





# Visual Comparative Analysis of Process Variants

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**Abstract.** Data visualization plays a central role in process mining, particularly when analysts need to compare multiple process models, often representing different *process variants*, to assess changes, detect deviations, or benchmark performance. However, effectively supporting such comparative analysis remains challenging. To investigate this problem, we combine three perspectives: interviews with nine process mining analysts, established visual analytics principles, and an analysis of existing process mining visualizations. Based on this analysis, we identify key challenges for comparative analysis, including weak support for goal-driven analysis, insufficient scalability, and limited flexibility. Based on these insights, we propose an interactive approach for the flexible, scalable, and goal-driven comparison of multiple process models. The approach enables dynamic, goal-driven highlighting of differences and similarities, allowing analysts to tailor comparison based on specific analysis objectives. We developed a prototype implementing the main concepts and interaction mechanisms, and evaluated its perceived usefulness and usability through two workshops with a total of ten participants (students and experts). The results provide initial design insights for visual analytics techniques supporting process variant comparison and highlight directions for future research.

**Keywords:** Process mining · Visual process comparison · Process model comparison · Data visualization

## 1 Introduction

Data visualization is fundamental for analyzing complex datasets and uncovering actionable insights. In process mining, visualization techniques are crucial for understanding process execution and evolution over time [19]. Event logs often capture process executions that can differ significantly along key dimensions, such as geographic location, customer type, or time period [1]. These differences

give rise to distinct *process variants*. Comparing such process variants is crucial to identify structural differences, inefficiencies, and behavioral deviations [21].

The Directly-Follows Graph (DFG) is one of the most commonly used types of process visualization [11,28]. It provides an intuitive representation of control-flow behavior in an event log, helping users understand the process [30]. However, when several process variants are combined into a single DFG, the resulting model tends to obscure the differences between them, leading analysts to draw misleading conclusions about the true behavior of the process [28]. A common solution is to split the event log, and generate a DFG for each subset [7]. While this technique preserves the distinguishing characteristics of each process variant, it introduces a new challenge: analysts must now interpret a collection of DFGs to uncover meaningful similarities and differences between them.

Despite the value of data visualization in process mining, the ability to view multiple visualizations simultaneously and extract insights remains challenging. Recent work highlights the potential of combining visual analytics with process mining to better support these analytical tasks [19]. However, existing tools are not designed to handle multiple process models or to adequately support visual comparison across multiple process models [23]. Consequently, analysts often rely on manual and error-prone methods to compare models [16]. To better understand these practices, we interviewed nine process analysis experts, which revealed limitations in current tools for flexible, goal-driven, and scalable comparison of multiple models. The aim was to explore how and why they carry out visual comparisons of process models in practice. Through an in-depth analysis of existing solutions and practices, we identified three key challenges that remain insufficiently addressed: (C1) adaptability and goal-driven comparison, tailoring both the comparison and its visualization according to specific goals; (C2) scalability and clarity in multi-model comparison, supporting intuitive exploration and visualization as the number and complexity of models increases; and (C3) flexibility in the analysis of differences and similarities, supporting the identification of both commonalities and deviations without restricting the comparison to a single perspective.

To address these challenges, we propose a set of comparative strategies to support the visualization and exploration of collections of DFGs, together with visual designs that improve cross-model comparison. Our approach is grounded in key visual design principles [12,13]. We focus on DFGs as they are the most widely used notation in process mining tools and are well understood by analysts [18,28]. We implemented our approach as a tool prototype that supports analysts in identifying structural similarities and differences across process variants, and in tailoring visualizations to specific analysis goals, such as highlighting control-flow aspects. We evaluated our prototype through two workshops with ten users, including both students and experts, who tested it using a real event log and provided feedback on its usability and usefulness. The evaluation revealed positive user perceptions regarding the usefulness of the proposed interaction mechanisms and visual comparison strategies.

The paper is structured as follows. Section 2 reviews related work. Section 3 describes the research method. Section 4 details the identified challenges. Section 5 presents the conceptual approach to visually compare process models. Section 6 presents the evaluation of the implemented tool functionalities through two workshops. Section 7 discusses implications, opportunities for improvement, and future research. Finally, Section 8 concludes the paper.

## 2 Related Work

Building on representative work in visual process comparison, we examine current approaches in terms of the visualizations they employ, comparison methods, and how these results are reported to users. Presenting results effectively is crucial, as visualization supports interpretation and communication [13]. Then, we distinguish between approaches based on process models and those relying on alternative representations, with limitations discussed in Section 4.

