Evaluating the Perceived Quality and Functionality of DEMO Models' Representations in the Health Domain

David Aveiro[1,2,3][a], Vítor Freitas[1,3][b], Dulce Pacheco[1,2,4][c] and Duarte Pinto[1][d]

[1]ARDITI - Regional Agency for the Development of Research, Technology and Innovation, 9020-105 Funchal, Portugal

[2]NOVA-LINCS, Universidade NOVA de Lisboa, Campus da Caparica, 2829-516 Caparica, Portugal

[3]Faculty of Exact Sciences and Engineering, University of Madeira, Caminho da Penteada 9020-105 Funchal, Portugal

[4]School of Technology and Management, University of Madeira, Caminho da Penteada 9020-105 Funchal, Portugal

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Abstract: Demo's (Design and Engineering Methodology for Organizations) Way of Modelling encompasses a collection of interconnected models and diagrams designed to depict an organization's structure and operations in a cohesive and platform-independent manner. Nevertheless, there has been a contention that the syntax and semantics of DEMO models are overly intricate and cluttered, posing challenges for laypeople in terms of interpretation. Our research team has been working on improvements to the DEMO Modelling language for Enterprise Ontology. Previous work had shown challenges in using standard DEMO notations for model communication and validation, prompting the development of new representations. This study evaluates these representations through quality and functionality testing using a health domain case and health professionals with domain knowledge. The results of the conducted tests reveal significant differences in perceived quality and functionality between the new and traditional DEMO representations. These findings indicate a strong preference for the new representations over traditional ones. This study underscores the importance of focusing on users in enhancing the effectiveness of modelling languages like DEMO, particularly in complex domains such as healthcare. The results suggest that these new representations have the potential to improve the perceived quality and functionality of DEMO models in various practical applications, including health-related information systems.

1 INTRODUCTION

DEMO (Design and Engineering Methodology for Organizations) consists of a method and language standard based on the theories of Enterprise Ontology. As the essence of enterprise engineering lies in the systematic analysis and design of an organization's business processes, enabling improvements in efficiency and effectiveness, our research team has been working on improvements to the DEMO Modelling language representations. The latest developments are published in (Pinto et al., 2021) and (Gouveia et al., 2021), reporting the results of a large-scale modelling project on the legal domain, where practice has shown that the standard DEMO notations were making model communication and validation a difficult process. The new notations were, afterwards, formally evaluated, in the same domain, in studies published in (Pacheco et al., 2022b) and (Pacheco et al., 2022a), expressing that these offer greater accessibility and a more straightforward understanding, whether for professionals engaged in the represented processes or those possessing expertise in DEMO.

The research contributions of this paper are providing a new assessment of the perceived quality and functionality of the newly proposed enterprise engineering's DEMO model representations, now on the health domain, through the analysis of NexusBRaNT, an information system to support cognitive rehabilitation.

Quality and functionality testing is widely recognized as the most effective method for identifying the genuine problems that can impact user performance and preference (Wang and Caldwell, 2002). To assess the perceived quality/functionality of the newly

[a] https://orcid.org/0000-0001-6453-3648
[b] https://orcid.org/0009-0002-0667-5749
[c] https://orcid.org/0000-0002-3983-434X
[d] https://orcid.org/0000-0002-8451-5727

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proposed representations for DEMO Process and Fact Models, we recruited a sample of health professionals in the field of psychology, with domain knowledge of the modelled processes and modelled system.

Section 2 presents our research context, first the theoretical basis of DEMO, a summary of the aforementioned NexusBRaNT scenario, and the DEMO models addressed in our study. Section 3 presents the study context with participants' characterization, method and procedures followed, and the main contributions of this paper, namely the evaluation and comparison of the Perceived Quality and Functionality of the traditional and newer diagrammatical representations of DEMO's Process and Fact Models. Conclusions and future work are found in section 4. Owing to constraints on page space within the paper, images had to be resized, but higher resolution versions can still be accessed[1].

