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The Effect Of Process Map Design Quality On Process Management Success

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Abstract

Process maps are intensively used by organizations to provide a holistic view of all processes and the relationships between them. They assist in easier navigation through the processes and enable an understanding of the company's operations without necessarily going into process depth. Regardless of their apparent significance, hardly any research has been done in conceptualizing process map design. In this paper, we bring awareness to this topic, by assessing the compliance of 15 process maps to the nine principles for cognitively effective design of visual notations introduced by Moody (2009). In addition, we employ the cognitive fit theory to verify if the process maps are designed in accordance to the goals companies planned to achieve through BPM. By this means, we were able to reach conclusions, such that a process map that does not comply with the criteria stated by the principles is difficult to interpret, and thereby yields unwanted, unanticipated or no beneficial effects.

Keywords: Process Map, Visual Notation, Cognitive Effectiveness, Cognitive Fit Theory, Process Management Success.

1 Introduction

Process maps are embraced by organizations as the foundation of business process management (BPM) initiatives. They play an important role in providing an overview of all processes, such that the basic functioning of a company can be understood without necessarily going into details, which are typically shown in singular BPMN process model. In contrast, the process map focuses on depicting classifications, relationships and dependencies between singular processes. These aspects are typically shown as a visual representation serving as means for basic communication and for increased understanding of current business processes (Kesari, Chang, & Seddon, 2003). Based on the process map design, the next steps of the BPM lifecycle could successively follow (Dumas, et al., 2013). In view of that, the process map quality is essential for process management success.

Many research efforts have been done on the design and redesign of process models (Kock, et al., 2008). Lately, new techniques for navigating through large collections of process models have been the focal point of research (e.g. Raduescu, et al., 2006; Dijkman, et al., 2012; Zhiqiang, et al., 2012). One way of dealing with a big amount of models is through the use of a process architecture. A process architecture is a collection of systematically organized process models within one organization (Malinova, et al., 2013). Typically a process map is the entrance to the different levels of a process architecture, where the detailed process modeling takes place. Different approaches to process architecture design have been defined (e.g. Dijkman, et al., 2011; Malinova, et al., 2013). Also the significance of process architecture for BPM success has been emphasized (e.g. Sedera, et al., 2004; Bandara, et al., 2005; Rosemann, 2006). Regardless of its evident importance, process map design has hardly been subject to research. Practitioners seem to approach this challenge rather as an art where they rely on their own creativity and a loosely defined set of concepts in designing a process map. As a result, a diversity of process map designs is used in practice, despite that most aim towards the same goal. Many of them are evident cases of craftsmanship, where the concepts used for their design are not based on generally accepted engineering principles for designing visual notations (Moody, 2009). Since the appeal of a model has an effect on the user's usage, it is important for such to be designed appropriately (Recker, et al., 2011). Given this diversity, there is a strong demand for research into the concepts used and represented in a process map.

In this paper we address this gap by assessing the cognitive effectiveness of process maps from 15 organizations. We do this by examining the degree to which process maps comply with the principles for designing cognitively effective visual notations (Moody, 2009). In addition, we employ the cognitive fit theory, where we argue that a process map that does not comply with the criteria stated by the principles is difficult to interpret, and thereby yields unwanted, unanticipated or no beneficial effects.

The next sections of this paper are structured as follows. First, we present the state of the art, where we define a process map and clarify its role. Next, we revisit existing literature concerning process maps and process architectures, complementing it with some examples from practice. Then we discuss our analysis approach. After that, we present our findings in two parts. First, we show the extent to which the process maps have been designed according to the principles introduced by Moody (2009). Next, we analyse the cognitive fit of the process map design with the respective goals the company initially had with BPM and compare this to the effects they experienced. In the last section we provide implications of our study for practice and research, and a summary of our contributions.

