. Hidden dependencies refer to a cognitive configuration where the user deals with one notational entity that depends on another but the dependency is not fully visible in the notation itself.

Premature commitment refers to when notations require that decisions be made prior to having all needed information and knowing all the related task ordering constraints.

CDN analysis was chosen as a part of our methodology because we wanted to explore the cognitive aspects of the use of notations and investigate the relation these and the communicability diagnostic provided by SIM. CDN have been conceived to be combined with other methods and approaches. [Blackwell et al, 2003] Therefore, our intent to expand the results of semiotic inspection using CDN is totally legitimate.

After this first phase of analysis, we examined the indications we got and designed the internal triangulation experiment to investigate computer-mediated designer-user communication in BPMN modeling tasks using ARIS EXPRESS. We used first phase indications to define the user profile and the specific modeling tasks to be performed in a test experiment. This procedure provided the necessary cohesiveness between out method's phases and allowed us to investigate aspects of both the emission and the reception of the designer-user computer-mediated communication.

The leading participants' profile characteristic was defined as 'people with experience in business modeling'. This, we hoped, would reduce the chances of possible effects of not knowing how to perform the proposed tasks. We recruited four participants with experience in business modeling, but all of them used another business modeling notation (Event-Driven Process Chains [Davis et al, 2007]) in professional practice. They all knew the theory of BPMN, but had never really used it to build or modify a business model. Hence, they fit the ARIS EXPRESS targeted user profile as far as BPMN was concerned (beginners or occasional users). The profile of the main researcher herself was similar, which increased her awareness to identify what kinds of aids and scaffolds would be helpful to fulfill the proposed test tasks.

The domain selected for the experiment was known by all four participants, so the investigation could be totally focused on modeling with BPMN and interacting with ARIS EXPRESS. The process chosen for the experiment was the submitting a paper to a conference. This was a simple process, purposefully selected to keep the focus of the investigation on BPMN and ARIS EXPRESS.

Very briefly, the selected process starts when the author submits a paper for review. The reviewing coordinator checks if the paper topic is related to the conference. If so, the paper is forwarded to the reviewers. Reviewers then send their review to the review coordinator, who then notifies the paper's acceptance or rejection to author.

3.2 Data Analysis

After the execution of test experiments with all participants, the collected data (audio recording of the verbal protocols during the tasks performed, the modified version of the model used in the tasks, audio recording of interviews and the researcher's annotations made throughout the experiments) was analyzed.

The starting point for the analysis was the audio recording portion of the data. While listening to the audios, also guided by annotations made throughout the experiments, the researcher could identify communicability symptoms related to the understanding and use of notations (signification systems) offered by ARIS EXPRESS. These symptoms were detected and described using semiotic and cognitive characteristics that emerged from the first phase of the method.

DA was used because it provides additional evidence to support findings obtained with SIM and CDN. Specifically, because it can analyze natural language discourse about not only BPMN with ARIS EXPRESS, but also about other notations used to model business processes and about all the factors involved in performing the tasks proposed in the experiment, DA produces rich evidence that can describe or explain how users perceive and interpret signs and notations in the specific context of interest for our research. Hence, by combining DA with SIM and CDN we obtained a kind of closure to the interpretive analysis cycle of our investigation.

For triangulating the semiotic results of previous analysis, we analyzed the participants' discourse and the researcher's annotations looking for evidence of discrepancies between the designer's message and the users' interpretation of it. While the participant talked about his understanding about modeling and notation as presented by ARIS EXPRESS, the researcher asked further questions about relevant portions of the notation and interface signs that appeared to have been misunderstood in view of the designer's message. To verify and cross-check the evidence, the researcher got back to SIM results or even the CSMod tool interface itself.