2 RESEARCH CONTEXT

In this section, we will provide a comprehensive overview of DEMO's theories, models, and representations to ensure that readers are well-informed. Subsequently, we will delve into an examination of the information system utilized in this study, specifically within the health domain. Following that, we will introduce the representations of the DEMO models that are subject to evaluation in this research.

2.1 DEMO Theories, Models and Representations

The Design and Engineering Methodology for Organizations (DEMO) is a methodology centred on the PSI theory of Enterprise Ontology to provide a set of models and diagrams for representing an organization, which are interconnected and allow a comprehensive specification of an enterprise in a neutral way (Dietz and Mulder, 2020a).

Enterprise ontology aids in creating a shared language within an organization, reducing misunderstandings and fostering effective communication. Thus, every organization's operations are a network of transactions, according to the PSI theory (Dietz and Mulder, 2020c). Each transaction represents a path within the complete transaction pattern, which is a universal pattern in all organizations (Dietz and Mulder, 2020b). According to Dietz and Mulder (Dietz and Mulder, 2020c), a business process consists of a sequence of procedural steps, which are in turn steps within transactions of specific transaction types that are integral to a business process type within the organizational structure of an enterprise.

A collection of models and diagrams are used in DEMO's way of modelling to depict an organization. The Cooperation Model (CM), Action Model (AM), Process Model (PM), and Fact Model (FM) are the referenced aspect models. They are related to one another and provide platform-independent representations of coherent information. As this paper is focused on the updated representations of DEMO's PM and FM, we will not delve into the other two aspect models.

The Process Model outlines the business processes that occur as a result of actions performed by actors within the organization. The PM includes process step types and applicable existence laws for both internal and external transactions. It also reveals the process step types and occurrence laws, including occurrence quantities, for different transaction types.

The Fact Model represents the organizational products of the organization. It includes entity types, value types, property types, and attribute types relevant to the organization, along with the applicable existence laws. Additionally, it captures event types and occurrence laws related to transitions in the organization (Dietz and Mulder, 2020a).

2.2 The Information System to Support Cognitive Rehabilitation

NexusBRaNT is an online platform to access the BRaNT[2] (Belief Revision applied to Neurorehabilitation Therapy) project's back office. The BRaNT project's objective is to create technological tools that support cognitive rehabilitation in domestic settings through the assistance of artificial intelligence, while also offering solutions to enhance the resilience of healthcare systems.

This platform, then, specifically caters to health professionals involved in cognitive rehabilitation, including psychologists, neuropsychologists, therapists, and others. It encompasses several key features, including patient management, neuropsychological assessment management, and cognitive training management.

For the modelling of the NexusBRaNT system, and following the notation proposed in (Gouveia et al., 2021), in total, 224 fact types were specified, with 31 concept types encompassing 193 attribute types. A total of 20 neuropsychological instruments

[1] http://bit.ly/keod-2023-paper-192

[2] https://www.arditi.pt/en/projetos-finalizados/brant-project.html

are available for registration, collectively comprising 144 attributes. Each instrument has a varying number of attributes, ranging from 2 to 17. These numbers from the specified models highlight the complexity of information requirements within NexusBRaNT. Consequently, we considered it a suitable candidate for an evaluation of the perceived quality and functionality of the new DEMO Model representations.

2.3 Evaluated DEMO Model Representations

In this subsection, we will initiate a comprehensive examination of the disparities between the recently introduced Process Model (Version A) and the conventional DEMO PSD (Version B). Following this analysis, we will proceed to expand upon the distinctions found between the newly proposed Fact Model (Version C) and the established DEMO OFD (Version D). It is essential to note that all the models discussed herein are situated within the scope of the previously mentioned NexusBRaNT case.

2.3.1 Process Model

In (Pinto et al., 2021), in the context of a large-scale modelling project in a municipality, a novel approach to represent the PM was introduced (Version A), which combines some elements of the standard DEMO PM with both the CM and the AM, thus extending the conventional notation (Version B) presented in (Dietz and Mulder, 2020a). The main goal was to provide a more agile and comprehensive solution to specify and present the essence of organizational reality in a more visually appealing and concise manner, making it easier for both modellers and stakeholders to understand.

