How Novices Model Business Processes

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Abstract. In this paper, we examine the design of business process diagrams in contexts where novice analysts only have basic design tools such as paper and pencils available, and little to no understanding of formalized modeling approaches. Based on a quasi-experimental study with 89 BPM students, we identify five distinct process design archetypes ranging from textual to hybrid, and graphical representation forms. We also examine the quality of the designs and identify which representation formats enable an analyst to articulate business rules, states, events, activities, temporal and geospatial information in a process model. We found that the quality of the process designs decreases with the increased use of graphics and that hybrid designs featuring appropriate text labels and abstract graphical forms are well-suited to describe business processes. Our research has implications for practical process design work in industry as well as for academic curricula on process design.

Keywords: Design skills, process modeling, design quality, experiment.

1 Introduction

When seeking to (re-) design business processes to organizations increasingly use graphical documentations of their business processes – so called process models [1]. These models act as blueprints of organizational processes, and are a key tool for making re-design decisions, i.e., decisions about where, how and why changes to the processes should be enacted to warrant improved operational efficiency, cost reductions, increased compliance or better IT-based systems.

Essentially, a process model is a cognitive design tool allowing the process analyst to offload memory and information processing, and to promote discovery and inferences about the process at hand [2]. When the process design activity is not computer-supported (e.g., through a modeling tool), analysts use basic tools such as pencil and paper to illustrate how a business operates at present (as-is process design) or in the future (to-be process design).

Our interest in this paper is in the way analysts use the affordances offered by paper and pencil to create diagrammatic representations of business process designs. Specifically, we seek to understand how novice analysts create business process design representations when they are uninformed of any process design method (such as a process modeling notation like BPMN [3]). We have several reasons for this specific focus of our study. First, in organizations, the share of employees equipped with method knowledge about process design methods is typically radically low. Domain

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experts involved in process (re-) design work are often unable to review a (semi-) formalized process model or to provide meaningful feedback. In some cases domain experts even reject process models because of a lack of exposure and training in process modeling methods [4]. Second, process design artifacts (e.g., the process models) are meant to facilitate a shared understanding in the organization, which therefore includes employees unfamiliar with the chosen process design method. Third, studies of process design in industry practice [5] still report on the widespread use of 'butcher paper' process design work. Typical workshops on process design employ design tools such as whiteboards, flip charts and post-its to capture knowledge about a current or future process [6]. Fourth, informal sketches and diagrammatic drawings were found to be key to any design activity, as they serve as an externalization of one's internal thoughts, and assist in idea creation and problem-solving [7, 8], two key skills to support business process re-design. Deriving insights on these external representations may therefore promote an understanding of how individuals form their own cognitive framework in process design work [9]. In conclusion, understanding how uninformed analysts externalize their conceptions of a business process design using a basic cognitive tool such as paper and pencil is an important object of study.

When given basic cognitive design tools without the use of a (semi-) formalized design method, individuals have numerous ways to illustrate a business process design. For instance, their design diagrams may entail the use of textual descriptions, graphical icons, geometric shapes, or even cartoon sketches, to name just a few. An example for such an informal design diagram, representing an airport check-in and boarding process, is given in Fig. 1.

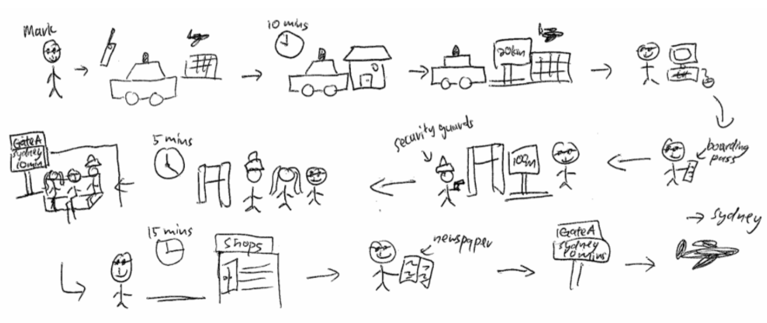

Fig. 1. Example of an informal business process diagram

The aim of our research is two-fold. First, we seek to understand which design forms novice analysts choose when conceiving business process diagrams with paper and pencil. Second, we seek to establish differences between these process design types in terms of their ability to convey relevant information about the business process represented. To that end, in this paper we report on an empirical analysis of process design work carried out by a team of student analysts as part of their university coursework. We state the following research questions:

RQ1 How can process design representations chosen by novice analysts be characterized?