2 Background

Process maps provide an aggregated visual overview of all processes of an organization. They facilitate basic understanding of the way an organization operates, without necessarily going into details. Process maps normally depict various process categories, where ideally an emphasis is placed on the processes core to the organization. A process is considered to be core if it directly contributes to sales. All the other processes are either parts of a core process, or ones that manage, support or measure its performance. While a single process model shows a detailed description of the process flow, a process map depicts the set of all processes in a company and how they are related to each other. Process maps design involves two steps. First, all processes an organization consists of are collected, and the process dependencies are clearly defined. Second, appropriate symbols to represent the processes and their relationships should be picked and depicted, such that an easier navigation through the processes will be enabled (Tolsby, 1993). It has been reasoned that an obvious communication flow between processes contributes to a good understanding of business process models, hence enabling a higher success rate than one that is harder to interpret due to hidden process dependencies (Kock, et al., 2008).

Up until now a considerable amount of research has been done on BPM practice and tools for business process modelling. Often, they refer to process maps as an important step of the BPM initiative. A study by Heinrich et al. (2009) suggests some requirements for developing a process map. They claim that process redundancy could be avoided through process standardization, and a process map facilitates process standardization. Weske as well argues that by clearly identifying the interfaces of the processes, sources of inefficiencies would be avoided (Weske, 2010, p.47). In his book he illustrates a process map of a manufacturing company, where processes are depicted and their dependencies are clearly indicated (Schmelzer, et al., 2006; Weske, 2010). Harmon gives an example of a process map containing three types of processes: core, management and support. He states that the core processes describe a value-chain in terms of sub-processes, whereas the other two process categories are used to support its performance (Harmon, 2007, p.82-86). Similarly, the Architecture of Integrated Information Systems (ARIS) also proposes the use of value chains where in addition the inputs and outputs of processes are shown (Davis, 2001).

Also the creation of a process map has been discussed. Zur Muehlen designs a process architecture for storing BPMN models, where the first level is the so-called milestones level, that serves as a process map of the most important processes (zur Muehlen, et al., 2010). This process map outlines phases of the process that end in milestones. He claims that this manner of storing processes is easily transferable to other organizations that need to manage the quality of BPMN models in large-scale modelling. Dijkman et al. (2011) propose for organizations to make a distinction between shapes for primary and support processes. This makes it easier to identify the primary processes that directly add value for the client, while the rest only supports their execution. The study by Malinova et al. (2013) on the other hand empirically identified the way organizations store their process models on the different levels of a process architecture. They identify four process architecture designs, and state that in addition to each organization classifying their process models in different business units, they could be furthermore hierarchically decomposed. This is illustrated through a process map consisting of compartments containing process models with a particular granularity. Yet another study about process architectures identifies patterns for possible relations between process models and anti-patterns used for representing process interdependencies in a process architecture (Eid-Sabbagh, et al., 2012). They argue that by using this approach, errors that occur in process model collections could be potentially avoided, eventually providing better understanding of the interdependencies between the process models.

Nevertheless, to the best of our knowledge there have been hardly any studies on the design of process maps. As a result of the evident lack in concept standardization for process maps, companies rather rely on their own design capabilities. Addressing this gap has been the motivation for this study towards a cognitively effective design of process maps.

3 Research Design

For our study we employ the Physics of Notations and its nine principles proposed by Moody (2009). These principles are Semiotic clarity, Perceptual discriminability, Semantic transparency, Complexity management, Cognitive integration, Visual effectiveness, Dual coding, Graphic economy and

Cognitive fit. They provide the basis of discussing visual notations from the perspective of cognitive effectiveness. This collection of principles is well suited for studying process maps due to their sometimes rich and colourful representation and because they rely on the extent to which the visual variables introduced by Bertin (1983) have been used within one visual representation. The visual variables include horizontal and vertical position, shape, size, colour, brightness, orientation and texture. Also the fact that elements in process maps have not yet been standardized suggests an analysis rather from a visual angle as opposed to a formal angle. Finally, it has been shown in relation to detailed process models like BPMN that the consideration of these principles has a significant effect on understanding (Figl, et al., 2012). Next, we describe the collection of process maps we investigated and the way we conducted the analysis.

3.1 Data Collection

We used two sources to collect the data from 15 different organizations involved in this study. First, we conducted interviews with 8 organizations that also provided us with prints of their process map. We also extracted that portion of the interview transcripts concerning their reasons for adopting BPM and the consequent effects. The other 7 organizations stem from published case studies, where the process map of the company was included, and the reasons and consequences the organizations want to achieve through BPM were clearly stated (Kern, 2012). Table 1 shows the process map ID and the organization's respective industry.