Figure 1 provides an explanation of each symbol used in Version A.

Figure 2 (Version A) represents the Process Model for NexusBRaNT's Neuropsychological Assessments and Training Programs Process, while Figure 3 shows the traditional DEMO notation in (Dietz and Mulder, 2020a) (Version B). It is worth noting that the terms "transaction" and "task" are used interchangeably due

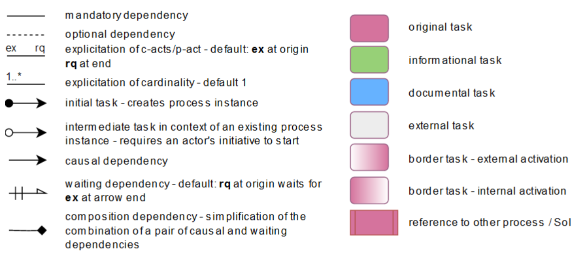


Figure 1: Process Model Notation (Version A).

to quality and functionality concerns, as reported in (Pinto et al., 2021).

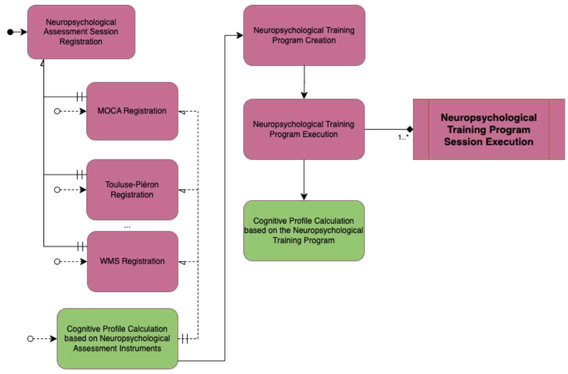
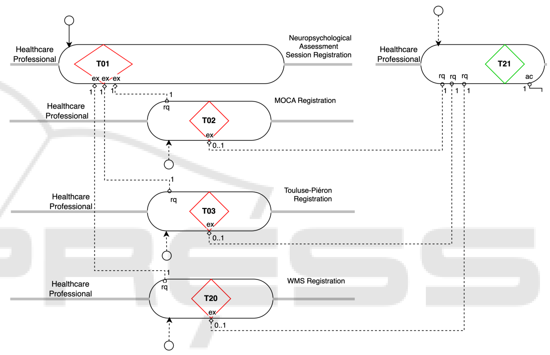
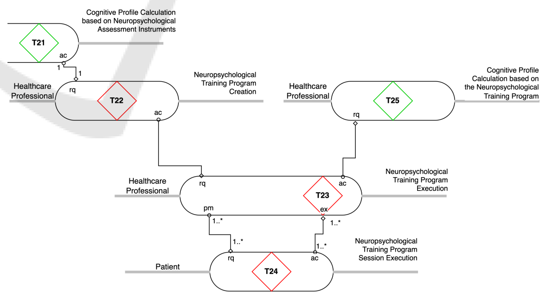


Figure 2: Process Model (Version A) for NexusBRaNT's Neuropsychological Assessments and Training Programs Process.



(a) DEMO traditional PSD (Version B) Part 1.



(b) DEMO traditional PSD (Version B) Part 2.

Figure 3: DEMO traditional PSD (Version B) for NexusBRaNT's Neuropsychological Assessments and Training Programs Process.