RQ2 How good are different types of process designs in describing important elements of a business process?

We proceed in the following manner. First, we review prior work on process modeling as a design activity, and related work from design disciplines that provide an understanding of the design process as such. We then discuss our research model. Next, we discuss how we collected data on informal business process designs by novice analysts, and how we prepared this data for analysis. In section 4 we give the results from our study, and present a discussion of these results in section 5. We conclude this paper in section 6 by reviewing contributions, implications and limitations.

2 Background

2.1 Prior Work

The common aim of process design representations such as process models is to facilitate a shared understanding and to increase knowledge about a business process, so as to support problem solving for making (re-) design decisions, a task performed by business analysts and systems designers, for instance, in the context of organizational re-structuring, compliance management or workflow implementations. Following Simon [10], we can classify process modeling as a design activity because process models are used to represent the (process) problem so as to make potential solutions apparent. Being the most commonly employed cognitive vehicle in process (re-) design work, process models are therefore asked to be readily and intuitively understandable by the various stakeholder group engaged in this work [11].

Various approaches have been suggested to measure the quality of a process model (e.g., [12, 13]). Yet, these only apply to formalized process modeling methods such as Petri Nets, EPCs or BPMN only. However, these approaches are not applicable to informal design representations such as sketches, diagrams or text that do not follow an explicit meta model and well-defined syntactical rules. For us to be able to judge the quality of informal business process design representations, we turn to diagram correctness criteria suggested by Yang et al. [14], and the quality of a process design as its ability to accurately represent all the important constituent factors of a business process in context, i.e., the *activities*, *events*, *states*, and *business rule* logic that constitute a business process [15]. We complement these process-specific correctness criteria with two criteria found to be important in general design work, viz., *temporal* and *geospatial* design information [2, 16]. These two criteria, in a process design, relate to where (geographical location) and when (temporal location) work tasks in a business process have to be carried out.

Fig. 2 illustrates how typical cognitive design vehicles, in this case a BPMN process model, meet these criteria. Specifically, it shows that *temporal* and *geospatial* design information is normally absent from these design representations.

Process modeling, as any design work, is a cognitive activity [17]. Regardless of the work discipline, designs bear similarities, particularly in terms of the cognitive approach taken by the designer. For instance, an architectural student is more likely to generate multiple solutions to a problem before arriving at a final design, whereas a science student is more likely to analyze a problem thoroughly before drawing out only one design solution [17].

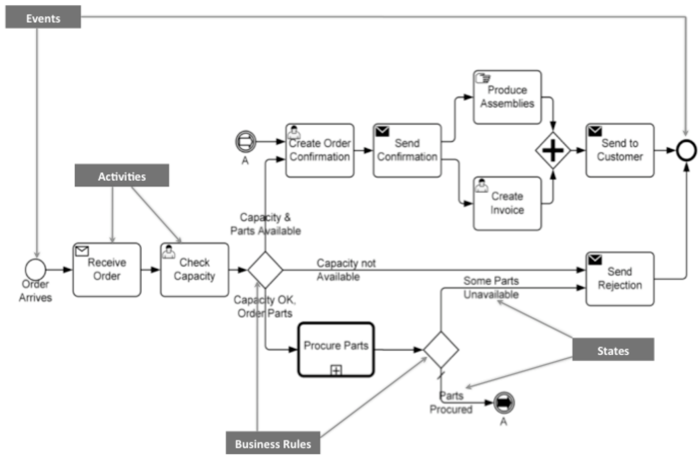

Fig. 2. Important Constituent Process Elements in a BPMN Diagram

Viewing process modeling as a design activity suggests the importance of prior experience in design approaches (e.g., experience in process modeling methods) to this activity. For instance, Wang and Brooks [18] found that novice modelers conceptualize important domain elements in a fairly linear process in contrast to experts, who were found to have better analysis and critical evaluation skills.

Looking at the artifacts created in process design work, business process diagrams, at a very simple level, typically entail the use of graphic icons, basic geometric shapes, and textual information [11]. Several studies highlight the importance of visual means to aid understanding of the design outcome – which is the key premise underlying process modeling [19]. Visual attributes function as an aid for the human mind to recognize and group objects in diagrams [20]. Work on imagery have shown how images have particular properties [21] that can affect interpretations. These findings suggest that different types of visual aids used in business process design will affect interpretation and understandability of the created process models.