ID	Industry	ID	Industry	ID	Industry
PM1	Service/Airline	PM6	Service/Bank	PM11	Service/Consulting
PM2	Service/Bank	PM7	Manufacturing/Energy	PM12	Service/Medical
PM3	Service/Insurance	PM8	Service/Public Transportation	PM13	Service/Retail
PM4	Service/Hospital	PM9	Service/Real Estate	PM14	Service/Consulting
PM5	Service/Waste Management	PM10	Manufacturing/Energy	PM15	Service/Insurance

Table 1. Industries

3.2 Process Map Analysis

The analysis is done in two stages. First, we assess the cognitive effectiveness of the process maps. We only focus on the design of a process map, without going into the process details. We evaluate the extent to which the process maps are designed according to the principles for designing cognitive effective visual notations (Moody, 2009). A process map is cognitively effective if it is self-explanatory, hence not much effort is needed for a user to understand how the company operates. To evaluate this, we examine for each principle the extent to which different visual variables are used for the elements of the process maps (Bertin, 1983; Moody, 2009). Additionally, we study the process relationships, where a relationship could be explicit or implicit. A relationship could exist between processes belonging to the same or different process category.

Second, we use cognitive fit theory in order to examine if a cognitive fit exists between the way a process map has been designed, and the goals companies had with process management. According to this theory, a cognitive fit would support the goal achievement of the company (Vessey, 1991). Hence, we examine the process maps in order to discover if a process map design infers certain meaning, and if this meaning leads to an effect towards achieving some of the initial goals. We argue that if a process map that does not conform to the criteria stated by the principles is difficult to interpret, thereby yielding unwanted, unanticipated or no beneficial effects.

4 Research Findings

4.1 Primary Notation

Each process map represents some knowledge about the processes in an organization. There are two types of notations used for knowledge representation. Primary notation (or formal syntax) concerns the formal concepts used in all process maps, something that is there without the aid of visual representation. Secondary notation (or concrete syntax) goes beyond the formal concepts, and is typically used to increase the cognitive effectiveness of the information conveyed (La Rosa, et al., 2011). We observed commonalities in the primary notation the process maps provide. We found that companies typically differentiate between six categories of processes. *Management processes* are concerned with the development of the company's strategy and usually manage the core processes. *Core processes* are those most important for the company (e.g. processes that contribute to the profit; routine processes). Similarly, *Main processes* have direct impact on value-creation. *Support processes* support the execution mainly of the core (or main) processes and are called by necessity. *Sub-processes* are part processes of a core (or main) process that need to be executed in order for the core (or main) process to complete. *Analysis & Measure processes* are processes that are used to analyse and measure all processes in an organization.

Besides the six process categories, there were also some evident relationships between the processes. These we classified into internal and external relationships. Internal relationships are those that happen between processes that belong to the same category of processes. Such a relationship could be a core-to-core process relationship, which indicates that there is a process order among the core processes. Another internal relationship is process containment, where a subset of sub-processes is contained within one core (or main) process. External relationships on the other hand appear in a process map where there is a notion of an input and output. These process maps clearly indicate the input and output of some processes (e.g. customer, supplier and/or product).

4.2 Secondary notation

Primary notation alone is not sufficient for a process map to clearly depict how a company operates. In the absence of such explicit knowledge, practitioners often apply informal solutions such as the use of secondary notation (Moody, 2009). Secondary notation is when additional visual variables are utilized in order to help encoding the intended information of a process map. We observed a set of symbols companies use beyond the primary notation (Table 2). Each symbol has some meaning and a unique ID which we use during the course of this paper. A combination of the symbols typically forms one process map.