The Neuropsychological Assessments and Training Programs Process starts with a healthcare professional creating a new Neuropsychological Assessment Session for a patient, which includes one or more neuropsychological assessment instruments. These instruments, that can be of twenty different kinds (resumed in the diagram with "..." to make it legible), evaluate the patient's current cognitive capabilities and can be paused or resumed during the session. Once all tests in the session are concluded, a Cognitive Profile Calculation based on Neuropsychological Assessment Instruments can take place. The result of this calculation is then used by the healthcare professional as the baseline for the creation of a Neuropsychological Training Program for that patient. The program must then start within the following 15 days, typically consisting of multiple Neuropsychological Training Program Sessions (that are a different process of their own, as they include multiple tasks in each session depending on their specificities) but can also be a single session. After completing all scheduled training sessions, another Cognitive Profile Calculation based on the Neuropsychological Training Program is performed to assess the patient's progress compared to the initial assessment, concluding the process.

This representation (Pinto et al., 2021) solved several issues regarding current DEMO CM and PM representations. The Coordination Structure Diagram and Process Structure Diagram of the latest DEMO version (Dietz and Mulder, 2020a) were considered, both by stakeholders and modellers alike, to be complicated to grasp and with extensive line clutter (Pacheco et al., 2022b; Pacheco et al., 2022a). The way we represent the PM - Figure 2 - is semantically richer by: (a) presenting task names much closer to day-to-day operations; (b) clearly separating the concerns of process composition, task causation, and task waiting; and (c) the connectors representing the composition perspective with diamonds, the causal links by connectors with arrows, and the waiting links by the connectors with double-crossed lines. Regarding links between tasks, in DEMO's notation dashed meant optional and non-dashed mandatory. The use of numbers at the end of connectors to represent that essential concept is harder/slower to interpret than the line expressing the concept, so their use was limited to reflect cardinalities higher than 1. The proposed notation in (Pinto et al., 2021) offered a new layer of depth in the comprehension of the modelled process, improving the readability of the limits of the scope with the use of specific symbols to represent other related processes.

To address the gaps in the process information that could overburden the model, a Transaction Description Table (TDT), that allows for the addition of relevant text-intensive data such as descriptions, associated rules, conditions for transactions to take place, time constraints, and other related elements was also introduced in (Pinto et al., 2021), as can be seen in Figure 4. For instance, let's consider the "Cognitive Training Program Execution" task. Its origin task is "Cognitive Training Program Creation". Upon completion, this task can trigger the "Cognitive Training Program Session Execution" task and the "Cognitive Profile Calculation based on the Cognitive Training Program" task. Additionally, specific conditions and rules that must be taken into consideration for the task to proceed are specified, along with any applicable time constraints. In the example, only after all programmed sessions have finished, can the Cognitive Profile Calculation be executed.

By utilizing this table, we gain a comprehensive understanding of each task's characteristics and relationships within the system. It serves as a valuable resource for analysing and organizing the various elements involved in task execution, facilitating not only the implementation of more refined system specifications, but also the understanding and validation, by an organization's collaborators, of important details of process flow and execution.

2.3.2 Fact Model

In (Gouveia et al., 2021), a novel approach to representing the FM was introduced (Version C), whose resulting model on the context of NexusBRaNT can be seen in Figure 5, which proposes a new way of capturing and organizing facts in a more flexible and extensible manner compared to the traditional DEMO FM (Version D), represented in Figure 6 in the same context, presented by (Dietz and Mulder, 2020a). The main goal of Version C is to provide a fact-oriented and declarative solution that focuses on capturing the essence of the system's structure and behaviour. It is important to note that Version C emphasizes the separation of concerns between structure and behaviour, while Version D integrates both aspects within the FM.

The new representation proposed in (Gouveia et al., 2021) addresses several issues identified with the traditional DEMO FM representation. It simplifies the diagram by reducing line clutter and provides a more intuitive and semantically rich depiction of facts and their relationships. Version C of the Fact Model introduces symbols and notations that improve the comprehension of the modelled system, such as the use of clear entity and fact type names that are closer to the day-to-day operations.