Often, conceptual design work is carried out using informal sketching, a process of mental imagery [22], with the purpose of identifying properties of imaged elements to enable the retrieval of information from memory. Like drawings, sketching across multiple disciplines plays a consistent role in the generation, development, evaluation, and communication of ideas [9], which suggests their applicability to process (re-) design activities.

Within sketches as well as more formal process diagrams, the use of graphical icons, in addition to geometric shapes, is often prevalent. This is because graphic icons are quicker and easier to recognize than text [23]. The two types of graphic icons typically used in process diagrams can be categorized as *Concrete* and *Abstract*. *Concrete*, high-imagery and high frequency graphics, are often represented with freehand sketches of objects such as stickman figures and telephone icons (see Fig. 5c-Fig. 5e), while *Abstract* are low-imagery, low-frequency graphics that entail geometric shapes and arrows [24] (see Fig. 5b). Also, process diagrams typically feature textual information in the form of labels attributed to geometric shapes (like activity boxes) or additional free-text descriptions. Textual information plays a vital role in ensuring proper interpretation and association, as well as to enhance the building of a cognitive model [20]. Textual information further enhances the graphical information in a process diagram, because textual and graphical information can be processed in parallel through the complementary receptor channels of the human brain [25].

In conclusion, we assert that a study of process design work with informal representation forms should consider, at least:

- which representation aids are used in the process design (e.g., the use of textual means, geometric shapes, iconic imagery, and the like);
- to what extent process design means enable a reader to receive all relevant information about a business process (such as important events, activities, states, or business rules);
- whether and how temporal or geospatial information about the business process is conveyed; and
- how individual experience levels, specifically with design work, with modeling approaches or with the process itself, contribute to the design work.

2.2 Research Model

Based on our review of relevant work, we conceptualize the above research objectives that we attempt to address in this study in the research model shown in Fig. 3.

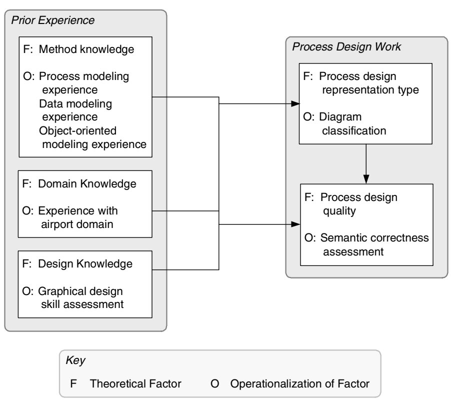

Fig. 3. Research Model

In line with our research questions, first, we seek to understand the types of process design representations chosen by novice analysts. To that end, we seek to ascertain to which extent prior experience determines the type of process design representation used. As per Fig. 3, we distinguish two forms of experience: Following Khatri et al.

[26] we differentiate (a) *experience with a method* (a modeling approach) from (b) *experience with a process* (knowledge of the process domain). We anticipate that novice analyst with an educational or working background in any formalized modeling approach (data-, process- or object-oriented) would have a predisposition towards the diagramming representation typically associated with the modeling approach, which can be expected to affect their preference for such a process design representation type. Domain knowledge has been shown to affect modeling processes and outcomes [26], and may thus influence both the type and quality of the process design conceived. Given the importance of graphical and visual cues in conceptual design work [20, 21] we further expect that novice analysts with *experience in graphical design work* may choose a design representation format that is more graphically than textually oriented.

Second, we seek to examine the outcome of the process design work. Following Fig. 3, our interest in the outcome of the design process is two-fold, namely the *type of process design representation* chosen by the novice analysts, and the *quality of the designs created*. In the following, we describe how we collected data to examine our research model.

3 Method

Data collection was conducted using a three-part quasi-experiment conducted with a group of Information Systems students enrolled in a Business Process Modeling subject unit as part of their university Information Systems course. The experiment took place during opening minutes of the very first lecture in the subject in a lecture hall, consuming approximately 25 minutes.

The first part of the experiment captured demographic information about the students, viz., their level of education (under-graduate or post-graduate), gender, English Language as their arterial language, their experience in formalized modeling methods (process-, data- and/or object-oriented), and their familiarity with the procedures at an airport, which was the process domain selected for our study.