Symbol	Description	Symbol	Description
s1	Explicit process order	s7	Process
s2	Implicit process order	s8	Process
s3	Implicit process influence	s9	Process
s4	Explicit process order	s10	Process
s5	Input/Output		
s6	Process contains subprocesses	s11	(Process category)

Table 2. Symbol Description

Figure 1 portrays the 15 process maps used for this study, depicting only the secondary notation. Each row is a process category, starting from the first row where the management processes are show, until the last row where the analysis & measure processes are stored. Note that there is no special row for the sub-processes, but instead they are contained in the core or main processes. Each process map has a unique ID, which we refer to throughout the rest of this paper.

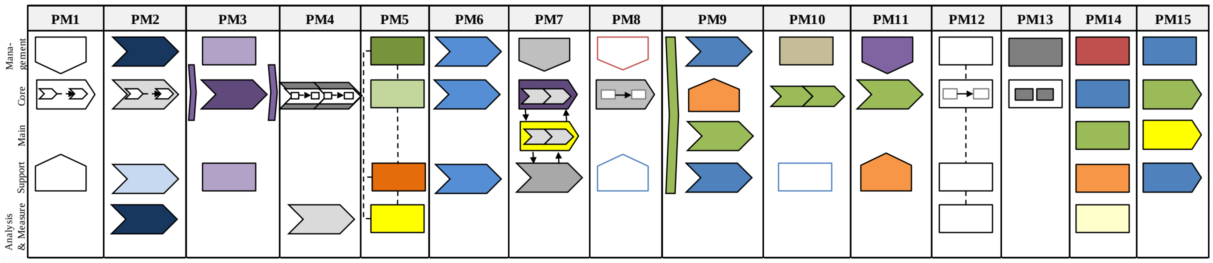

Figure 1. Process Maps

4.3 Evaluation of the cognitive effectiveness of Process Map design

Moody (2009) introduces nine principles for designing cognitively effective visual notations. Based on this work, we evaluate the conformity of each process map with the principles and the help of the visual variables introduced by Bertin (1983).

Semiotic clarity (P1) states that one symbol should correspond to exactly one semantic construct (Moody, 2009). We assume that management, core, main, support, sub- and analysis & measure processes have similar purpose in all organizations, hence according to this principle all process maps should represent these processes using the same or similar symbol. However, in practice this is not the case. We found that multiple symbols are used to represent the processes belonging to the same category, ensuing symbol redundancy (Figure 2). Similarly, more process categories use the same symbol to represent one meaning, ensuing symbol overload. To clarify as shown in Figure 2, three process maps use s7, seven process maps use s8 and four process maps use s9 to represent the management processes, thus resulting in symbol overload.

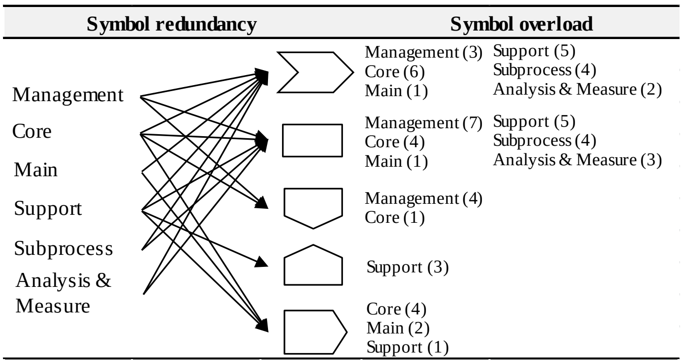

Figure 2. Semiotic Clarity

Perceptual discriminability (P2) ensures that the different symbols used in a process map are easily distinguishable from each other (Moody, 2009). According to this principle, a process belonging to one category should have at least one characteristic that makes it distinguishable from the processes belonging to the other categories. In particular, core processes should be emphasized, as these typically form the core competence of the company. The perceptual discriminability of each process map is measured based on the visual distance between the symbols used to represent the processes in each category. The visual distance is the number of visual variables on which the symbols from each category differ (Moody, 2009).