In Version C, relationships between concepts are depicted using arrows, representing an association where an attribute in one concept refers to instances of another concept (Gouveia et al., 2021). This allows for a clear representation of the connections and dependencies between concepts. To explicitly represent dependency laws, a dark-filled circle is utilized. This

ID	Source	Section	Process	Name	Task Kind	Executing Function	Description	Origin Task(s)	Waits for task(s)	Target Task(s)	Conditions/Rules	Time Constraints
Cognitive Training Programs (6 tasks)												
T64	UC		**Cognitive Training Programs**	Cognitive Training Program Execution	O	Health Professional	Performance of all the games selected in the creation of the training programme	T61 - Cognitive Training Program Creation	T65 - Cognitive Training Program Session Execution	T65 - Cognitive Training Program Session Execution T 66 - Cognitive Profile Calculation based on the Cognitive Training Program	if all sessions have been completed, proceed to calculation	must start no later than 15 days after the creation of the programme

Figure 4: Excerpt of the Transaction Description Table (Version A).

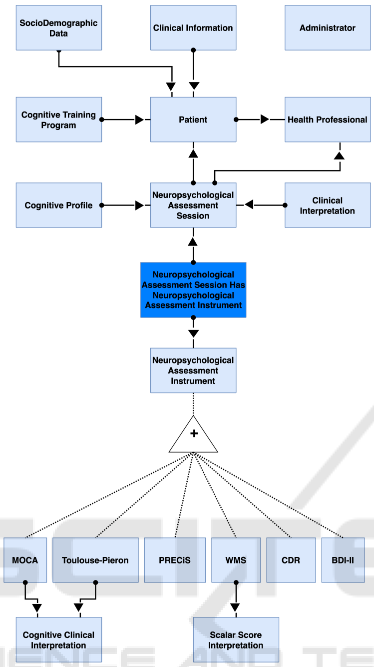


Figure 5: Fact Model (Version C).

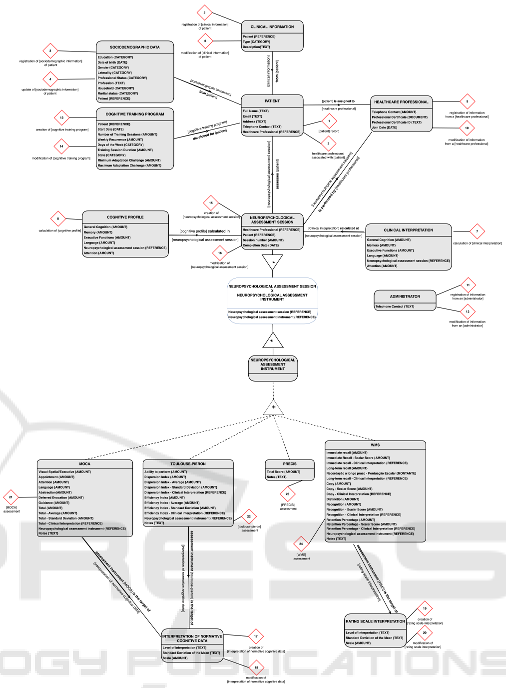


Figure 6: DEMO traditional OFD (Version D).

symbol indicates that the existence of an instance of one concept is dependent on the existence of an instance of the concept connected to it (Gouveia et al., 2021). For example, a Cognitive Training Program cannot exist without referencing an existing Patient instance.

In addition to the improved notation, Version C of the Fact Model separates the concerns of structure and behaviour, focusing solely on capturing the facts and their relationships, rather than explicitly modelling state transitions or processes. Once the main concepts and relationships are specified, the next step is to identify the relevant attributes associated with each concept. The Concept Attribute Diagram (CAD), of which a section can be seen in Figure 7, proposed in (Gouveia et al., 2021) is used for this purpose.