For triangulating the cognitive results of previous analysis, we analyze the participants' discourse, using DA, where the evidences of semiotic issues where identified, by looking for elements in the notation that could be associated with any of the fourteen dimensions defined in CDN. Just like in phase 1, this cognitive exploration was motivated by semiotic evidence identified in the semiotic part of the analysis. CDN results from phase one were also used as input for the phase two analyses. Upon finding such elements we then examined the following factors:

- ***Presence or absence of corresponding cognitive characteristic.*** For example, upon finding evidence that the participant was talking about 'visibility' in BPMN with ARIS EXPRESS notations, we checked whether he or she was referring to the presence or absence (lack) of visibility in the notation.
- ***The impact of presence or absence of cognitive characteristics.*** For example, once we identified that the participant was talking about the presence of 'visibility' in a certain notation, we looked for evidence of value judgment: did this have a positive (+) or negative (-) impact on the participant's processes to perform the tasks proposed?

The combination of methods is governed by the communication (emission and reception) of design intent through interface signs. Therefore, SIM and DA are applied first. Once we have a characterization of the designers' message to the user for the tasks performed, we can proceed with CDN complemented by DA. The latter tells us how the designers' message is received and used by participants to accomplish specific goals, whereas CDN highlights specific cognitive characteristics of signs (emitted by designers and received by users). Together, the three help us gain a deeper understanding of modeling processes supported by various interface sub-languages (i. e. notations or representation systems), with their structural and functional inter-relations.

In the final diagnose phase, categorization of perceived symptoms and relations between semiotic and cognitive characteristics also appear to indicate issues with the "message", at emission (by designers or receive (by users) time, disturbing the participant in performing their tasks.

4 TASKS AND FINDINGS

Two tasks were defined to be performed by participants during the test experiment: 1) To narrate one's understanding about a business model designed in BPMN with

ARIS EXPRESS, and 2) to propose and execute a modification on the same business model using BPMN with ARIS EXPRESS.

4.1 Findings of phase one analysis

In this phase we identified the target user that ARIS EXPRESS' designers intend to communicate with through this tool's interface. The ARIS EXPRESS documentation indicates that this is a tool for both beginners in business process modeling and occasional users. There is a large amount of available documentation for the interested user (video tutorial, manual, etc.) and a very active discussion forum about the tool[2], but when it comes to actually supporting for modeling tasks in line, ARIS EXPRESS does not provide the support one would expert. The basic constraints of business modeling are communicated to the user (e. g. ARIS EXPRESS prevents the user from erroneously connecting two start events, the connector direction always goes out of an start event and always points towards an end event, etc.), but more complex support and orientation – which are precisely the problems that beginners are likely to face, for example – about the BPMN modeling language, the modeling process or the purpose of using models, none of these are available. It would be expected, since the user profile intended are beginners.

During the semiotic and cognitive inspections, we identified that ARIS EXPRESS relies heavily on the OMG[3] specification of BPMN [OMG, 2011a] to support the understanding and modeling tasks considering BPMN. In the documentation area of ARIS EXPRESS, all support information is redirected to the OMG website. In other words, ARIS EXPRESS designers delegate help and support to OMG. Considering that the participants in our experiment did not have experience in modeling with BPMN, we looked specifically for further notational support. ARIS EXPRESS provides a poster4 for quick reference. All the main elements of models are displayed on it. There are only a few elements of BPMN in the poster, with a brief description of their purpose in modeling purpose.

This complementary notation of ARIS EXPRESS was not considered enough for users without BPMN experience. So, we looked for more support regarding OMG specification, which according to ARIS EXPRESS is "responsible for BPMN", again a clear sign of delegation. We came across the BPMN poster at the OMG BPMN specification website . The BPMN poster (Figure 3) provided by OMG presents a larger number of elements and also complementary descriptions and variations of those elements. For example, the activity concept can be represented indicating seven different types of tasks element. When the activity is a manual task, a "hand" icon is displayed into the activity element.