The second part of the experiment aimed at assessing the students' ability to draw graphical diagrams, as a proxy measure for graphical design skills. To that end, a picture of the Sydney Opera House was projected to the participants, who were to draw an accurate sketch of the image on a blank piece of paper. The rationale behind the Sydney Opera House image was based on the assumption that the majority of the participants would be familiar with the landmark, as it represents one of Australia's most prominent features. Students were given ten minutes to complete this task but task times were not recorded.

The third part of the experiment was to examine the students' ability to create a business process design representation. A specific process scenario was portrayed in textual format to the participants as a narrative of an actor seeking to travel to Sydney. This included a detailed account of the arrival at the airport, followed by check-in and boarding procedures and leisurely activities taken in between. The rationale behind this activity was to provide a business process with which both domestic and international students would have some level of familiarity with (as opposed to a business process in a specific industry vertical – for instance, insurance – where results could have been significantly biased due to non-existence of any domain knowledge). Students were asked to draw a model that represents the airport process scenario as accurately and completely as possible, within ten minutes, using only a blank piece of paper.

Overall, 89 students participated voluntarily in the study. Complete data about all three parts of the experiment were provided by 75 students (84%).

4 Analysis and Results

Data analysis proceeded in several steps. First, we coded the demographic information obtained. Our specific interest was in students' experience of airport processes (domain knowledge), as well as experience in formal modeling methods – process modeling knowledge (PMK), data modeling knowledge (DMK), and object modeling knowledge (OMK).

Second, we assessed the quality of the Opera house drawings, to create a measure of graphical design skills. To that end, all drawings were provided to a professional artist, who judged each drawing using a six-item drawing quality measure that assessed *composition* (COM), *proportions* (PROP), *perspectives* (PERS), *shading* (SHAD), *drawing style* (STY) and *overall impression* (IMP) of the drawings on a 7-point scale (1 = very bad, 4 = neutral, 7 = very good).

Third, to distinguish different process design representation types, we categorized the various types of process design representations created in the third part of the experiment, in accordance with their aesthetic design properties. This assessment included the examination of the relative use of graphical icons, textual information, and sequential flow or structure of the process diagram. To ensure coding reliability, all diagrams were assessed separately by three research assistants, who then, iteratively, met to discuss, defend and revise their coding work until consensus was reached.

Fourth, we attempted to measure the quality of each process design representation. To that end, we adapted the semantic correctness criteria suggested by Yang et al. [14] to the constituent elements of business process models (activities, events, states, business rules, see [11]) and other design artifacts (temporal and geospatial information, see [2]), in a six-item 5-point scale (1 = aspect not at all represented, 5 – aspect fully represented). Again, we used a three-member coding team and an iterative consensus-building process to ensure validity and reliability of our assessment.

Using this data, the following sections report on the analyses carried out to address the two research questions as per our research model (see Fig. 3).

4.1 Identifying Process Design Types

Our coding of the 75 process diagrams resulted in the identification of five process design archetypes. This assessment was based on the aesthetic representation of the process diagrams, such as frequency of graphic use, textual information, and the sequential flow of the process structured within the Euclidean space afforded by the piece of paper. Similar to the Physics of Notations suggested by Moody [27], we found that the archetypes could be differentiated based on their use of text and graphics.

Fig. 4 positions the five identified archetypes along a continuous scale from dominantly textual (type I) to dominantly graphical (type V) representation formats, and describes key traits of each design type. Fig. 5a-5e provide examples for each design archetype.