To provide additional context and details about the modelled facts, a Fact Description Table (FDT), depicted in Figure 8, is introduced in (Gouveia et al., 2021). The FDT allows for the inclusion of text-intensive data such as fact descriptions, associated

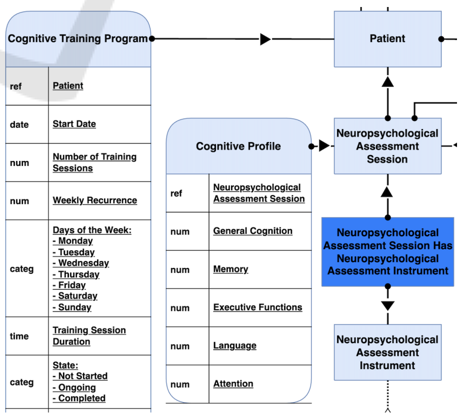
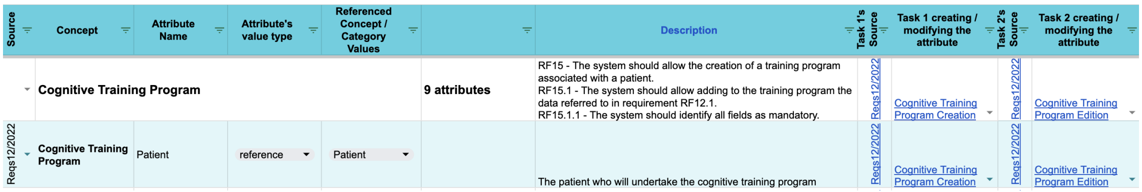


Figure 7: Excerpt of the Concept Attribute Diagram (Version C).

rules, conditions, and other relevant elements. This enables a comprehensive understanding of the facts and their properties.



Source	Concept	Attribute Name	Attribute's value type	Referenced Concept / Category Values		Description	Task 1's Source	Task 1 creating / modifying the attribute	Task 2's Source	Task 2 creating / modifying the attribute
	Cognitive Training Program				9 attributes	RF15 - The system should allow the creation of a training program associated with a patient. RF15.1 - The system should allow adding to the training program the data referred to in requirement RF12.1. RF15.1.1 - The system should identify all fields as mandatory.	Reqs12/2022	Cognitive Training Program Creation	Reqs12/2022	Cognitive Training Program Edition
Reqs12/2022	Cognitive Training Program	Patient	reference	Patient		The patient who will undertake the cognitive training program	Reqs12/2022	Cognitive Training Program Creation	Reqs12/2022	Cognitive Training Program Edition

Figure 8: Excerpt of the Fact Description Table (Version C).

In this depiction of the FDT, we provide an in-depth analysis of each concept along with its corresponding attributes. The table encompasses a comprehensive overview of all attributes associated with each concept, including their scope, source, concept, name, value type, referenced concept/values, description, and the tasks responsible for creating and modifying the concept. By organizing this information in a structured manner, we gain valuable insights into the characteristics and relationships of each concept within the system. The table serves as a valuable resource for understanding the various attributes associated with each concept, facilitating effective conceptual analysis.

3 VALIDATION

Within the field of information systems, many approaches to quality have been proposed (Krogstie, 2012), but it is still a problematic notion. Process models may be difficult to comprehend due to the (un)formality of the modelling language, the complexity or size of the model, or the effort needed to deduce its important properties (Krogstie, 2016). Our study hypothesized that subjects would evaluate Versions A and C as having higher overall perceived Quality (H1) and would also perceive the diagrams on Versions A and C as more functional (H2).

In this section we will present the study's participants, method, procedures and results of the study to validate the Perceived Quality and Functionality of the DEMO Models, comparing the current notation with the newly proposed ones (Pinto et al., 2021; Gouveia et al., 2021).

3.1 Participants

To assess the perceived functionality of the newly proposed representations for DEMO Process and Fact Models, we recruited a sample of health professionals in the field of psychology, with domain knowledge of the modelled processes and implemented system (*N* = 10, nine females and one male, *Mdn* age = 34, age range = 28-58 years). All participants have a Human and Social Sciences background. Namely, among the participants, two are currently pursuing a Bachelor's Degree in Psychology, one is currently pursuing a Master's Degree in Clinical, Health, and Well-Being Psychology, and the remaining seven are health professionals in the field of psychology (Scholar levels: Bachelors degree *N* = 2; Masters degree *N* = 7; and Doctoral degree *N* = 1). Notably, two of these health professionals are directly associated with the NexusBRaNT project, adding valuable expertise and insights to the study.