In Figure 1 we can see process maps varying in the visual distance. There are process maps where only one visual variable is used to represent all processes from all categories, hence the visual distance being zero (e.g. PM6, PM12). As a result these process maps are difficult to interpret. On the other hand, we also observe that process maps that use only one symbol for all processes use additional visual variables, such as color (e.g. PM14), brightness (e.g. PM4, PM13) or size (e.g. PM2, PM5). The darker the color (e.g. PM4, PM13), or the bigger the size (e.g. PM2, PM5), the more probable it is that the process belongs to the core category. Besides, there are process maps that use different symbols for each process category (e.g. PM1, PM3, PM7, PM8, PM9, PM10, PM11, PM15). In particular, emphasis is placed on the core process category, where usually the shape, color and/or size are pronounced (e.g. PM1, PM3, PM8, PM10, PM11). This enables users to intuitively focus on the important processes as these values are readably distinguishable by the human mind (Bertin, 1983; Moody, 2009).

Semantic transparency (P3) exists when the symbols used for the processes imply the contents of the process category (Moody, 2009). Additionally, we check if the relationship between the processes is semantically transparent. A semantically transparent relationship could be explicit or implicit, and could exist between processes belonging to the same or different category. An explicit relationship is one that through additional shapes (s1) or proximity between two processes (s4), a relationship could be immediately inferred. An implicit relationship is one in which through the shape (e.g. s2, s3, s7) or position of the processes, some process relationship or influence could be deduced. This principle only focuses on the relationship between processes belonging to the same category. The relationship between processes belonging to different categories is later on assessed by the principle of cognitive integration.

Figure 1 shows that all shapes used to denote the processes are mnemonic, that is, the meaning of the process is implied by its shape. Such as the arrow-shaped process (s7) (e.g. PM2, PM3, PM4, PM6, PM7, PM9, PM10, PM11) implies some process order. The horizontal pentagon-shaped process (s11) (e.g. PM1, PM7, PM8, PM15) could also imply process order, but also a process category. The vertical pentagon-shaped processes (s9, s10) imply some support towards the processes it points to. And the rectangle-shaped processes (s8) indicate a single activity. However, this is insufficient to make absolute statements. For that reason, we classify the shapes in the category of *semantic mnemonicity*, where additional explanation is necessary in order to infer the meaning of the process category (Moody, 2009). Besides, many process maps explicitly show the subset of sub-processes contained in a core process (e.g. PM1, PM2, PM4, PM7, PM8, PM12, PM13). Namely, for a core process to be performed, a set of sub-processes needs to be executed. Similarly, some process maps indicate the process order, either by the help of an arrow (s1, s2), or the proximity between the processes (s4) (e.g. PM4, PM7, PM8, PM10, PM12).

Complexity management (P4) is the ability of a visual notation to represent information without overloading the human mind (Moody, 2009). In this context, it is the ability of a process map to represent the operations of a company, such that a user would be able to discriminate between the process map elements and to comprehend the number of elements on the process map at a single time (Moody, 2009). The most common mechanism for dealing with this type of complexity is by categorizing the different processes. This is initially shown through the primary notation, where the processes are divided into different categories, each category having a distinct name (management-, core-, main-, support-, sub-, analysis & measure processes) and containing only one type of shape. In addition to the names, some process maps also emphasize certain process categories with a different color. This helps users to immediately recognize the core process category (e.g. PM1, PM6, PM8, PM10).

Cognitive integration (P5) makes sure that the different process categories are integrated with each other. We observe that the combination of symbols used within one process map helps in understanding the dependency between the process categories. Here again, we differentiate between explicit and implicit dependency. For instance, the dependency of the process categories is implicitly shown in the process maps PM1, PM8 and PM1. This is due to the shapes used (s9, s10), where it is implied that the management processes manage and the support processes support the core processes. On the other hand in PM5 and PM12 the use of a dashed line (s3) points toward some influence between the process categories. Furthermore, there are process maps (e.g. PM4, PM7) where the relationship between all process categories is explicit (s1, s6). This aids to an easier understanding of the process order and dependency between the process categories.

Visual effectiveness (P6) states that at least 3 visual variables should be used for a process map to be visually saturated (Moody, 2009). A visually saturated process map is one that appropriately uses visual variables, such that the shape is mnemonic, the important processes are emphasized, the process order is shown, and the dependency between the process categories is visible. Otherwise, the process map is non-visual. Our analysis shows that eight process maps are cognitively effective because they combine three or more visual variables to convey the information (e.g. PM1, PM3, PM4, PM7, PM8, PM10, PM11, PM15). The rest uses two or less visual variables, which makes them difficult to interpret.