**Result representation with process models.** Several approaches use process models to visualize differences. Ballambettu et al. [3] and Syamsiyah et al. [26] rely on DFGs to compare multiple process models and present the results within a unified DFG, using colors and varying node and edge thicknesses to highlight changes. This can be used to reveal structural differences and changes in DFG annotations, such as frequencies and flow time. While these studies analyze multiple process models simultaneously, the remaining approaches are designed to compare only two models at a time. Jalali et al. [16] incorporate probabilistic information using stochastic DFGs to display behavioral differences with color-coded edges. They compare process models using Markov models and stochastic DFGs, applying a cut-off level to filter insignificant variations. In contrast, other approaches use alternative graph-based representations. For instance, Bolt et al. [5] rely on transition systems to detect statistically significant differences between models in terms of any measurement annotations, and display the similarities and differences of business rules between them. Similarly, Wang et al. [29] use Petri nets to detect structural and behavioral differences between processes, displaying key process structures common between them.

In addition, several commercial process mining tools support visual comparison of business processes using process models<sup>5</sup>. For example, Apromore highlights deviations between two variants with color-coded annotations, while Celonis, LANA (now part of Appian), and Signavio allow users to compare multiple variants. Specifically, Signavio and LANA use color overlays and Celonis shows side-by-side comparisons. In addition, tools like ARIS, Minit, and UiPath support process model overlays and interactive exploration of structural and behavioral differences showing DFGs or BPMN models. Other tools, such as BusinessOptix, EverFlow, mpmX, myInvenio, PAFnow, and QPR ProcessAnalyzer, provide visual process comparisons considering different scopes and methodologies. For instance, BusinessOptix focuses on scenario-based comparisons, Ev-

<sup>5</sup> <https://www.processmining-software.com/>

erFlow and mpmX provide dashboards for variant analysis, and myInvenio and QPR allow structural and behavioral comparisons with some predictive analyses.

**Result representation without process models.** Other approaches present process comparison outcomes by means other than process model visualizations. For instance, Nguyen et al. [20] use a matrix-based representation, using perspective graphs for statistical comparison between two process models from multiple attributes. The result is a difference graph visualized as a color-coded matrix, where nodes are columns and edges are cells. Van der Aalst et al. [2] assess how well a model can reproduce event sequences recorded in an event log using Petri nets. The outcome of this analysis is a degree of similarity between them, expressed as a numerical value between 0 and 1. Van Dongen et al. [10] compute the similarity between two process models based on causal footprints, which represent essential behavioral constraints. While such approaches provide numerical outputs, Van Beest et al. [4] capture behavioral differences through statements in natural language based on frequency-enhanced prime event structures, e.g., “In variant 2, b occurs after a, while in variant 1 it does not”. Finally, Bin et al. [6] propose a custom notation for describing difference patterns between two process models represented as process structure trees. For example, the notation “ $\emptyset$  VS R” indicates that *task R only exists in the second process model*.

### 3 Research Method

We follow the principles of Design Study Methodology [24] commonly used in visualization research. Following this methodology, we analyze real-world problems faced by process mining analysts doing comparative analysis of process variants and then design a visualization system to address them. All supplementary materials related to the research method are available in our repository.<sup>6</sup>

#### 3.1 Understanding the Problem

We analyzed the problem from three different perspectives. First, we made a structured review of related work focused on multi-model process comparison considering academic approaches and commercial tools. Second, following the *understanding work practices* approach in visualization research [15], we conducted semi-structured interviews with nine process mining experts to gain insights into how and why visual comparisons of process models are performed in practice. The number of participants is consistent with prior work in this area [15]. The interview protocol included 19 questions in three parts: (i) *demographic information* (3 questions), capturing participants’ role and background; (ii) *process mining experience* (4 questions), addressing expertise, years of experience, and typical tasks; and (iii) *process mining analysis practices* (12 questions), focusing on exploratory analysis of event logs, use of process models, comparison of multiple process variants, and tool features and limitations. Each interview lasted

<sup>6</sup> <https://doi.org/10.5281/zenodo.20393413>

approximately one hour and was conducted remotely, recorded, and transcribed. Finally, we considered established principles of comparative visualization [12,17] to guide the analysis of existing techniques and to interpret findings from the interviews. The insights obtained in this stage were used to identify challenges and user needs described in Section 4

### 3.2 Conceptualization and Prototype Evaluation

To address the challenges, we introduce a set of comparative strategies and visual designs for multi-model process comparison, grounded in principles of comparative visualization [12,13]. The framework adopted guided the systematic derivation of visualization mechanisms for multi-model comparison through identifying core comparative elements, deriving associated challenges, and linking them to visualization strategies and design choices to manage perceptual and cognitive load. The resulting approach is detailed in Section 5.