2 http://www.ariscommunity.com/group/aris-express-support

3 The Object Management Group (OMG) is a non-profit computer industry consortium responsible for the UML and BPMN specification

4 http://www.ariscommunity.com/aris-express/poster

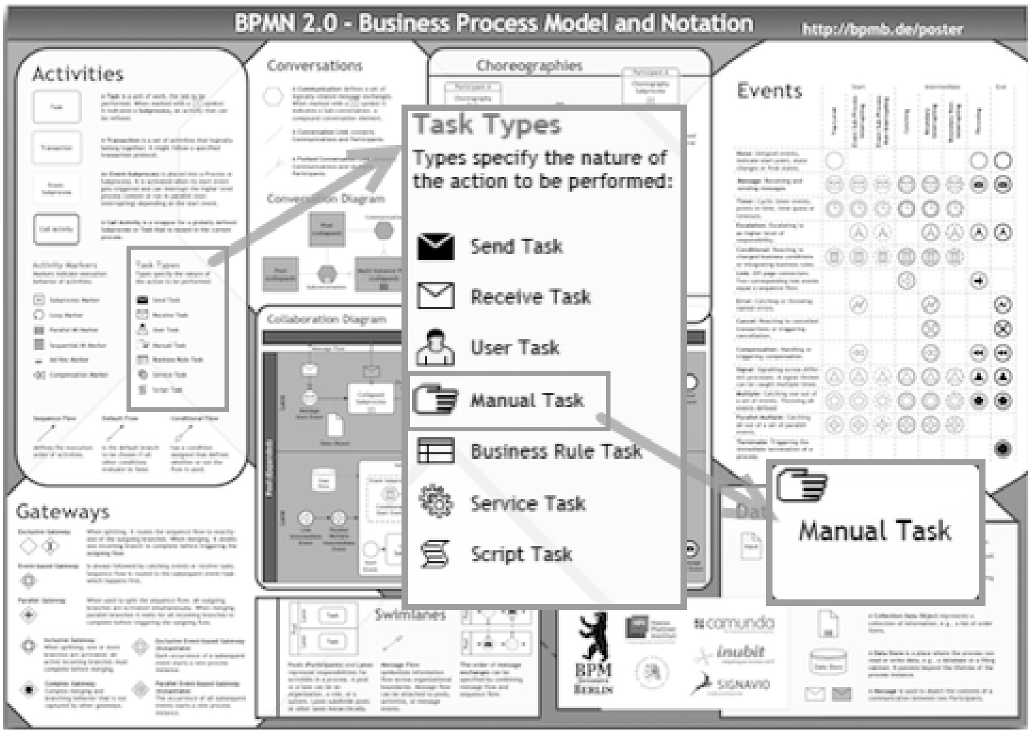


Figure 3. BPMN Poster by OMG with manual task highlighted

This resource seemed to be very useful for the participants that did not know BPMN in practice. It was taken as another type of notation that could enable the participant to perform the understanding and modification tasks proposed for the experiment. To investigate communicability aspects in this particular case, we decided to inspect representations for two types of tasks pertaining to the context of our experiment's process model: manual tasks and user tasks (Figure 4). Their meaning could only be completely clarified when combined with the OMG BPMN specification. [OMG, 2011a]

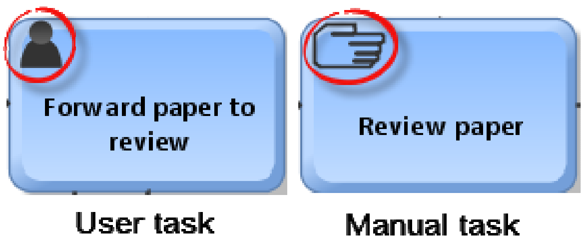


Figure 4. User and Manual task elements

The OMG BPMN specification defines a manual task as a type of task which is assigned to a person or group of people and is never actually executed by an IT system. A user task is a type of task where a human performs the task with the assistance of some software application. Because the latter pointed at a potentially ambiguous situation, where the reception of a message sent by the interface (the task icon) would probably need more notational support, not provided by the ARIS EXPRESS, we decided to use it in the experiment. Our aim was to see if the participants would get the message about the signification of task types as encoded by the notation's icons. Because of such findings during analysis, we decided to take the OMG BPMN specification and the BPMN poster as additional support material for the experiments.