Dual coding (P7) encourages the use of text to complement graphics, which makes the encoding of information more effective compared to graphics or text alone (Moody, 2009). First of all, all process maps use a combination of graphics (e.g. shapes) and text (e.g. process names). However, some process maps utilize additional abbreviation in the form of labels that indicate the process order (e.g. PM1, PM6, PM7). Whereas other use tags to specify the process roles either on each process or an entire process category (e.g. PM5, PM7, PM10). There are process maps where a process abbreviation is attached to each process implying some process reuse (e.g. PM7, PM10). Others use text to clearly specify the input and output of each process category, where the output of one is seen as the input of the next process category (e.g. PM7). Similarly, two process maps clarify the meaning of each color with the use of a legend (e.g. PM5, PM7).

Graphic economy (P8) makes sure that the number of visual variables used in one process map is cognitively manageable (Moody, 2009). In addition to the principles of complexity management and semantic transparency, here we examine if the combination of all visual variables within one process map is comprehensable, so that users with few perceptible steps would be able to recognize the process differences and dependencies. To simplify, we form three categories of process maps. The first category consists of process maps that are well cognitively manageable (PM1, PM4, PM7, PM8 and PM11). This category is based on the shapes and/or explicit relationships used for and between the processes and process categories. Most process maps from this category use symbols inferring some implied meaning, such as the vertical-shaped pentagon pointing to the core processes (s9, s10), implying that the management processes manage and the support processes support the core processes. Whereas the arrow-shaped processes indicate a process order (s7, s11). Some in addition explicitly show the relationship between the processes belonging to different categories (PM4, PM7)

PM3, PM9 and PM10 belong to the second category of process maps. Although these process maps use a variety of symbols, the relationship between the process categories is not shown and the symbols used in PM3 and PM10 do not imply any dependency between the process categories. However, PM9 could infer more meaning based on the different shape (s10) used for the core processes, where we assume that the core processes support the performance of the management processes.

The third category of process maps (PM2, PM5, PM6, PM12, PM13, PM14, PM15) is most difficult to interpret. Most process maps from this category use only one symbol for all process categories and the relationship between the process categories is nearly impossible to be identified. Thus, the interpretation of the processes could potentially lead to errors or misinterpretations.

Cognitive fit (P9) suggests that depending on the goals and audience, the process map should be designed accordingly (Moody, 2009). Here we only address the audience for whom the process map has been designed, whereas the next subsection focuses on the cognitive fit between the goals and process map design. Based on the process map compliance to the principles, we can say that a visually saturated process map, with explicitly shown order and dependencies between the processes and categories, is a cognitively effective process map that is suitable for advanced users as well as novices (e.g. PM1, PM4, PM7, PM8, PM11). While those process maps that have been classified as non-visual (e.g. PM2, PM3, PM5, PM6, PM9, PM10, PM12, PM13, PM14, PM15) are intended for advanced users (e.g. employees with years of experience already familiar with the processes).

Figure 3 summarizes the cognitive effectiveness of all process maps, based on their compliance to the principles. Each X* in the figure denotes a complete compliance to the respective principle. An X stands for partial compliance to the principle. Whereas a / means that the process map does not comply to the corresponding principle. Further explanation could be additionally seen below Figure 3.

Principle		Cognitive effectiveness														
		PM1	PM2	PM3	PM4	PM5	PM6	PM7	PM8	PM9	PM10	PM11	PM12	PM13	PM14	PM15
P1	Semiotic clarity	/	X	X	X	X	X	X	/	X	X	/	X	X	X	X
P2	Perceptual discriminability	X*	/	/	X*	X	/	X	X*	/	X*	X*	/	/	X	X
P3	Semantic transparency	X*	X*	X	X*	X	X	X*	X*	X	X*	X	X*	X	X	X*
P4	Complexity management	X*	X	X	X	X	X*	X	X*	X	X*	X	X	X	X	X
P5	Cognitive integration	X	/	/	X*	X	/	X*	X	/	/	X	X	/	/	/
P6	Visual effectiveness	X	/	X	X	/	/	X	X	/	X	/	/	/	/	/
P7	Dual coding	X	/	X	/	X	X	X	/	X	X	/	/	/	/	/
P8	Graphic economy	X*	/	X	X*	/	/	X*	X*	X	X	X*	/	/	/	/
P9	Cognitive fit	X	/	/	X	/	/	X	X	/	/	X	/	/	/	/