We implemented a prototype tool to explore and assess the proposed approach. The prototype implements the proposed comparative strategies and designs, and it enables analysts to compare multiple process models. The prototype evolved through several iterative cycles involving internal testing, refinement of interaction mechanisms, and adjustments to the visual comparison strategies based on emerging design considerations. We evaluated the prototype in two workshops: one with five domain experts and another one with five students. The study combined *Visual Data Analysis and Reasoning* and *User Experience* methods [15]. Participants performed analysis tasks using the prototype and provided feedback through open question and questionnaires. Each workshop lasted approximately two hours, and sessions were recorded and transcribed. The goal of the workshops was to obtain exploratory qualitative feedback regarding the usefulness, usability, and applicability of the proposed interaction mechanisms and visual comparison strategies. Further details are provided in Section 6.

## 4 Challenges in Visual Process Comparison

Visual comparison of multiple process models is a central activity in process mining practice. Our interviews show that analysts frequently use process visualizations as part of their exploratory analyses and regularly compare process variants for tasks such as conformance checking, benchmarking and cross-context analysis. DFGs were highlighted as particularly useful for this purpose. As one participant emphasized, *“I find DFGs... one of the most important things in process mining to compare processes together to find where processes differ”*.

Drawing on a critical analysis of existing approaches, established principles of comparative visualization [12,17], and insights from our interview study, we identify three key challenges that reflect both recurring needs highlighted in prior studies [7,16,21] and limitations observed in current tools.

#### 4.1 Adaptability and Goal-Driven Comparison (C1)

Comparison tasks involve two key elements: a set of *targets* (i.e., elements to compare), and an *analysis action* that defines the analytical goal [12]. In our context, the targets are multiple process models, and the actions focus on identifying structural or behavioral similarities and differences between them.

Our interviews reveal that analysts employ both exploratory and hypothesis-driven analysis. Exploratory analyses often begin without a fixed purpose, requiring flexible comparison strategies that support pattern discovery, insight generation, and shifting analytical focus. Even when a clear hypothesis exists, existing tools often fail to align with the analytical intent (cf. Section 2), making it difficult to focus on the most relevant information. This misalignment is evident in many existing approaches that highlight multiple aspects of the comparison between process models without considering the user’s analytical intent. For example, Ballambettu et al. [3] simultaneously present structural and behavioral differences without, regardless of whether both are relevant to the task. This lack of focus can introduce visual clutter and increase cognitive load.

The need for adaptive, goal-driven comparison is supported by prior visual analytics research. Von Landesberger et al. [17] highlight algorithms and interactive visualizations for specific tasks within unified systems, and Gleicher et al. [12] argue that interactivity and customization improve the comparison relevance of the visual outputs and support insight generation aligned with the analytical actions. This is consistent with cognitive perspectives on process mining, which emphasize theory-guided analysis driven by the analyst’s goals [25].

**Challenge C1.** Visual process comparison techniques should support goal-driven analysis by allowing users to define and adjust analysis actions, and by adapting the visualization accordingly. This includes enabling focus on specific aspects, such as behavior or performance, while maintaining clarity and supporting effective insight generation.

#### 4.2 Scalability and Clarity in Multi-Model Comparison (C2)

Scalability is a well-known challenge in visual analytics, where the number and complexity of targets affect interpretability [12, 17]. In process mining, this issue is particularly pronounced: process models are inherently complex, and analysts often need to compare multiple variants derived from event logs (e.g., grouping cases by resource) [23]. This leads to comparison scenarios with many dense models, which are difficult to interpret jointly.

Existing approaches provide limited support for such scenarios. Only a few [3, 26] handle comparing more than two process models at once, restricting the ability to analyze multiple process variants simultaneously. This limitation also appeared in our interviews, where several participants noted that current tools restrict comparisons to two models despite the need to analyze multiple variants.

Scalability and clarity are closely tied: as the number and complexity of process models increases, maintaining clear visualizations becomes more difficult [12]. Approaches for comparing several process models [3, 26] typically display all results in a single view, causing visual clutter. One interview participant

emphasized the importance of simplifying visualizations and focusing on relevant cases to avoid overwhelming users. Additionally, while seven participants reported that DFGs are useful for comparison, especially to detect activities, loops, or deviations, they also highlighted several limitations related to scalability and clarity, including difficulties comparing many models, managing numerous process variants, and inconsistent node positions across graphs.

