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 users what model builders propose. Computer-supported modeling (CSMod) traditionally concentrates on helping users build models with various kinds of notations. 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 Business Process Modeling Notation (BPMN). 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: Computer-supported modeling, Semiotic engineering methods, Cognitive dimensions of notations, Discourse analysis, Communication, Modeling notation, BPMN.

1 Introduction

In software development professional practice, one of the main roles of models is to create and express common ground, that is, shared basic understanding of the essence of the modeled object, entity, event, or other. [1] 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.

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. [2]

Although CSMod tools have been extensively analyzed from a software engineering perspective [1] [3] [4], 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?

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Because the ultimate purpose of models in the context of software development activities is to 'communicate' meanings and to 'signify' common ground.

This paper reports on research based on Semiotic Engineering [5], 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. 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 is made available to the model builder. In this way he should be able to explore how his message can be received by other software development team members, across space and time.

We have done a qualitative study of a small-size modeling case using BPMN with ARIS EXPRESS (AE). [6] This in-depth study had two major phases. In the first one we carried out an inspection of AE using SIM, the Semiotic Inspection Method [7], along with a cognitive analysis of the notations that can be used with it. For this we used CDN, the Cognitive Dimensions of Notations Framework [8]. The second phase, in which we collected empirical data and additionally used discourse analysis (DA) [9], served as an internal triangulation for our research findings. We registered and analyzed four participants' modeling activities with AE 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. Moreover, we believe that the methodology that we have used - which we have been testing in totally different contexts - 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 and AE. Then we outline the methodology we have used: a two-phased analysis combining SIM, CDN and DA. Next we present our findings in each phase and our conclusions 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 and AE for the experiment because together they support the business modeling, which can be used as the starting point for software development, thus a means of communication between business stakeholders and software development professionals. Based on these models, the group defines the scope and context where technological support is meant to be applied. [4] [10]

BPMN is said to be readily understandable by all business players, from business analysts to technical developers [11] and it has been the object of several studies aiming at investigating its capability and suitability to represent the business context through modeling as well as exploring its capability to communicate and visualize

business contexts. [4] [12] Because of its research history, we decided to use BPMN in our investigation, combining the cognitive and semiotic power of CSMod tools in building communicative models.

AE [6] is a free modeling tool that offers a small subset of features from the professional ARIS Platform products[1]. It has been chosen because participants of our study knew how to use it, 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. Our research question in this study was: how does this tool support the process of 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 experiments, in various versions of models used in test tasks, and the researcher's annotations made throughout the experiments. Another important piece of evidence was the AE interface itself, which in this research is considered a key piece of empirical evidence of the CSMod tool design intent as communicated to the users via software.

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. This hybrid set of data was analyzed using a combination of three methods: SIM [7]; the CDN framework [8] and discourse analysis (DA) [9]. The method we used is a two-phased analysis with a final diagnose phase. All three phases were performed by the same researcher, as described below.

3.1 SIM and CDN Analysis of the CSMod Tool

The first phase of the method was carried out to give the researchers an in-depth understanding of AE as used for modeling business processes with BPMN. AE also supports other modeling notations, but the focus of this research lies solely on BPMN.

SIM helps us to identify the various sign systems and notations with which AE' designers communicate their entire design vision to users. This method allows us to characterize how interface designers organize 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."

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

In this message the first person "I" refers to the designer, whereas the "you" refers to the user. In accordance with Semiotic Engineering [5], 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.

Since SIM frames 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 to inspect cognitive dimensions of BPMN with AE 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).

CDN proposes a set of design principles for creating or evaluating notations. In practice, it provides a common vocabulary for discussing many cognitive factors of such representation systems. CDN have been conceived to be combined with other methods and approaches. [8] 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 AE. This procedure provided the necessary cohesiveness between method's phases and allowed us to investigate aspects of both the emission and the reception of the designer-user computer-mediated communication.

We recruited four participants with experience in business modeling, but none of them had really used BPMN in *professional* practice. This an explicitly targeted user profile for AE (beginners or occasional users). The profile of the main researcher herself was similar, which increased her awareness in identifying 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 the modeling tasks using BPMN with AE. The process chosen for the experiment was the submission of a paper to a conference. This was a simple process, purposefully selected to keep the focus of the investigation on BPMN and AE.