3.2 Method and Procedures

To evaluate the perceived quality and functionality of the new and old versions of DEMO Models' diagrams, a short questionnaire was designed, based on previous work on the Quality of representations and Functionality evaluations in the context of the SEQUAL framework (Krogstie, 2016). The questionnaire included questions related to functionality, such as participants' agreement on the diagrams' functionality and their preference for one version over the other. Two dimensions from the SEQUAL framework, Empirical Quality (EQ) and Social Pragmatical Quality (SPQ), were also included to assess the perceived quality of the diagrams. The questionnaire consisted of 10 items on a six-point scale ranging from 1 = *strongly disagree* to 6 = *strongly agree*, and one question related to Functionality ("is it functional?"). Two questions were negatively phrased and reversed before the statistical analyses.

Participants were instructed to evaluate both Versions A and B of the Process Model diagrams and Versions C and D of the Fact Model diagrams. The survey included three questions where subjects were forced to pick which version (A or B; and C or D) they considered as more functional (e.g., which version is "more suitable to support the execution of your tasks").

Functional suitability, as defined in software quality models, pertains to how well a system fulfills functions in line with both explicit and implicit requirements (ISO, 2011). It can be broken down into three aspects: functional completeness, functional correctness, and functional appropriateness. (ISO, 2011). Functional completeness evaluates whether the set of functions covers all specified tasks and user objectives, ensuring no crucial functionality is missing. Functional correctness assesses how accurately the system produces results with the required precision, verifying that it meets expectations without errors. Functional appropriateness measures how well the provided functions support users in achieving their intended tasks and objectives effectively.

The experiment began with a briefing about the study and users providing informed consent. The briefing covered key DEMO concepts. The new and old representations of the PM, and then the FM, diagrams were then presented to the participants, followed by a questionnaire to assess their perceived quality and functionality. The scale EQ revealed good internal consistency ($5-items, N=10, \alpha=.72$). The scale SPQ also reached a good internal consistency ($5-items, N=10, \alpha=.76$). In the next section, participants were given a scenario in which they had to decide where to find information when uncertain about forwarding a specific process. They could choose between Version A/C of the diagram, Version B/D, or consulting the technical manual. Participants assessed the likelihood of this scenario occurring on a six-point scale ranging from 1 (definitely not) to 6 (definitely yes). Additionally, the questionnaire included demographic questions about age, gender, scholar level, and background. Participants were also asked to self-report their knowledge levels in three areas: Neuropsychological Assessments and Training Programs Process, NexusBRaNT system, and DEMO, using a scale from 1 (*null*) to 6 (*very good*). Comments and suggestions for improvement were collected by the researchers. Statistical data analyses were performed using computer software (IBM SPSS Statistics, version 27 for MacOS X).

3.3 Results

Wilcoxon tests were employed to compare the perceived Quality and Functionality of the diagrams. The findings indicated that the Version A of the Process Diagram and Transaction Description Table was perceived to have a significantly higher level of EQ (*Mdn* = 5.1, *SD* = .56) compared to Version B (*Mdn* = 2.7, *SD* = .51), with a z-value of -2.83 (*p* = .005), with a large effect size (*r* = -.89) (Field, 2013). Regarding SPQ, Version A is also perceived as higher (Version A: *Mdn* = 5.46, *SD* = .42; Version B: *Mdn* = 2.72, *SD* = .65), with a z-value of -2.81 (*p* = .005), also with a large effect size (*r* = -.89) (Field, 2013).