The OMG BPMN specification defines a manual task as a type of task which is assigned to a person or group of people and is never actually executed by an IT system. A user task is a type of task where a human performs the task with the assistance of some software application. Because the latter pointed at a potentially ambiguous situation, where the reception of a message sent by the interface (the task icon) would probably need more notational support, not provided by the ARIS EXPRESS, we decided to use it in the experiment. Our aim was to see if the participants would get the message about the signification of task types as encoded by the notation's icons. Because of such findings during analysis, we decided to take the OMG BPMN specification and the BPMN poster as additional support material for the experiments.

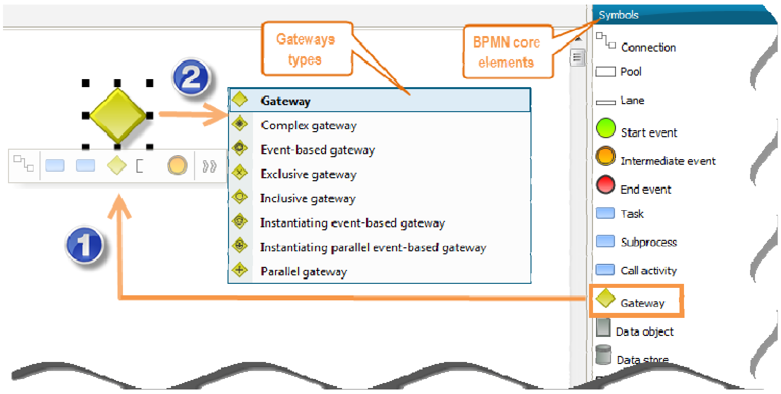


Figure 5. Core element and type definition

During this phase, we also identified a core set of model elements defined by the OMG BPMN specification [OMG, 2011a] that were the most salient elements offered by ARIS EXPRESS interface. This realization was only made possible by cross-referencing between ARIS notation and OMG BPMN specification. Such elements could be further detailed by subsequent typing, if applicable. For example, regarding the gateway element, once the user adds the core element into the process model (Figure 5-1), ARIS EXPRESS "asks" the user which type the user wishes to assign to this element (Figure 5-2). Figure 5 presents the gateway element and available types that users can associate to it in BPMN. This is an interesting strategy of communication in ARIS EXPRESS, to present BPMN elements in increasing levels of detail. However, we did not know how this strategy would be received by users. In order to have some feeling about reception, we decided to include an additional modeling tool (Signavio Process Editor5) for contrast.

The Signavio Process Editor[5] is a web-based process modeling platform and, as a result of academic initiative, it can be used free of charge. It was chosen as an extra modeling tool for the experiment, because its strategy for presenting the core elements and the complete set of BPMN elements is different from that of ARIS EXPRESS.

The user can choose to work with the complete set or only with the core elements of BPMN (Figure 6). This tool does not handle all of the BPMN elements. For example, tasks do not have types. However, because the purpose of including this second tool was only to investigate if the strategy of showing upfront the complexity of BPMN elements would benefit the participant or not, this was not considered to be a problem. The exact same business model presented in ARIS EXPRESS could be presented in the Signavio Process Editor. Furthermore, the inclusion of a second CSMod tool in the experiment had the advantage of stimulating the participants' comments and thoughts

5 http://www.signavio.com/en/academic.html

expressed in interviews. Nevertheless, the focus of research remained on ARIS EPRESS. Signavio was used only as a contrastive reference.