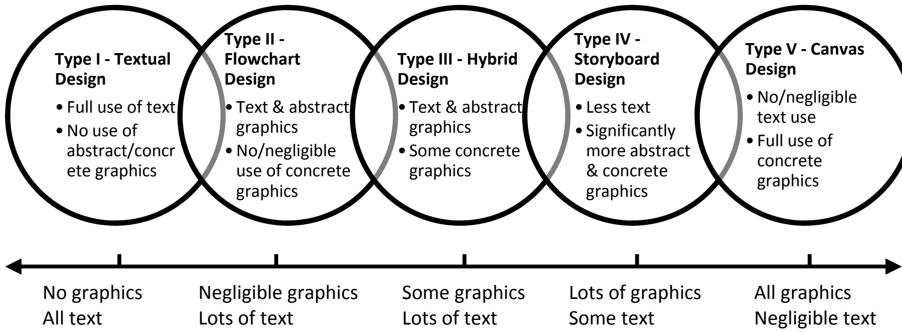

Fig. 4. Process Design Archetypes

The first type, *Textual design*, resembles very closely that of an algorithm pattern. This design type does not utilize any form of graphical illustration but uses lines of words as the primary representation of process information. The second type, *Flowchart design*, contains textual information embedded within graphical shapes that are of abstract nature, i.e., lines/arrows and/or boxes and borderlines around captions, and generally have a sequential flow that, to some extent, resembles more formal modeling techniques used for process-, data-, or object-modeling, and of course, the classical flowchart. The third type, *Hybrid designs,* uses concrete graphics (such as stickman figures, telephone icons and the like) to supplement the textual labels and descriptions in the presence of abstract graphics (shapes and boxes). The Hybrid design also follows a structured process flow of information. The forth and fifth design types are notable due to the distinctively dominant use of concrete graphics over and above textual representations. The *Storyboard design* uses a great variety of concrete graphics such as icons, complemented with brief textual descriptions, typically in the form of verbs and nouns.

Resembling a real "Storyboard", this design type further features segmented pieces of information, some partitioned as objects within rectangular boxes (abstract graphics) or swim-lanes, and were structured in a flowing manner to accommodate the Euclidean space and orientation of the paper. As for the *Canvas design*, the entire process is illustrated with concrete graphics without any meaningful use of textual information, occupying the entire page of the paper to provide a picturesque view of the scenario. Due to the "picture-painting" nature of this design, the diagram lacks any precise representation of the process flow, or detailed textual information.

Having distinguished the five different process design representation types, we examined whether any of the experience factors we considered (method, domain or graphical design experience) was significantly associated with any of the design representation types chosen by the participants. To that end, we ran logistic regression analyses [28] for each design type (DT1-5), using as independent factors three binary variables PMK, DMK, OMK capturing respondents' prior experience with modeling methods, and six factor scores (IMP, COM, PROP, PERS, SHAD, STY) describing the graphical design skills as per the evaluation from a professional artist. Last, for the factor domain knowledge we created a binary variable groupDK that grouped respondents into two groups (high/low) as per their self-perceived rating of familiarity with airport procedures.

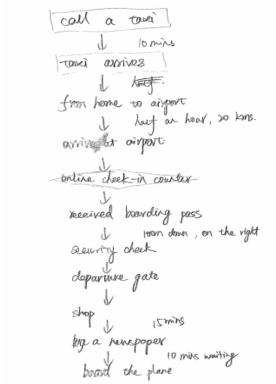

Fig. 5a. Process Design Type 1: Textual (1 diagram)

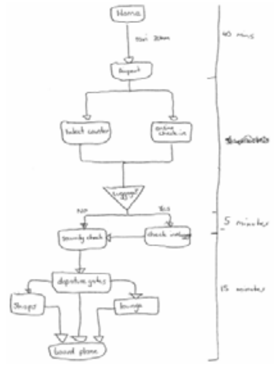

Fig. 5b. Process Design Type 2: Flowchart (54 diagrams)

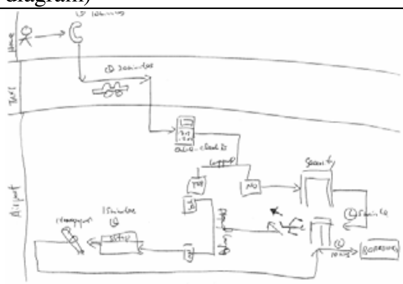

Fig. 5c. Process Design Type 3: Hybrid (6 diagrams)

Fig. 5d. Process Design Type 4: Storyboard (11 diagrams)

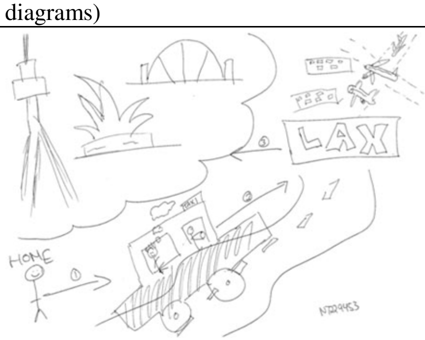

Fig. 5e. Process Design Type 5: Canvas (3 diagrams)

We omit a complete description and discussion of the results. The results from the logistic regression analysis showed that there are no significant relationships between the independent variables considered with DT1 (textual design), DT3 (hybrid design) and DT5 (canvas design). It may well be that the non-significance of the results for DT1 and DT5 is due to the limited sample size.