**Challenge C2.** Visual process comparison techniques should scale to large collections of complex process models while maintaining visual clarity. This requires supporting the analysis of multiple variants without overwhelming users.

### 4.3 Flexibility in Comparing Differences and Similarities (C3)

Prior research emphasizes that comparative visualizations must support balanced exploration of similarities and differences to support reasoning [12, 17]. Our interviews reinforce this need. Seven out of nine participants said that highlighting both similarities and differences, for instance through color coding or annotations, would improve the comparison process. However, current visual process comparison approaches mainly focus on identifying differences, limiting the ability of the analysts to recognize similarities between the process models. For instance, Jalali et al. [16] detect behavioral differences based on activity frequency and time between activities. Only a few approaches consider similarities, but they do not rely on process model visualizations [2, 10].

**Challenge C3.** Visual process comparison techniques should allow analysts to switch between exploring similarities and differences across process models. This requires defining actions that explicitly focus on both types of goals and providing explicit encodings that enable analysts to emphasize or adjust the importance of each depending on the task.

## 5 Conceptual Proposal for Visual Comparisons

Building on established principles of comparative visualization [12, 13], particularly Gleicher’s framework, our proposal defines comparative elements, their associated analytical challenges, and corresponding visualization strategies and design choices to support visual multi-model comparison. The supplementary material provides DFGs used in the evaluation to show the application of these strategies and design choices. Figure 1 illustrates these interrelations in our approach, which is described in detail below.

### 5.1 Comparative Elements

Comparative visualization begins by specifying the inputs in terms of *targets* and *actions* [12]. In our case, the targets are a collection of DFGs generated from several filtering and data manipulation tasks on the event log to create multiple process variants, with each DFG representing one process variant.

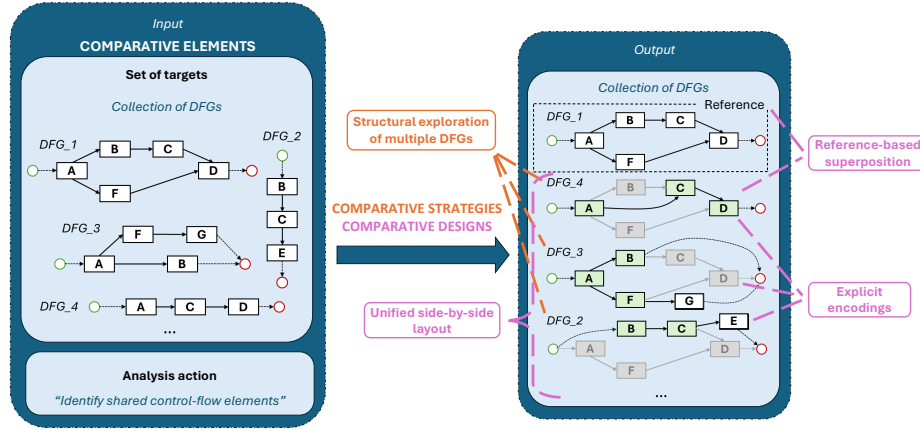


Fig. 1: Overview of the proposed comparative visualization approach.

Regarding the actions, considering that successful comparison approaches avoid covering too much at once [12], we focus on three control-flow analysis actions: (1) *Identify shared control-flow elements*, which highlights nodes and edges that are shared across the compared models; (2) *Identify exclusive control-flow elements*, which highlights nodes and edges that appear only in a specific model and not in others; and (3) *Identify missing control-flow elements*, which highlights nodes and edges that are absent in a specific model but present in other models. These actions operationalize different comparison goals, enabling analysts to flexibly focus on similarities and differences depending on their analytical intent (C3). They are implemented as selectable options within our approach’s foundation, where each choice triggers the corresponding comparative strategies and designs to support the intended analysis (C1).

## 5.2 Comparative Strategies

To facilitate comparison of large and complex DFG collections (C2), we propose two complementary strategies, grounded in principles of comparative visualization [12]. Comparative strategies define high-level design choices that determine which aspects of the targets are shown and how they are visually encoded.

**Structured Exploration of Multiple DFGs.** To address the need to handle large collections of process variants (C2), we introduce a *sequential scanning* strategy, where users scroll and examine each DFG individually. To accomplish this, we enable users to sort the collection by a criterion relevant to the analysis task at hand, such as similarity between models or statistical measures like case count or mean duration. Displaying the most informative models first enables users to focus on relevant process variants and stop scanning once sufficient insight is gained, reducing cognitive effort. For instance, when a user is interested in a specific set of activities, models containing the full set can be displayed first, followed by those with most, few, or none of the activities.