When comparing the CRD, CAD and FDT (Version C) to Version D, the first is perceived as having a higher level of EQ (*Mdn* = 4.7, *SD* = 1.1), when compared to the current DEMO representation (*Mdn* = 2.34, *SD* = .61), *z* = -2.67, *p* = .008, having a large effect size (*r* = -.84) (Field, 2013). On variable SPQ, Version C also obtained higher results (Version C: *Mdn* = 4.88, *SD* = 1.24; Version D: *Mdn* = 2.6, *SD* = .71), with a z-value of -2.71 (*p* = .007), also with a large effect size (*r* = -.86) (Field, 2013). These results provide full support for our hypothesis (H1), suggesting that Versions A and C are perceived to possess superior quality.

Previous research has suggested that some individuals prefer acquiring new information through formal models, while others find a combination of formal and informal statements to be more comprehensive (Krogstie, 2016). In our study, we asked participants to pick, between Version A and Version B: (a) which one they consider to be easier to understand the sequence of tasks; (b) which one is easier to visualize and understand the tasks related to their professional activity; and, finally, (c) which one do they consider to be more suitable to support the daily execution of their tasks. All ten participants picked Version A, indicating that they perceived Version A as having higher quality, functionality, and overall attractiveness. We asked analogous questions for comparing Versions C and D. Again, all participants chose the newer representation (Version C). These findings offer empirical support for our hypothesis (H2), indicating that Versions A and C are perceived to exhibit superior functionality.

When prompted to select the probability of consulting the Version A of the diagrams, Version B, or the Manual, in the case of doubt, the majority of the participants stated that they prefer Version A (*Mdn* = 5.3, *SD* = .82), rather than Version B (*Mdn* = 2.9, *SD* = .99) or the Manual (*Mdn* = 3.7, *SD* = 1.83). We asked the same question but to compare Version C and D. All participants have also shown a clear preference for Version C (Version C: *Mdn* = 4.9, *SD* = 1.1; Version D: *Mdn* = 2.8, *SD* = .79; Manual: *Mdn* = 3.6, *SD* = 1.78).

The results clearly demonstrate a strong preference for the newer representations over the conventional ones, even when compared to the manual, which participants are more familiar with. The new representations of DEMO's PM and FM present all the essential information visually pleasing and concisely, ensuring ease of comprehension for both modellers and stakeholders. Incorporating symbols and notations that enhance the understanding of the modelled system is a clear advantage of the new representations.

4 CONCLUSIONS AND FUTURE WORK

In this paper, we have presented our research efforts in enhancing the DEMO modelling language. Specifically, we have focused on evaluating the functionality of new DEMO model types using the case of NexusBRaNT.

The evaluation of the perceived quality and functionality of the new and conventional versions of DEMO's PM and FM diagrams was conducted through a questionnaire-based survey. The results indicated that the newer versions of the diagrams are perceived to have significantly higher quality and functionality compared to the traditional versions, in terms of comprehensibility, visualization, and suitability for supporting participants' daily tasks. The results also indicate that the enhanced DEMO models offer a promising approach to simplify and accelerate the modelling of software solutions, as the new representations are evaluated as cognitively more effective than DEMO's current representations.

The revised DEMO PM and FM diagrams have also been integrated into the low-code platform DISME (Dynamic Information System Modeller and Executer) (Andrade et al., 2018; Aveiro and Freitas, 2023; Aveiro et al., 2023). New pilot projects aimed at system implementation are on the horizon, promising additional instances in diverse domains to augment the existing dataset and bolster the findings of this study.

However, there are still several areas that require further attention and future work. While our quality and functionality evaluation provided positive results, it is essential to conduct additional evaluations with a larger and more diverse user group to ensure the generalizability of the findings.

As the main limitation, we identify the small sample size. Therefore, results must be interpreted with caution and generalizability of the findings may be limited.

In conclusion, our research's primary contributions encompass an enhanced understanding of how users perceive the new DEMO models' representations concerning their Quality and Functionality, with a particular emphasis on the Process and Fact Models, more accessible and inclusive to all stakeholders engaged in an organization's daily operations. With ongoing efforts, we envision the newly proposed DEMO models becoming an invaluable tool in modelling efficient information systems in various domains.

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