3.2 Triangulating Results with Empirical Observation and Discourse 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.

We looked for empirical evidence of occasional discrepancies between the designer's communicative intent and the users' interpretation. We used DA to analyze the participants' discourse and collect signs of how they received the designers' message. While listening to the audios, guided by additional annotations made throughout the experiments, the researcher identified symptoms of communication breakdowns regarding the interpretation and use of notations deployed by AE. These symptoms

were detected and technically characterized according to the AE designer's communication strategies (SIM) and their presumed cognitive impact on users (CDN). Upon finding such elements we then examined two factors that together connect CDN and SIM, that is, they allow us to relate semiotic characteristics of communication through interface signs and notations with the empirical evidence of cognitive processes that are in place when the communication is received. The two factors are:

- Presence or absence of a corresponding CDN feature. For example, upon finding discourse evidence that the participant was talking about '*visibility*' in BPMN with AE notations, we checked whether he or she was referring to the presence or absence (lack) of visibility in the notation.
- The perceived impact of presence or absence of CDN features. For example, once in the presence of evidence regarding '*visibility*', we looked for discourse evidence of value judgment: did this have a positive (+) or negative (-) impact on the participant's performance during the proposed task?

In the final diagnose step of the method, a categorization of perceived symptoms of communication breakdowns (phase 1) along with the relations between semiotic/cognitive characteristics and the participants discourse about their experience (phase 2) contributed to indicating significant aspects of the communication-through-models process in this case study.

4 Tasks and Findings

Two tasks were used in this experiment: 1) To narrate one's understanding of a proposed business model built with AE using BPMN; and 2) To propose and execute a modification of this specific business model using BPMN with AE.

4.1 Findings from Semiotic and Cognitive Inspections

We identified the targeted user that AE' designers are addressing through the interface by looking at AE documentation. It says that this is a tool for beginners in business process modeling and also for occasional users. There is a large amount of documentation available (video tutorial, manual, etc.), but when it comes to actually supporting modeling tasks *in line*, AE is not as helpful as one would expect. The basic constraints of business modeling are communicated to the user (e. g. constraints for connecting types of elements), but active orientation and support for using the BPMN language in modeling process are not available. This would not only be expected, given the targeted users, but also perfectly feasible (technologies providing *over the shoulder* task-related help are used in most office applications, for example).

During semiotic and cognitive inspections, we also identified that AE relies heavily on the OMG[2] specification of BPMN [11] to support the understanding and modeling

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

tasks. In other words, AE designers delegate help and support to OMG. Since our participants, didn't have much experience in modeling with BPMN, we looked specifically for notational support material. Two complementary resources were found: the AE poster[3], provided by AE documentation, and the BPMN poster[4], provided by OMG specification, which according to AE is "responsible for BPMN". The latter seemed very useful for participants with little practice in using BPMN. 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 process tasks and user process tasks (Fig. 1). Their meaning could only be completely clarified when the poster was combined with the complete OMG BPMN specification.

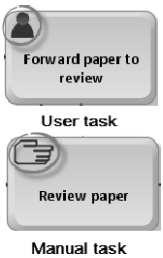

Fig. 1. User and Manual process task elements

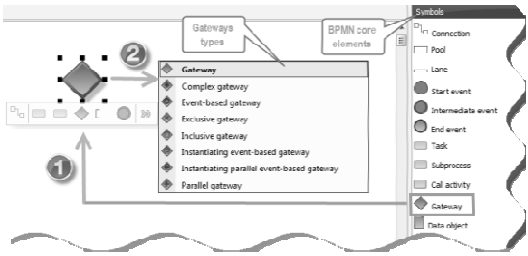

Fig. 2. Core element and type definition

Manual tasks are defined as those whose achievement is assigned to a person or group of people, never actually being executed by an IT system. *User tasks* are those performed by a human being with the assistance of some IT system. Because the latter pointed at a potentially ambiguous situation (is it a user's or a system's task?), and the reception of the message sent through the interface (where this task is represented by a "puppet" icon) would probably need more notational support, not provided by the AE, we concluded that this case would be particularly interesting to explore in our subsequent experiment test. We also concluded that, to support participants fairly while they would be trying to interpret interface signs, we should give them access to the OMG BPMN specification, the BPMN poster and the AE poster.