For DT2 (flowchart design) however, we found a significant association with previous domain knowledge (Beta = 1.465, p = 0.039). This result suggest that people highly familiar with airport procedures tend to prefer a flowchart-based representation of airport processes, unlike the representation format of current process modeling methods. Interestingly, for this design, process modeling method knowledge was a largely insignificant predictor (Beta = -0.444, p = 0.534). This finding suggests that domain expertise dominates method expertise as a predictive factor. It might well be that the thorough understanding of the domain facilitates the capability to abstract the process into the form of flowcharts while pure method expertise is not sufficient to clearly identify and isolate the individual steps of this process.

For DT4 (storyboard design), we found a significant association with object-oriented modeling method knowledge (Beta = -3.619, p = 0.009). Note that participants unfamiliar with object-oriented modeling methods showed a significant association with predominantly graphic storyboard process designs, whereas those with object-oriented modeling method knowledge did not choose this design type. This could indicate that the loose and creative structure of storyboard forms a contrast to the conceptually advanced ideas of object-orientation and its paradigms such as coupling and decomposition.

4.2 Evaluating Process Design Quality

Next, we examine the data collected about the quality of the process designs, as per our six-item semantic correctness measure adapted from [14]. We proceeded in two steps.

First, we ran a Univariate Analysis of Variance (ANOVA, [28]), with *Design Quality* (DQ) as an aggregate dependent variable, computed as the average total factor score of the six semantic correctness scale items. As independent factors we used *design type* (DT), the binary grouping variable *domain knowledge* (groupDK), the three measures for previous modeling *method knowledge* (PMK, DMK and OMK) and the *graphic design* score overall impression (IMP). The ANOVA results showed that design type (F = 12.459, df = 4, p = 0.000) and previous domain knowledge (F = 9.569, df = 1, p = 0.005) are significant predictors of the aggregate design quality measure, whilst the other independent factors as well as all interaction effects were insignificant. The results from the ANOVA specifically showed that higher levels of domain knowledge results in higher quality designs, and that more textually oriented process design representation types achieved higher quality scores than the graphically oriented process design representation types (as per the classification in Fig. 4).

To examine these results in more detail, we then ran a Multivariate Analysis of Variance (MANOVA), with the six semantic correctness measures as dependent variables, and the same input factors as above. Table 1 gives selected descriptive results from the MANOVA about the impact of the design type, and Table 2 displays corresponding significance levels.

Table 1. Multivariate ANOVA: Selected Descriptive Results

DT with highest *mean* results	State	Task	Event	Business Rules	Time	Distance
DT1	5.00	5.00	1.00	4.00	4.00	5.00
DT2	2.98	3.81	2.81	4.06	3.15	3.07
DT3	2.50	3.00	1.33	3.17	3.00	3.67
DT4	2.73	2.82	1.27	3.09	2.91	3.73
DT5	1.00	1.00	1.00	1.00	1.00	1.00

The results from Table 1 and Table 2 suggest that there is relationship between the type of design employed by the students to represent the business processes and the different dimensions of the quality of these designs. Specifically, Table 1 suggests that more textually oriented design types are better in representing the *State*, *Task*, *Event*, and *Business Rules* aspects (under elimination of DT1 – which only featured one case). The purely graphical design, DT5 Canvas, scored the lowest aggregate in representing all six factors that entail the design quality. We note specifically that DT2 (Flowchart) scored the highest aggregate in all aspects of quality, except for *Distance*, which is best represented with DT4 (Storyboard). Table 2 shows that these score differences were significant, except for the quality dimension *Business Rules*, where we did not identify a significant association with the type of design used. These findings suggest that the use of graphical shapes in combination with textual encoding leads to superior design representations, and offer some empirical evidence for the theory of effective visual notations offered by Moody [27].

Table 2. Multivariate ANOVA: Significant Results of design type and interaction effects

Independent variables with *significant* results	Significance levels					
	State	Task	Event	Business Rules	Time	Distance
DT	0.005	0.002	0.011	-	0.003	0.007
DT & PMK	-	-	-	-	0.002	0.001
DT & OMK	-	-	-	-	0.017	-
DT & groupDK	-	-	-	-	-	0.016

Table 2 further suggests important interaction effects stemming from the type of knowledge possessed by the participants. We note that participants with prior process modeling knowledge, when exercised with their choice of design, achieved higher quality scores for their representations of *Time* and *Distance*. Subjects with object modeling knowledge were found to be better in representing *Time* with their design type, while those with previous domain knowledge were found to be better in representing *Distance*.