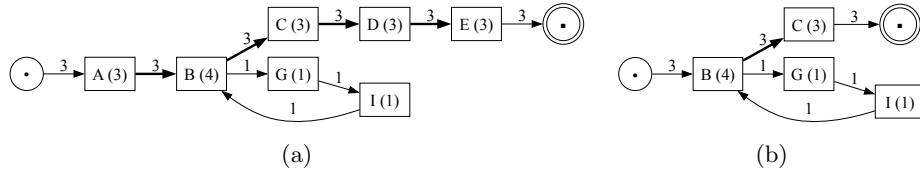


Fig. 2: Example of visual simplification of a DFG. (a) Full process view. (b) Process fragment between activities  $B$  and  $C$ .

**Visual Simplification of DFGs.** We enable the interactive simplification of DFGs through a set of user-driven mechanisms that reduce complexity (C2) while preserving interpretability. Unlike conventional filters, which are applied before visualizing the results, these mechanisms allow users to iteratively refine DFGs and immediately observe their impact. To this end, our approach integrates standard filters for activities and transitions based on frequency thresholds [28] with three additional visual simplification mechanisms:

**Activity hiding** reduces DFG size by hiding selected activities. Similar to common filters, it adds edges between preceding and subsequent activities to preserve structure even if transitions did not occur in the original log [28].

**Fragment focusing** enables users to concentrate on a segment of the DFG between two selected activities for detailed examination. This need has been identified in previous work as a key requirement for effective process analysis [21]. For instance, Figure 2a displays the full process, while Figure 2b presents a filtered view that isolates only the portion of the process between activities  $B$  and  $C$ , hiding all nodes and edges outside this process fragment.

**Annotation selection** removes irrelevant visual elements, such as colors, activity frequencies, or performance metrics, simplifying the DFG without losing key comparative insights. For example, users focusing on structural differences can hide frequency or performance annotations from nodes and edges.

### 5.3 Comparative Designs

To visually present similarities and differences between multiple DFGs, we devise two comparative visualization designs for multi-model process comparison grounded on established approaches, namely *juxtaposition*, *superposition*, and *explicit encodings* [13]. These designs are combined and adapted to support different analysis actions and address the challenges identified in Section 4.

**Unified Side-by-Side Layout.** To support sequential scanning of an ordered collection of DFGs (C2), we adopt a *juxtaposition* design by arranging models in a vertical column with an uniform layout [12], i.e., we enforce consistent node and edge positions across all DFGs. To achieve this, we generate a union DFG that aggregates all unique activities and transitions across the collection, and compute a single layout on this unified graph. Each DFG then reuses these positions, displaying only the elements present in that model. This shared layout preserves

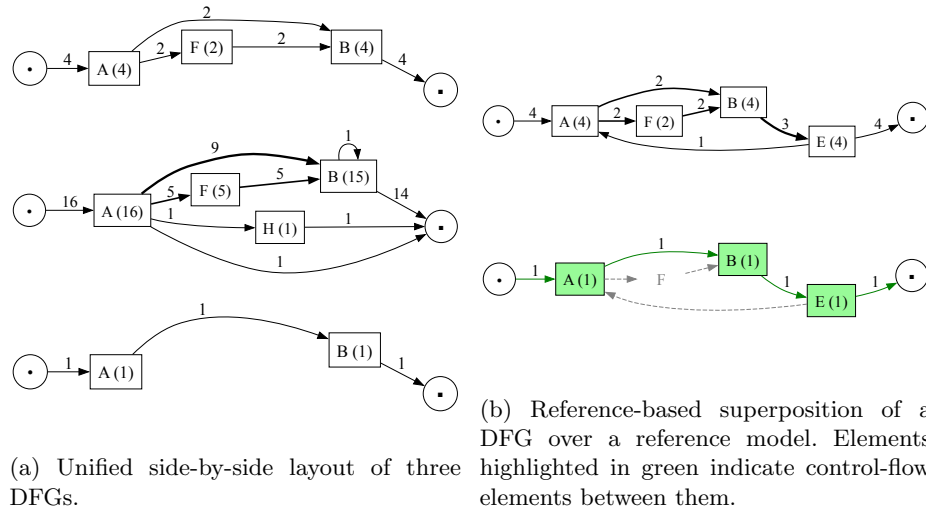


Fig. 3: Examples of visual comparative designs.

spatial consistency, enabling efficient scanning and direct structural comparison while reducing cognitive effort [13]. Figure 3a illustrates this approach with a collection of three DFGs representing different process variants.