P1: X-process maps using same symbol for more than one process category
P2: X-processes in different categories have a unique characteristic;
X*-processes in different categories have a unique characteristic+emphasis on core
P3: X-mnemonic symbol
X*-mnemonic symbol+transparent relationship in the core process category
P4: X-categories; X*-categories + emphasis on core category
P5: X-implicit category relationship; X*-explicit category relationship
P6: X-visually saturated
P7: X-abbreviations used
P8: X-distinctive characteristics or relationship between categories
X*-distinctive characteristics and relationships between categories
P9: X-easy to understand by a novice

Figure 3. Cognitive effectiveness of the process maps

4.4 Effects from Process Map Design

Next, we employ the cognitive fit theory to match the goals with each corresponding process map design. According to the cognitive fit theory, the effective processing of a task requires an appropriate representation of the subject matter (Vessey, 1991). As tasks contribute to the achievement of goals, we adopt this theory here. Specifically, a process map as a representation should be designed in such a way that the achievement of BPM-related tasks is best supported. In case the process map does not provide explicit information which is relevant, the tasks being conducted towards goal achievement might be affected in a negative way.

Goal		Effect														
		PM1	PM2	PM3	PM4	PM5	PM6	PM7	PM8	PM9	PM10	PM11	PM12	PM13	PM14	PM15
G1	Strategic alignment				⊖		⊖	⊕	⊕	⊕			⊖			
G2	Process transparency	+	⊕	⊖	⊕		⊕	+	⊕	⊕	⊕	⊕	⊕	⊕		⊕
G3	Work manual	⊕	⊕	⊕	+	⊕	⊕	+	+	⊖		+	⊕	⊕	+	⊕
G4	Process navigation	⊕	⊕	⊖	⊕	⊖		⊕	+		⊕	⊖	⊕	⊕		+
G5	Process redundancy		⊕				⊕	⊖	⊕	⊕	⊖	⊖			⊖	
G6	Decision-making tool		⊖				⊕		⊕	⊕	⊖	+			⊕	
G7	Role definition	⊕			⊕	⊕	⊕	⊕	⊕	⊕	⊕	+	⊕	⊕	+	
G8	Process measurement		+	+	⊕	+	+	⊕	⊕		⊕		⊕		⊕	
G9	Process efficiency	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊖	⊕	+		⊕	⊕

⊕ the goal was accomplished + an unanticipated effect ⊖ the goal was not accomplished

Figure 4. Effects from BPM

In order to examine this, we first identify the goals each organization planned to reach with BPM. Next, we consider the effects organizations experienced after the BPM implementation. This results in nine common goals as shown in Figure 4. This figure depicts the intention to accomplish a goal as a circle. The plus or minus sign shows the actual achievement.

Next, we map the cognitive effectiveness in terms of each principle for all process maps with the respective effects. This helps us to spot potential connections between process map design and process management success. To clarify, while the effects of certain goals are apparent and could be derived from the way a process map has been designed, others are not that obvious. For instance, for G9 additional information beyond the process map design is necessary.

Six companies indicated *strategic alignment* (G1) as a goal, from which three claimed to have experienced it as an effect (PM7, PM8, PM9). Interestingly, these companies use the same appropriate symbols to represent the management processes (s9, s10). Since this category comprises of processes where the company's strategy is embodied, by elucidating a relationship between the management and the core process categories, the company ensures that the management processes manage the core processes, thus guaranteeing strategic alignment. On the other hand, for the three companies (PM4, PM6, PM12) that did not accomplish this goal we might hypothesize that this could be a partial consequence of an inappropriate choice of symbols for the management processes.