Perusing MANOVA we further found a number of interesting effects on design quality stemming from prior experience of the subjects. Table 3 summarizes the significance levels for the different types of prior experience captured.

Table 3. Multivariate ANOVA: Significant Results of prior experience

Aspects with *significant* results	**State**	**Task**	**Event**	**Business Rule**	**Time**	**Distance**
PMK	-	-	-	0.037	-	-
PMK & DMK	0.023	-	-	-	-	0.010
DMK	-	-	-	-	0.023	-
DMK & GroupDK	-	0.032	-	-	-	-
OMK	-	-	-	-	0.018	-
OMK & GroupDK	-	-	-	0.047	-	-
OMK & PMK	0.006	-	-	-	-	-

Examination of the data displayed in Table 4 shows that those participants with knowledge of process modeling methods achieved higher scores for representing *Business Rules* (p = 0.037). Students with both process and data modeling knowledge achieved higher scores for representing *States* (p = 0.023) and *Distance* (p = 0.010). *Time* was well represented by students with data modeling knowledge (p = 0.023) and those with object modeling knowledge (p = 0.018). The data also showed the existence of an interaction effect between students with both data modeling and domain knowledge in representing *Tasks* (p = 0.032), while those with object modeling and domain knowledge represented *Business Rules* well (p = 0.047). Last, we found an interaction effect concerning the representation of States (p = 0.006), for those participants with both object and process modeling knowledge. These findings suggest that different method knowledge, solely or when combined with other method or domain knowledge, can increase the specific level of quality in a business process diagram.

5 Discussion

The finding that design representation forms chosen to conceptualize business processes range from predominantly textual, to hybrid, to predominantly graphical types, and the finding that some of the design types, more notably the combined graphical and textual types, achieve higher quality scores, extend our understanding on the use of conceptual design tools and the quality traits of the design outcomes.

We turn to Dual Coding theory [29] to discuss our results. This theory stipulates that text and graphics together can provide a more effective conveyance of information than using either on their own. We find that design types two (Flowchart) and three (Hybrid) both fall under this banner. Yet, the results regarding the relative superiority of the Flowchart over the Hybrid design type provides an important extension of Dual Coding theory, by suggesting that text and *abstract graphics* (shapes such as boxes, circles and arrows) apparently are more effective in displaying important domain semantic elements than the combined use of text and *concrete graphics* (icons such as stickman figures – as found in design type 3, hybrid).

And indeed, during the three-member evaluation of the process diagrams, it was reported that certain concrete icons, when unfamiliar with the given context, tended to create a certain level of ambiguity towards the end-users. For instance, one of the coders mis-interpreted a sketched icon representing the utility of an online check-in facility (as per context scenario), as a public restroom. This anecdotal evidence further corroborates our findings on the Hybrid design.

Moody's [27] theory of effective visual notations provides a rationale for this finding. The use of concrete graphics such as icons can in some instances violate the notion of monosemy whereby a symbol should have one predefined and independent meaning. This is not to say that all concrete graphics used in diagrams are undefined. For instance, the use of concrete graphics such as stickman figures, which clearly represent the main actor in a process, or a combination of a stickman with a telephone icon, followed by a taxi vehicle, can clearly indicate the representation of the actor calling a taxi as described in the process scenario. Such icons are of a semantically immediate nature, which allows novices to establish its meaning based on their appearance alone [27]. Still, the only partial and inconsistent use of semantically immediate concrete graphics in more graphically oriented diagrams (types 3, 4, or 5) may explain why the more textually-oriented process diagrams, such as the Flowchart design, which employ abstract graphics such as geometric shapes and arrows, appear to provide more clarity in conveying process information. Moody [27] highlights such symbols as being semantically opaque, in which the relationship between a symbol's appearance and connotation is merely arbitrary. Note that we found that predominantly students with notably high levels of domain knowledge tended to employ this design type with increased use of text and semantically opaque symbols. This finding would suggest specifically that geometric shapes can faithfully be used to describe different constituent elements of a process such as activities (typically rectangles), events (typically circles) or business rules (typically diamond-shaped gateways). It also highlights the important role of appropriate textual labels and the importance of conventions to guide the textual semantic specification of these labels.

Further note that the Flowchart design was also found to be the most favored type of design by the majority of students (72%), which may not only indicate preference, but perhaps also the novice's default way of conveying process information (using bare minimum concrete graphics).