**Reference-Based Superposition with Explicit Encodings.** To complement the unified side-by-side layout and support analysis of similarities and differences (C2, C3), we introduce a reference-based *superposition* design with *explicit encodings*. Models are overlaid on a shared layout, preserving spatial coherence and users' mental maps [13].

A key element is the introduction of a *reference model* as a stable visual baseline. Users can select any DFG from the collection, or the union DFG, as the reference. Each model is compared against this reference, reducing visual complexity and avoiding multiple pairwise comparisons (C1, C2). The reference is rendered in the background with unboxed nodes and dashed edges to deemphasize it. A selected model is then superimposed using color encodings to highlight structural similarities and differences while preserving contextual information.

Explicit encodings further support goal-driven analysis and clarity (C1, C3) by allowing users to control which aspects are emphasized. The visualization adapts accordingly, maintaining focus and avoiding clutter. Figure 3b illustrates this design: the top graph shows the reference model, while the bottom graph overlays another DFG. Shared nodes and edges are highlighted in green, while elements only in the reference remain in the background.

Together, these visual designs provide the foundation for comparing multiple process models, combining shared layouts, reference-based comparison, and adaptive visual encodings within a unified framework.

## 6 Evaluation

To obtain exploratory feedback regarding the usability and applicability of our approach, we implemented it as a prototype integrated into VISCoPro [22], a tool that creates collections of DFGs from event logs. Using Streamlit<sup>7</sup>, we extended the tool with the proposed strategies and visual designs, enabling analysts to visually identify structural similarities and differences across DFGs. The source code is publicly accessible in our repository<sup>8</sup>.

### 6.1 Evaluation Method

We evaluated the prototype through two workshops: one with five domain experts with diverse levels of experience in process mining, and another one with five master’s students who have prior knowledge in process mining. Four experts also participated in the interview phase, ensuring continuity between problem identification and solution evaluation. In line with common practices in visualization studies, involving three to five domain experts is usually sufficient to gather meaningful qualitative insights [15]. The workshop format was chosen because it enables active interaction between the moderator and participants, allowing misunderstandings to be clarified immediately, and promotes discussions that reflect real-world scenarios they typically face [27]. The goal of the workshops was not to quantitatively measure analytical performance or compare the approach against existing tools, but to gather exploratory qualitative feedback regarding the proposed visual comparison strategies and interaction mechanisms.

Following the guidelines of Thoring et al. [27], the workshop was structured into three parts. Full details are provided as supplemental material in our repository. In the first part, we introduced our conceptual proposal for visually comparing multiple process models based on Gleicher’s framework [12]. We then demonstrated how these proposed strategies and designs were implemented in the prototype and how to use them.

In the second part, participants used the tool to perform three tasks that required the comparison of multiple process models. They were encouraged to explore specific functionalities to assess their usability. For these tasks, we employed a simplified version of the Domestic Declarations event log from the 2020 Business Process Intelligence Challenge [9]. These tasks were designed to reflect realistic comparison scenarios and to elicit the use of key features of our approach, such as sequential scanning, subset selection, and reference-based comparison. For example, one task required participants to identify similarities in a specific part of the process across resources. They had to use the appropriate comparison action to highlight commonalities and fragment focusing to inspect that part of the process in detail. As participants worked through the tasks, they shared their screens, allowing the group to observe their visualizations and collaboratively discuss potential improvements, challenges, and suggestions. These