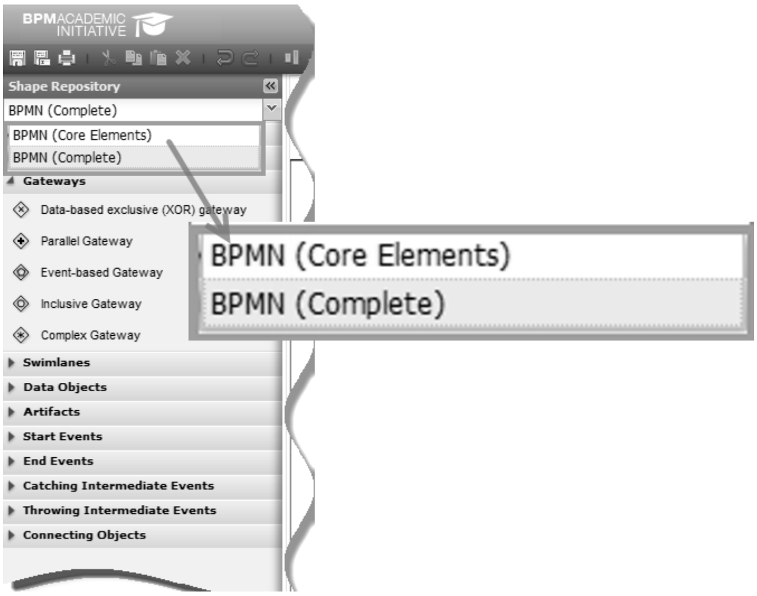


Figure 6. Signavio core and complete BPMN set of elements

Guided by findings at the end of phase one, we thus completed the design of the test experiment. There would be three parts in the whole procedure: 1) An explanation about the experiment's objective, its duration, the data collection methods used along the experiment (audio recording and annotations) and a presentation of support resources for notations (the BPMN poster, the ARIS EXPRESS poster and OMG specification of BPMN); 2) a presentation of the simple business process model to be used in the experiment, with an explanation of the two tasks that participants should be able to achieve with it: understanding what it means and modifying it; and finally 3) an interview to discuss various aspects of the experiment: BPMN and other notations for business modeling; the participant's experience with BPMN in the experiment and other situations; the use of support resources like the BPMN poster, the ARIS EXPRESS poster and the OMG specification of BPMN; the presentation of the same business model in Signavio Process Editor[5]; comments about the executed tasks in both systems, highlighting the differences between strategies to present the BPMN elements; and finally any other comments about the tasks, any clarification for the researcher about the participant interaction, or complementary information of any part.

4.2 Findings of phase two analysis

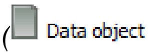
The experiment was carried out in accordance with the experiment design defined above. Some of the most relevant findings in phase two are presented next. An important preliminary observation about such findings is that most of the evidence came (not surprisingly) from the modification task, when supposedly understood meanings must be put to use for objective purposes. In the understanding task, all participants reported that they had an overall understanding of the process. They even offered suggestions for improving the process in a subsequent modification task, but when it came to actually using BPMN with ARIS EXPRESS to execute modifications, all of them were challenged. Either they needed some kind of external support, or they just verbalized that they did not know how to implement the idea that they had for modifying the process using BPMN with ARIS EXPRESS.

Two broad meaning categories emerged from the data:

•"Previous experience" - The participant narrates some situation that he had experienced in connection to modeling business process, which guided his choice of notations or interactions to perform the proposed tasks.

•"Aha! moment" - The participant suddenly gains instant understanding (insight) about ARIS EXPRESS and how it would serve his purpose to represent what he intended to do with the business process model.

The participants, in a way or another, also gave us evidence of the importance of defining their intent, what the model will be used for, before they select which elements will be needed to represent the model's designer's intent, what he wants to communicate to whom. The level of detail or abstraction in the model is fundamentally related to its purpose and its designer's intent. For different purposes, different representation views are needed. This sort of evidence was categorized as "Previous experience". Here is a piece to illustrate it:

"…for small processes like this there is no problem in using these elements (

), which are great to convey the understanding about the process. But when a process is too big, this kind of details pollutes the model … it might actually harm the understanding of the process 'overview."

