Virtual Business Role-Play: Leveraging Familiar Environments to Prime Stakeholder Memory During Process Elicitation

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Abstract. Business process models have traditionally been an effective way of examining business practices to identify areas for improvement. While common information gathering approaches are generally efficacious, they can be quite time consuming and have the risk of developing inaccuracies when information is forgotten or incorrectly interpreted by analysts. In this study, the potential of a role-playing approach for process elicitation and specification has been examined. This method allows stakeholders to enter a virtual world and role-play actions as they would in reality. As actions are completed, a model is automatically developed, removing the need for stakeholders to learn and understand a modelling grammar. Empirical data obtained in this study suggests that this approach may not only improve both the number of individual process task steps remembered and the correctness of task ordering, but also provide a reduction in the time required for stakeholders to model a process view.

Keywords: Business process management · Process elicitation · Subject-oriented business process management · 3D virtual worlds · Human-computer interaction

1 Introduction

Expert knowledge elicitation has traditionally been a problem of much significance within a wide range of fields [7]. Tasks ranging from software requirements elicitation to graphic design all require an accurate flow of information between developers and end users. The inaccurate communication of this information has the potential to manifest in a variety of ways[27], including extended development times, higher construction costs or irrelevant products.

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While each of these fields does not necessarily use the same exact approaches to elicit this information, the same general concepts and methodologies are implemented. This commonly involves having users try and articulate their requirements either verbally or technically, or using an observational approach to have analysts better understand the client perspective and the exact requirements for the task in question [7].

These elicitation approaches, however, do not always provide accurate and succinct information. While the end users may be able to visualise their exact requirements, it is common that they are not able to fully express them correctly [2]. This may be caused by assumptions that end users believe are universally understood, despite them not being explicitly stated [6]. This issue is compounded by the fact that the people who access this elicited information often adhere strictly to what has been outlined in an attempt to ensure that the end product closely matches what they believe is expected [20]. It is suggested that this is done because those who use this knowledge do not necessarily have the requisite background to evaluate the correctness and completeness of the information.

Business Process Management (BPM) is an approach which is commonly used to better formalise, analyse and optimise core business practices [25]. To achieve this, formal models are constructed outlining each of the potential tasks involved in various processes along with their respective execution structure. The goal in doing this is to analyse running processes over time to identify any metrics which may require attention [13]. Common examples include the time required to build goods, perform services or respond to clients. After issues are detected with existing processes, the business can then examine these process models to identify areas for improvement, either refining the models or reworking them entirely [25]. Despite these benefits, issues which arise in process modelling have the potential to result in a variety of concerns for businesses. In 2013, 46% of companies adopting BPM principles were spending upwards of half a million dollars annually on the methodology [15]. As accurate models are critical for business analysis and refinement [29], incorrect models can result in large amounts of wasted spending within a business.

The benefit of evaluating this role-playing elicitation approach with regards to BPM is that the accurate specification of task information is critical to the overall methodology [13]. Without accurate base models to capture task information, effective model analysis and refinement cannot easily be performed [11]. Furthermore, many of these processes are spatially distributed, involving tasks which closely map to real world items [33]. This suggests that priming users with the 3D virtual world will result in the recollection of task steps which may otherwise be forgotten [12].

1.1 Aim

In this study, an alternate method for eliciting process information from stakeholders will be examined. Rather than having these stakeholders try and verbally explain all of the various steps involved in a large task, they will instead specify this information with a role-playing approach. To facilitate this, a 3D virtual world has been developed which closely mirrors the process execution environment of the stakeholder. The user is then able to traverse this world and role-play each step they would normally complete in the process. As this is done, the tool captures the tasks performed as well as their sequence and other flow structures (such as conditions) to build a formal specification. Figure 1 provides an example of the virtual world developed for this study.

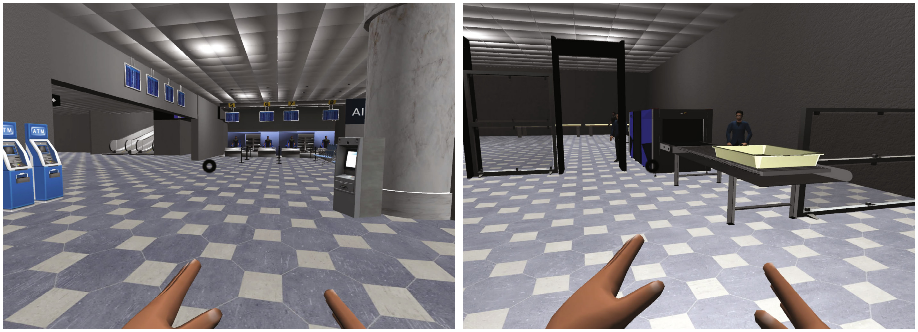

Fig. 1. Screen captures of virtual world airport scene

The goal of this approach is to place experts into a more familiar environment during task specification. In doing this, there is also the potential to prime user memory and adjust cognitive thought processes to assist with memory recollection [3].