Turning to what appears to be the second most used type of design (15% of students), the Storyboard design, we note that the simultaneous use of both graphics and text, plus a structured flow of process, may imply intuitiveness of graphical use to emphasize representation. And indeed, the theory of spatial contiguity [30] suggests that inclusion rather than segregation of both text and images can be more effective towards the end-user in terms of comprehension, regardless of spatial and verbal abilities. This theory may also contribute to explaining why we found only one case of design type 1, Textual design, as, per theory, such diagrams lack the intuitiveness of graphics for end-users.

Therefore, we posit that concrete graphic icons, in certain instances, enable a reader to receive and understand relevant information. They are aesthetically pleasing as people generally have a preference on real objects rather than abstract shapes. However, our study shows that abstract icons, in conjunction with the use of textual information, are beneficial for those who lack designing skills or diagramming expertise. It is also important to note that while graphics may be attributed a more readily intuitive appearance, an overuse of concrete graphics over and above textual or abstract graphical shapes can also be detrimental, as we have seen in the case of design type 5, Canvas design, which has the lowest design quality in conveying semantic correctness. Do et al. [7] studied how verbal protocols and reasoning account for inaccurate designing processes. Their findings suggest an impact of the verbal instructions (to draw a model of the airport scenario) given to the individuals who adopted the Canvas design. The novices interpreted the word "draw" literally, resulting in a strongly picturesque design of the process, thus signifying the imagery's congruence to one's perception and various psychological phenomena [31].

As a last item of discussion, we turn to the representation of the "non-standard" contextual process elements temporal and geospatial information.

We found that distances appeared to be best represented through the Storyboard design, whose dominant representation comprises of graphics, both abstract and concrete, with little textual annotation. Notably, we found the most prominent representation to be a signboard graphic icon with the unit of measure (e.g., 3 km).

Temporal information, on the other hand, was found to be best conveyed again through Flowchart designs. In this style, we found that temporal information was generally conveyed using text labels and abstract shapes such as additional timeline arrows complementary to the process flow. This finding could suggest that it is deemed more accurate for both the illustrator and the reader to use textual descriptions of time periods, as opposed to drawing a clock icon (a concrete graphic) to indicate a particular time or duration.

6 Conclusion

In this paper we reported on an experimental study carried out to examine how novices conceptualize their understanding of a business process using paper and pencil. We considered three main factors, namely, drawing skills, formal modeling method knowledge, and domain experience, to determine the impact on the quality of the process design against the resulting design types. Our findings reveal that the five types of design range from being dominantly textual, to a hybrid of text and graphics (both abstract and concrete), and to being dominantly graphical.

We acknowledge that our study bears certain limitations. First, the subjects observed were students and not business analysts. As such, our findings may only hold for novice analysts, which, however, was the desired cohort for our study. Second, there could be some subjectivity in our coding of data analysis. We attempted to mitigate potential bias through a multiple coder approach. Third, our attempt to ascertain the designing skills of the students could be seen as an assessment of their *drawing* but not their *design* skills. Another limitation is the potentially limited explanatory power of the statistical analysis due to the non-normal distribution of the design categories, and their relative sample size. For some design types we received only few data points, which renders some conclusions about these types difficult to make. Yet, our selected data analyses do not require normal data distribution, which increases our confidence in the results obtained. Still, an identified opportunity for lies in the recoding of the process models by a professional process modeler to ensure integrity in representing process information.

Our findings on the various types of design generated by students have provided insights on how individuals without experience in formal modeling method(s) conceptualize and externalize business processes. Specifically, the moderate use of graphics and abstract shapes to illustrate a process is more intuitive and would aid the understanding on the concept of process modeling. This would benefit the teaching aspect of business process modeling subjects, or any process-oriented disciplines, by introducing an informal approach before applying formal modeling methods. This is due to the nature of graphical illustrations being intuitive, such as that of concrete icons and abstract symbols used in the Flowchart, Hybrid and Storyboard designs. However, there is also a trade-off in the quality of process design when graphics are fully incorporated which suggests that while graphics can, to a certain extent, aid the understanding and communication of a business process, it could also result in a loss of information due to ambiguity and/or misinterpretation. On the other hand, process designs that fully utilize textual labels and descriptions, such as that in Textual design, may be useful in representing certain process information such as Business Rules, but are not entirely intuitive. We believe that our study provides some valuable insights on the cognitive aspects of novice process designers, which can be the basis for further cognitive studies in the field of business process design.

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