This piece evidence refers to the large set of elements provided by BPMN, contrasted with the lack of any orientation or support on how they are going to be combined. Model building depends on the modeler's communication intent, therefore there should be some protocol to define which elements should be used or not, when, why, and so on. Presenting a set of basic elements, separated from non-basic ones, is not enough to help users decide which elements are necessary.

Using Ellis and Gibbs's notions of social and technological protocols frequently used in groupware applications to mediate inter-user communication and coordination [Ellis et al, 1991], our finding is that modelers may resort to social protocols trying to compensate for the lack of a technological protocol encoded into (and made available by) the CSMod.

Regarding the lack of communicative categorization of BPMN modeling elements, we see in it the cognitive challenges associated with CDN's diffuseness dimension, the complexity or verbosity of the notation in expressing meaning. Without notational guidance, modelers (i. e. model designers) are prone to representing too much or too little with their models. In other words, because the CSMod Tool has a diffuseness problem, the products generated by using it may also suffer from the same problem. BPMN goal is to account for many different levels of representation, as mentioned in it specification. [OMG, 2011a] However, in order to make efficient and effective use of BPMN, model designers need to know which vocabulary or style they should use so that the targeted recipients of the model can understand it and use it for their own purposes along the chain of the software development process.

We thus have evidence that the presence of diffuseness has a negative (-) impact on the completion tasks.

The importance of name choices in business process modeling was also evidenced and categorized as "Previous experience". The name assigned to a given task element needs to communicate to the user of the model what the task is and means in the context of the whole business process model. Here is an interesting testimony: "…the task name indicated 'what' is going to be done…ok, 'notify paper rejection', but how? Here (portion of the model in Figure 7) it is clear because the message element has the word ‘e-mail’ on its name, but what if I didn’t have [the word] “e-mail” in the name? How is the notification done?”

In this piece of evidence, we could trace cognitive characteristics associated with two CDN dimensions: closeness of mapping and role-expressiveness. Closeness of mapping refers to directly to name choices for ARIS EXPRESS models. Since no guidance is provided for this decision, the closeness of mapping in resulting models will depend on other factors, typically an external social protocol established by those who build and use the models. [Ellis et al, 1991] The same is true of role-expressiveness, which is the expression of the purpose of an entity (the element that carries its name), and its relations with other model components. An analysis of role-expressiveness will define whether the notation user (or interpreter) can tell the function and relation of model components just by resorting to the resources made available to him or her by the CSMod tool interface.

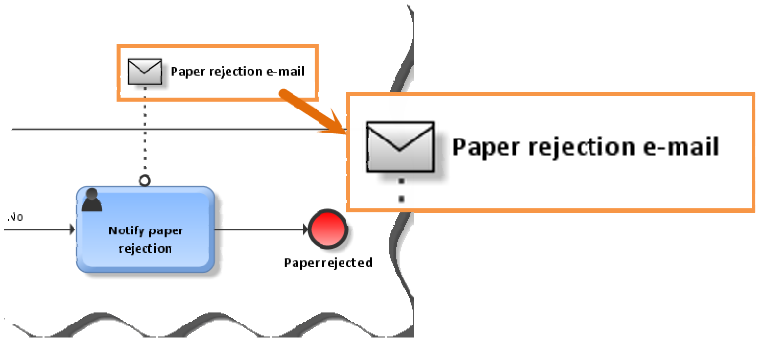


Figure 7. "Paper rejection e-mail" element

Let us take the illustration in Figure 7, as an example. The element in this situation is the task element and it is composed by its graphical representation () and the task name. However the naming criteria that lead to good communication of how the task relates to the whole process (which function it achieves, with or without the support of its relations with other model elements) is not part of any of the ARIS EXPRESS notational resources. Once again, good modeling practices will have to rely on some social protocol established outside ARIS EXPRESS. Both closeness of mapping and role-expressiveness cognitive characteristics were absent and had a negative (-) impact on the proposed task of understanding and use BPMN with ARIS EXPRESS for business modeling.