<sup>7</sup> <https://streamlit.io/>

<sup>8</sup> <https://doi.org/10.5281/zenodo.20393413>

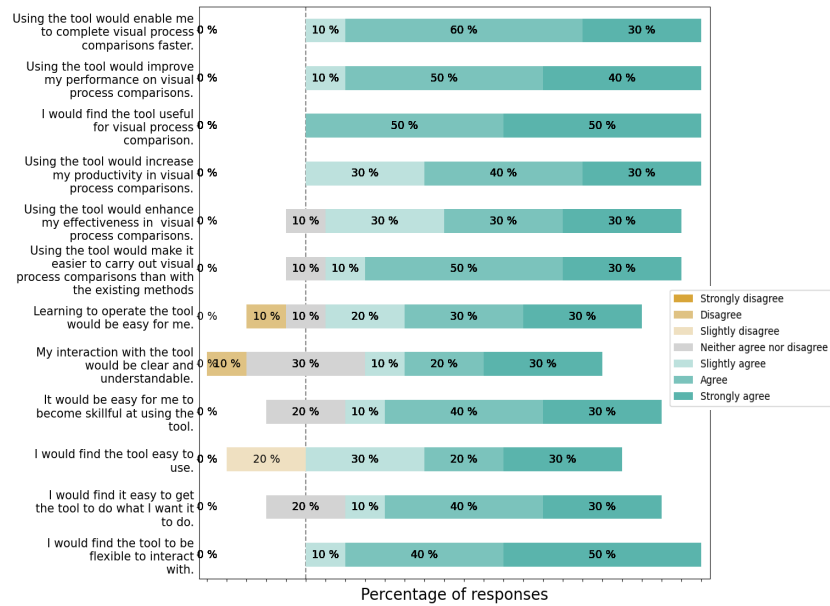


Fig. 4: TAM results for the comparative features. The first six items measure perceived usefulness and the following six perceived ease of use. The vertical dashed line marks the neutral point (4) on the 7-point Likert scale.

exchanges clarified which features were most valuable and which caused difficulties. The DFGs obtained are available in our repository.

In the final part of the workshop, participants completed a structured questionnaire to assess the usefulness and ease of use of the approach. The questionnaire was based on the Technology Acceptance Model (TAM), a well-established framework for explaining and predicting the adoption of new technologies [8]. TAM focused on two key constructs: perceived usefulness and perceived ease of use. Participants rated each item on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree), and responded to four open-ended questions about the strengths and weaknesses of our approach. Details about the evaluation are included in our public repository.

## 6.2 Evaluation Results

Overall, participants found the comparative features helpful. One participant noted, “*It’s a good overview of seeing all the different models side by side to compare more than just two of them*”. The consistent layout was repeatedly highlighted as really beneficial, as it allows users to quickly identify corresponding flows across models. As one participant explained, “*if the position is fixed you can really just look, for example, at Start Trip and check the next model at the same place to see whether it is there or not*”. Most participants emphasized that

this feature, combined with color encoding, allows users to make quick visual comparisons, even in complex scenarios.

Participants responded positively to the option of using a reference DFG and displaying it in the background of other process models. They noted that the reduced visual presence of the reference elements, which are rendered in the background, helps maintain context without overwhelming the main visualization. However, some participants pointed out that this approach could be harder to interpret with larger or more complex event logs. They suggested that it would be useful to have an option to show or hide the background reference model. Four of the five participants in one workshop suggested this.

The fragment focusing feature was highlighted as particularly valuable when working with larger or more complex processes. Participants noted that comparing entire processes can become impractical when many activities are involved. In these cases, it is beneficial to restrict the analysis to a specific subset of the control flow. As one participant explained, *“usually the processes are really huge with a lot of activities, so just focusing on a small subset is quite good”*. At the same time, participants acknowledged that selecting a fragment may sometimes hide relevant steps that occur just outside of it. However, they generally agreed that this limitation is not specific to visualization.

The activity-hiding feature was considered useful, particularly for exploratory analyses. Participants noted that many activities in real-world event logs may be irrelevant to a specific analysis. In such cases, manually hiding activities allows analysts to simplify the visualization temporarily and focus on the main process while still having the option to restore the hidden elements later.

To assess the perceived usability and ease of use of the comparative features, we analyzed responses to the TAM questionnaire (cf. Figure 4). The results suggest positive perceptions regarding the proposed comparison strategies and designs. The average perceived usefulness was 6.13 (median 6.1), well above the neutral midpoint of the scale, showing that participants perceived the tool as useful for comparative tasks. Perceived ease of use also scored above neutral (mean = 5.68, median = 5.65), suggesting that, while the system is generally easy to use, there remains room for improvement in simplicity and interaction flow. When comparing the two groups of participants, we found that the experts reported a slightly higher perceived usefulness of the system (mean = 6.23, median = 6.3) than the students (mean = 6.03, median = 6.0). However, students rated the system as easier to use (mean = 6.27, median = 6.3) compared to experts (mean = 5.10, median = 4.9). This difference suggests that prior experience with process mining tools may influence expectations regarding usability and interaction complexity.

The responses to the open-ended questions reinforced these findings. Participants praised the tool’s comparative capabilities; one described it as the *“fastest way to detect similarities/differences ever seen in process mining”*, while others appreciated the *“fixed positions”* and the use of the reference model. They also suggested enhancements such as adding *“patterns for performance metrics like time between Activity A and B has to be X or lower than...”* to support bot-

tleneck detection and root-cause analysis. Regarding the activity-hiding feature, participants suggested adding “*an overlay of the full process*” to preserve context when activities are hidden, and more control over visual elements, such as hiding or showing reference elements on demand. Finally, participants pointed out limitations related to scalability and visual complexity, noting that “*there could be too much information... if too many activities are involved*” and that comparisons may become “*overcrowded*” for larger datasets. This reinforces the need for future work on abstraction, filtering and scalable visualization techniques.