In the initial inspection phase, we also identified a core set of model elements defined by the OMG BPMN specification [11] that were the most salient elements offered by AE interface. 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 (Fig. 2-1) AE "asks" the user which type he wishes to assign to this element (Fig. 2-2). This is an interesting strategy of communication in AE, to present BPMN elements in increasing levels of detail. However, we did not know how this strategy would be received by users.

[3] http://www.ariscommunity.com/aris-express/poster
[4] http://www.bpmb.de/index.php/BPMNPoster

Guided by findings of phase one, we thus completed the design of the test experiment. The experiment was divided in three parts: 1) an explanation about the experiment's objective, duration, data collection methods, and a presentation of support resources for notations; 2) a presentation of the business process model to be used in the experiment and the tasks to be performed, an understanding what it means and how to modify it; and finally 3) an interview to discuss aspects of the experiment, the notations for business modeling, the participant's experience with BPMN, the use of support resources, their comments about the executed tasks, and free conversation about additional relevant aspects spontaneously raised during the interview.

4.2 Findings from Empirical Observations and Discourse Analysis

We should remark about findings in the second phase of our study that most of the evidence came (not surprisingly) from the *modification* task, when supposedly understood meanings had to be put to use for objective purposes. When it came to using BPMN with AE to *execute* actual modifications, participants either needed some kind of external support, or they just verbalized that they did not know how to express the idea that they had in mind for modifying the process using BPMN with AE.

Two broad meaning categories emerged from the data: 1) "*Previous experience*" - The participant narrates a situation experienced by him regarding business process modeling, which guided his choice to perform the proposed tasks; and 2) "*Aha! moment*" - The participant has a sudden insight about AE and how it would serve his purpose to represent what he intends to do with the business process model. Although finer meaning categories were clearly detectable, for the purposes of the research reported in this paper, the broad categories just mentioned are sufficiently expressive.

Participants gave us evidence of the importance of defining the model's purpose (the builder's intent) and the targeted model users. This powerful kind of evidence for an investigation about communication though models 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 (Data object *), 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 prevent [one from] understanding the process 'overview'."*

This piece of evidence refers to the large set of elements provided by BPMN, contrasted with the lack of orientation or support about how they are going to be combined to *mean* something. The evidence suggests that there should be some protocol (between modelers themselves and between modelers and users) defining which elements should be used or not, when, why, and so on.

Using Ellis and Gibbs's distinctions between social and technological protocols frequently used in groupware [13], we found evidence from interviews that modelers occasionally resort to social protocols when trying to compensate for the lack of technological communication and task-supportive inter-user protocols encoded into the CSMod tool. For example, since BPMN goal is to account for many different levels of representation [11], there are in this notation cognitive challenges associated with

CDN's *diffuseness* dimension*, the complexity or verbosity of the notation in expressing meaning*. In order to make efficient and effective use of BPMN, we learned that model builders need to know which "vocabulary" they should use so that the targeted model users can understand it and wield it for their own purposes. This was taken as evidence that the presence of *diffuseness* has a negative (-) impact (social protocol overheads) on the completion tasks.

The manual and user process tasks used in our experiment led to further evidence of communicability issues. Because issues were revealed by participants' insights that corrected previous misinterpretations, we categorized them as "*Aha! moment*". Typically participants did not understand a number of visual language elements. Some queried the support material for more information. When they got to the section with task type descriptions, they suddenly gained a new understanding, which helped them make a better sense of the model they were working with. This has to do with the cognitive dimension called *closeness of mapping*, *closeness of the representation to the domain.* BPMN is designed to communicate that the "puppet icon" (Fig. 1) represents a task performed by an individual or group *with* IT support necessarily. Since there are processes that are done by users *without* IT intervention, the notation, depicting a single human figure, was very confusing. Participants only *got the message* when they went over the BPMN specification.

A work-around for trouble with the visual representation of IT support 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 to use the data store (* Data store *) [the other is] the text annotation (* Text annotation *) element…neither BPMN, nor AE 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…".*

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, even if further social protocol agreements had to be made to achieve effective communication. The *secondary notation* cognitive characteristics were present and had a positive (+) impact on the proposed task.