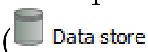
This case is different from the previous one, in the sense that we are not in face of an inheritance problem (i. e. the same problem verified in the modeling tool is handed down to the model it produces). We do not have a problem of ‘closeness of mapping’ or ‘role-expressiveness’ in BPMN or ARIS EXPRESS. We have a communicability problem – the designers fail to tell the users some critically important aspects of the modeling task. The result of such communicability issue is a potentially bad model, whose recipients will face the cognitive challenges associated with the indicated cognitive dimensions.

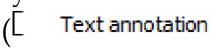
The BPMN user task and manual task (Figure 4) used in our experiment’s model, were associated with revealing further evidence of communicability issues for participants. These were categorized as “Aha! moment”. They could be identified because participants did not understand some of the language icons. Some participants queried the support material to get more information about BPMN, others did not. When the former got the section with task type descriptions, they suddenly gained a new understanding of the BPMN element (Aha! moment), which helped them to understand the model better. Before this happened, when questioned about which task they thought involved the use of IT in the process, they said that they needed more details to tell it.

But those queried the documentation found out that the task with the  icon was actually the one supported by IT. Those who had the insight confirmed that the right interpretation of model elements required more support because "the little doll" (which is what the image suggested to them) did not gave them the faintest hint about the use of IT for the task.

We related this evidence with the cognitive characteristics of abstraction, which refers to the level of abstraction (grouping) imposed by the notation. BPMN intends to communicate that the "doll icon" represents a task performed with IT support, but this was not the participants' understanding, until they went over the BPMN specification or poster. The BPMN with ARIS EXPRESS also bets on the user's capacity of abstraction to understand it. The abstraction cognitive characteristics were present and had a negative (-) impact on the proposed task of understanding and use BPMN with ARIS EXPRESS for business modeling.

This aspect has very strong relations with semiotic characteristics of visual representation languages. Abstraction is not easy to represent visually, in spite of all myths about the power of images. As Eco extensively shows in his Theory of Sign Production [Eco, 1976], icons are like texts in themselves. Categorical relations, like type/token (does the icon stand for a class or for an instance of objects?), as well as grammatical articulation (how do the various meaningful facets of the icon regularly relate to each other?), iconic representations are mostly prone to interpretive fluctuations that may – if fluctuations are not part of the communication intent – result in communicative breakdowns.

A work-around for trouble with this visual was further evidenced when one of the participants reported on the lack of a model element to represent the IT system: "…I saw two ways to do it: one is using the data store (

) [the other is] the text annotation (

) element…neither BPMN, nor ARIS EXPRESS restrict the use of those elements…this needs to be agreed prior to modeling, so that everybody modeling and using the models knows that the element represents an IT system…".

In this testimony, the participant also indicated the necessity of a prior agreement among model builders and model users. This is yet another indication that a social protocol is needed, in the absence of a technological protocol supported by the CSMod tool. This evidence fell into the "Previous experience" category, because the participant reported and implemented a solution based on previous experience in modeling projects.

This piece of evidence is associated with the cognitive characteristics of CDN's secondary notation, the ability to use notations beyond the formal syntax for expressing information or meaning. In this case, one element was used to represent what the user needed to communicate, although further social protocol agreements had to be made. The secondary notation cognitive characteristics were present and had a positive (+) impact on the proposed task.