## 7 Discussion

In this section, we outline design implications for visual process comparison tools, based on the identified challenges and evaluation feedback, and discuss limitations of our approach.

**Supporting adaptability and goal-driven comparison (C1).** Our findings suggest that the process of visual comparison is improved by making analytical goals explicit. Interviews revealed that experts vary between exploratory and hypothesis-driven analyses, often requiring flexible comparison strategies to obtain insights, since current tools do not always align with their analytical goals. Feedback from the workshops further highlighted that, even when using actions to guide comparisons and explicit encodings to emphasise particular aspects, some participants suggested enabling or disabling the display of reference elements in the background. Providing users with greater control can enhance interpretability and align comparisons with their analytical objectives, though it may require additional guidance, especially for less experienced analysts.

**Supporting scalable exploration of multiple models (C2).** Our interviews revealed that analysts frequently need to compare more than two process models at a time. This quickly becomes challenging due to increased visual complexity, cognitive load, and limitations in existing tools. Workshop feedback highlighted the importance of mechanisms that reduce visual complexity, such as consistent layouts, activity hiding or fragment focusing. In particular, participants repeatedly emphasized the value of consistent node and edge positions across DFGs. While recent work suggests that preserving the mental map in DFGs may not improve analysis performance in dynamic scenarios [14], our setting differs: we focus on static comparison across multiple variants. In this context, layout consistency plays a different cognitive role, helping alignment attention across models and enhancing the effectiveness of side-by-side comparison. Participants also stressed that effective multi-model comparison requires not only displaying multiple models, but enabling users to progressively narrow their focus while maintaining spatial consistency across views. Activity hiding and fragment focusing proved particularly useful for this purpose. However, our evaluation did not directly compare alternative scalability strategies, leaving their effectiveness in larger, more heterogeneous real-world collections as future work.

**Supporting comparison of similarities and differences (C3).** Our findings emphasise the importance of flexibly balancing the comparison of similarities and

differences in visual process analysis. Workshop participants valued mechanisms that make these aspects explicitly visible. In particular, the use of a reference model combined with color-based encodings was perceived as helpful for highlighting commonalities and deviations while preserving contextual information. Participants also indicated that providing specific comparison actions that directly enable the corresponding visual encodings is beneficial, allowing users to highlight either similarities or differences depending on their analytical goal.

**Limitations and future directions.** The findings should be interpreted within the scope of the present study. First, the evaluation focused on an exploratory assessment of the proposed approach through workshops with a small but diverse group of participants. While this allowed us to gather rich feedback on perceived usefulness, ease of use, and feature relevance, future studies could complement these findings with longitudinal investigations of its use in real-world settings and assessments of analytical performance. Second, the current work focuses on DFGs, which provide an intuitive and widely used abstraction of process behavior, making them a suitable starting point for investigating visual comparison mechanisms. However, they do not capture richer behavioral semantics such as concurrency or non-free-choice behavior. Exploring the applicability of the proposed approach to richer representations, including BPMN models and Petri nets, offers a promising direction for future research. Finally, the evaluation was designed to understand user perceptions and requirements rather than to benchmark the approach against alternative visualization techniques. Future work could therefore incorporate controlled comparisons and additional analytical measures, such as task completion time, and analytical accuracy, to provide a more comprehensive assessment of the approach.

## 8 Conclusions

This paper addresses the need for effective visual comparison of multiple process models, a central task in process mining practice. Combining expert interviews, analysis of existing approaches, and comparative visualization principles, we identified key challenges related to adaptability, scalability, and the comparison of similarities and differences. To address these challenges, we propose a visual approach that combines structured exploration of multiple DFGs with visual simplification mechanisms (activity hiding, fragment focusing, and annotation selection), enabling users to focus on relevant aspects of the comparison. In addition, we introduce a unified side-by-side layout and a reference-based superposition with explicit encodings to support the identification of similarities and differences across models. We implemented the approach in a prototype and evaluated it in two workshops. The results show that goal-driven comparison actions, consistent layouts, and simplification mechanisms are key for supporting effective multi-model analysis, improving interpretability and user control in practice. These findings provide design insights for interactive systems that support flexible, scalable, and goal-driven visual comparison of process models.

Future work will extend the evaluation to larger and more diverse user groups, include controlled comparative studies, and investigate the applicability of the proposed design implications across different process representations. We also plan to develop automated reference model selection strategies and extend the comparison mechanisms to additional perspectives, such as temporal performance and resources.

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