Process transparency (G2) is a goal of most of the 15 organizations. In this context, it entails transparency of the interfaces between processes, explicit process triggers and process familiarization. So, the process categories should be easily distinguishable, the process shape should imply a certain meaning, the relationship between the processes should be transparent, and the input, output and roles should be defined i.e. P2, P3, P5 and P7 should apply. Our results point to companies experiencing process transparency when all or a combination of the above principles hold. What we can see from Figures 3 and 4 is that PM1 and PM7 pop out, since these are the only organizations that achieved process transparency as an unanticipated effect and also the only process maps that comply with all four principles stated as a prerequisite.

For a process map to be used as a *work manual* (G3), it should have high cognitive effectiveness. Most importantly, an employee should be able to identify immediately the processes they are involved with, the process shapes should imply correct meaning, process order and dependencies should be explicitly shown and the design should be comprehensible by both, novices and advanced users i.e. P2, P3, P5, P7 and P9 should apply. We observe that, while there are some process maps that apply to all the above principles and are indeed used as work manuals, there are also process maps that do not comply with many of the above principles, yet they are still used as a work manual.

Process navigation (G4) entails explicit process order and dependency, end-to-end view of the core processes and integration among the process categories i.e. P3 and P5 should apply. We noticed an interesting pattern, where we find that eight from nine organizations that have achieved process navigation as an effect, have a transparent core-to-core relationship, an explicit process category relationship or both. What is more is that PM3, PM6 and PM14 are the process maps that use either only one symbol (s7, s8) to represent all processes or lack explicitly shown process category relationship. As a result, these organizations did not experience easier navigation through the processes.

Avoiding *process redundancy* (G5) is achieved by organizations that could handle process variants by explicitly showing process containments, integrate process categories and enable process reuse. Thus, P3, P5 and P7 should hold. Whereas Figures 3 and 4 indicate some correlation between the effects and cognitive effectiveness of these principles, it is not significant. This is mainly because there are organizations with no evident process redundancy effect, despite the fact that the principles indicate the contrary. We could claim the same for the *decision-making tool* (G6) goal, where a process map is intended to give a clear customer-request approach that will facilitate direct problem solving. For this, an explicit relationship between all processes in the process map should be provided, hence P3 and P5 should hold. Although for some organizations that have been faced with this effect at least one principle holds, there are many process maps that also comply with both principles, however the organization has not yet realized that the process map could indeed be used for this purpose.

Role definition (G7) enables limited access to processes, easier process identification and defined role cooperation. Regardless of P7 stating that only three process maps show roles on the processes (PM5, PM7, PM10), Figure 3 illustrates eleven additional organizations that defined roles as a result of the BPM implementation. Similarly, although only five process maps contain an analysis & measure process category (PM2, PM4, PM5, PM12, PM14), we would assume that this might help these organizations to reach the goal *process measurement* (G8). On the contrary, this effect was experienced by five additional organizations, where BPM helped to increase process monitoring and internal benchmarking.

Finally, we found that the *process efficiency* (G9) goal is most difficult to trace solely from the process map design.

5 Study implications and conclusions

In this paper we assessed 15 process maps from organizations by examining the extent to which their design complies with the nine principles for designing cognitively effective visual notations introduced by Moody (2009). We found that while some process maps combine various visual variables in order to represent their processes according to the goals they want to achieve, most put little attention on the process map design. We observed a significant symbol redundancy and overload, as a result of the diversity of symbols used to represent the same process category.

We point to valuable implications for research and practice. First, due to the diversity of the concepts used, we clearly showed that the design of process maps is merely based on the practitioner's capabilities for creativity. Because of this ambiguity issues caused by the use of different symbols, the necessity of ontology-based concept standardization for process map design has become apparent. In addition, our results partially explain the reason as to why certain goals have not yet been achieved. Thus, this study could be used as a guide for practitioners in order to avoid common errors and unanticipated effects. Therefore, our plans for further research are to provide a formal specification of concepts for process map design. This would help companies to use the same symbol in representing a similar semantic construct. We believe that this will contribute to an efficient cognitive processing of the organization's operations.

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