The use of ARIS EXPRESS to perform the modification task played an "educational role" with respect to BPMN. It provided some scaffolds to help the user in getting to know more about BPMN. When the user chooses a basic element to be placed into the process model, a list of types of that elements are displayed (Figure 8), letting the user know that he may be more specific (or not) in building the model. This evidence was categorized as an “Aha! moment”. The cognitive characteristic related to evidence manifested by users who experienced this was visibility. ARIS EXPRESS presents a contextualized visualization of the notation, step by step, enabling the user to build his understanding of how to represent what is intended. First the user needs a gateway, and ARIS EXPRESS leads him to think about what kind of gateway he needs, as seen previously in Figure 5. CDN’s visibility cognitive characteristics were present and had a positive (+) impact on the proposed task of understanding and using BPMN with ARIS EXPRESS for business modeling. Another importantly revealing evidence in this case is that ARIS EXPRESS interface design supports model builders better than model readers, in the sense that the interactive scaffolds like gradual unfolding of elements are offered to the user who engages in model modification (or creation). The aspect we want to highlight is that models must be understood before they are modified, as our experiment has shown.

5 CONCLUDING REMARKS

This research has shown that the user profile that ARIS EXPRESS supposedly targets (occasional users and beginners) and the intended user profile that emerges from an analysis of its designers’ message through the system interface. There is very little support for beginners using BPMN with ARIS EXPRESS.

The most interesting results from this study, however, have to do with the partial perspective adopted by the designers of the CSMod we used in test experiments. In spite of agreeing that models are communication artifacts playing a critical role in software development, we have clear evidence that they apparently believe that it suffices to support the expression phase of communication (and yet, they sometimes fail to do it correctly, for example by delegating to OMG the responsibility to communicate about BPMN). The reception phase is left almost completely unattended, except for the occasional support that model readers can get if they try to tinker with the model (e. g. click on elements as if they were about to edit them).

We should remark that many resources that could be used to improve model reading (i. e. the reception of communication through models) are already in place for model creation, or should be. For example, a BPMN CSMod tool interface could be so designed as to highlight the user task and IT system relation when the model is being used. Since this is a critical feature for this type of task and the “doll” icon representation does not help the understanding, the interface could show the name of the software application that supports the model tasks when the user hovers the mouse over it. (Figure 8)

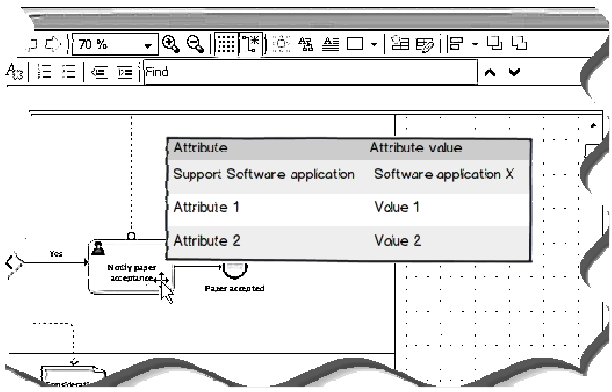


Figure 8. Software application that supports a User Task

A large volume of evidence pointed to the need of establishing a protocol outside the notation domain, so that the model designer would be able to build understandable representations. The participants reported that in their experience, regardless of notation or CSMod tool used, a social protocol among those who are building or making use of the models is indispensable. Thus we believe that the use of social protocols to overcome representational limitations is a path to investigate in trying to further the communicability of CSMod tools. The question to be addressed is: can such tools use the representational resources that they have (or should have) and support model reading as well as model building and editing? Information about signification agreements established in social protocols may provide insightful hints at the nature of representation and communication needs that may be more readily at hand than we suspect.

In the course of research towards the answer to the question above, we think that the combination of semiotic, cognitive and discourse analysis methods we have use covers the necessary range of phenomena that must be investigated if we want to discover the power of communication through models. Together, they can not only tell us about how the CSMod design message is composed and how it affects the users as they build, edit or read models with it, but also about the cognitive challenges associated with the supported notations.

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