The use of AE to perform the modification task played an "educational role" with respect to BPMN. It provided scaffolds to help users in getting to know more about BPMN. In the AE interface, when users choose an element to be placed in the process model, the list of this element's types are displayed, letting users know that they can be more specific in building the model. Evidence of how this was used (Fig. 2) was categorized as *"Aha! moments*". The corresponding cognitive characteristic was *visibility*, *ability to view all components simultaneously or two related components side by side at the same time*. In the illustrated situation in Fig. 2 the user needs a gateway, and AE leads him to think about what kind of gateway should be used. CDN's *visibility* characteristics were present and had a positive (+) impact on the achievement of the proposed task.

Another importantly revealing evidence in this case is that the AE interface design supports model builders better than model readers, in the sense that the interactive scaffolds like gradual unfolding of elements are offered only to the user who engages in model modification (or creation). Readers, however, would benefit much from unfolding the meaning and purpose of models built by others in very similar ways.

5 On Communication through Models

This research has shown that there are mismatches between the user profile that AE supposedly targets (occasional users and beginners) and the one that emerges from an analysis of emission and reception of its designers' message. Our study shows that the designers of the CSMod we used in experiments have in fact adopted a partial and more limited perspective than technology enables. In spite of agreeing that models are communication artifacts playing a critical role in software development, evidence indicates that they apparently believe that it suffices to support the *expression* of communication and *interpretation* will take care of itself. In other words, the reception phase of the overall communicative process 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 are already in place for model creation, or should be. For a flavor, 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* (not *built*). Since this is a critical feature for this type of task and the conventional "puppet" icon representation doesn't help understanding, the interface could easily show the name of the IT system that supports the tasks when the user hovered the mouse over it.

A large volume of evidence pointed to the need of a protocol outside the notation domain, so that the model builder would be able to build understandable representations. The participants reported that in their experience, a *social protocol* among those who are building or making use of the models is indispensable. 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 existing representational resources and support model building, reading and editing? Can information about signification agreements established in social protocolsbe at least partially encoded in technology?

In the course of research towards the answer to the questions above, we think that the combination of semiotic, cognitive and discourse analysis methods we have used conveniently covers the wide 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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References

1. Tortora, G.: UML in software engineering practice: Does the experience level matter? In: International Conference on Advances in ICT for Emerging Regions (ICTer), p. 88 (2011)
2. OMG, Unified Modeling Language (UML), V2.4.1- Infrastructure specification, Object Management Group (OMG), OMG Document formal/2011-08-05 (2011)
3. Moody, D.L.: The "Physics" of Notations: Toward a Scientific Basis for Constructing Visual Notations in Software Engineering. IEEE Transactions Software Engineering 35(6), 756–779 (2009)
4. Zhao, L., Letsholo, K., Chioasca, E., Sampaio, S., Sampaio, P.: Can business process modeling bridge the gap between business and information systems? In: Proceedings of SAC 2012, pp. 1723–1724. ACM, USA (2012)
5. De Souza, C.S.: The Semiotic Engineering of Human–Computer Interaction. The MIT Press, Cambridge (2005)
6. AG Software, ARIS EXPRESS, `http://www.ariscommunity.com/aris-express`
7. De Souza, C.S., Leitão, C.F.: Semiotic engineering methods for scientific research in HCI. Morgan & Claypool, Princeton (2009)
8. Blackwell, A., Green, T.: Notational systems: The cognitive dimensions of notations framework. In: Carroll, J.M. (ed.) HCI Models, Theories and Frameworks: Toward a Multidisciplinary Science, San Francisco, pp. 103–134 (2003)
9. Gee, J.P.: An Introduction to Discourse Analysis: Theory and Method. Routledge, London (2005)
10. Gruhn, V., Laue, R.: Reducing the cognitive complexity of business process models. In: 8th Cognitive Informatics, ICCI 2009, pp. 339–345 (2009)
11. OMG, Business Process Model and Notation (BPMN), Version 2.0, Object Management Group (OMG), OMG Document formal/2011-01-03 (2011)
12. Wohed, P., van der Aalst, W.M.P., Dumas, M., ter Hofstede, A.H.M., Russell, N.: On the suitability of BPMN for business process modelling. In: Dustdar, S., Fiadeiro, J.L., Sheth, A.P. (eds.) BPM 2006. LNCS, vol. 4102, pp. 161–176. Springer, Heidelberg (2006)
13. Ellis, C., Gibbs, S.: Groupware: some issues and experiences. Communications of the ACM 34 (1991)