1.2 Approach

To evaluate this role-play elicitation methodology, a tool using this role-playing approach has been constructed which utilizes the subject-oriented business process management (S-BPM) modelling grammar [10]. The efficacy of this new virtual world approach has been evaluated using the build-evaluate design science methodology [1]. This evaluation has been done in the form of an A/B comparative experiment, comparing the virtual world with a custom S-BPM process modeller also developed in this work. The experiment goal was to evaluate the ability of participants to accurately recall and order a series of process tasks while also exploring the way in which users interact with the world to construct process models. This has been compared with a 2D modelling approach in order to identify any major differences in both the modelling approach and the final model outputs.

Section 2 of this paper will examine the S-BPM language, particularly the individual subject views, as the virtual world currently generates outputs using this grammar. Section 3 outlines the features of the developed virtual world, with a focus on how users interact with the environment to complete tasks. Section 4 provides an overview of the experiment design, including hypotheses and approach. Section 5 provides results and section 6 analyses the significance of these results and whether they match original predictions. Section 7 considers the limitations of these findings in addition to any potential threats to validity. Section 8 considers similar research which has previously been conducted in this area. Finally, section 9 will conclude by summarising areas of interest and identifying the logical next steps to further evaluate this approach.

2 The S-BPM Language

The S-BPM modelling language follows a view-based modelling approach. Unlike traditional languages, complete S-BPM models are constructed by merging several individual subject views [10]. Each subject view describes the actions of a single entity. The language has been designed to follow closely with standard *subject-predicate-object* constructs, allowing stakeholders to both understand and construct their own process views [19]. These views are constructed by linking three possible states: *internal action*, *send* and *receive*. Internal actions represent actions completed by the subject, while send and receive states represent communication between subjects. An example S-BPM subject view can be seen in figure 4. This language has been chosen as it provides concise mapping between first-person virtual world actions and S-BPM model components without requiring participants to model the process from multiple viewpoints. Figure 2 shows an example of virtual world actions mapping to S-BPM components.

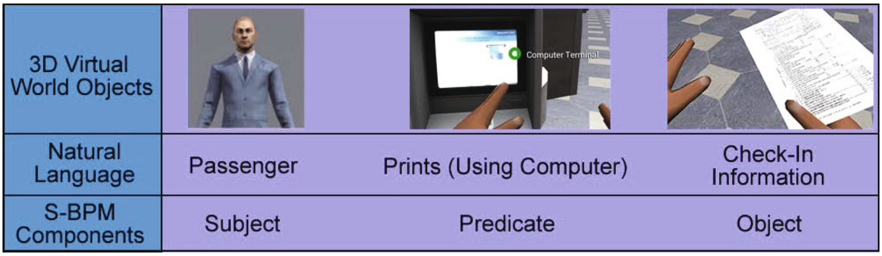

Fig. 2. Sample mapping of S-BPM natural language constructs to 3D Virtual World Objects

It should be noted that while the S-BPM language is believed to be the best fit for this particular elicitation approach, it does not mean that other modelling languages could not also map to virtual world actions. Work has been done investigating the possibility of producing a BPMN model from subjective viewpoints [28]. There is even potential for this world to output models of varying languages, as object interactions can be mapped in a largely language independent manner.

3 Virtual World Implementation

Virtual worlds are synthetic environments which provide users with an avatar through which they can interact with other users, or interact with the world itself to perform various tasks [9]. Virtual world research is extremely broad, examining potential in a number of fields including education, training and simulation [16]. A major issue in virtual world research, however, is that many of these worlds can be difficult to use without extensive training [30]. With this in mind, the features of the virtual world were carefully considered, with a user design experiment previously being conducted to evaluate tool usability [14].

The virtual world used in this work has been constructed using the Unity3D[1] game engine with the environments containing a mix of both modelled and prebuilt assets. The user is given an avatar through which they can traverse the world to interact with objects, as this is a core component for a role-playing based approach to process elicitation. The world used in this study has been constructed with a high degree of fidelity, including both high quality assets as well as well as objects which do not necessarily have core importance to process execution, despite previous work indicating that they do not meaningfully affect user priming in these environments [12]. The reasoning behind this choice is that while the walls of a building and other objects may be superfluous for priming memory, they are still critical for role-playing a process naturally. Furthermore, easy assess to recent 3D asset banks such as *Unity Asset Store*[2] or *3D Sketchup Warehouse*[3] has allowed the environments used in this study to be constructed in only a few hours, rather than the days or weeks which would have been needed previously.

3.1 Scene Interactions

The core concept with this role-playing elicitation approach is that users should be able to naturally traverse the environment and interact with objects similarly to how they would in reality. In the developed virtual world, almost all objects have this interaction capability, with the only notable exceptions being walls, floors or other objects which have no standard interactions. To interact with an object, users simply click on the object they wish to use. This will produce a list of common generic actions or allow the user to create an entirely new one if necessary. By providing a list of structured generic options, user commands are tagged, thereby providing additional structure to their responses and allowing for better categorisation and merging of different process views. This is particularly beneficial when working with view-based models as views are often merged by searching for matching strings [5]. After the user has selected their chosen generic action, they will be prompted to enter a more comprehensive explanation of the specific task being performed. Figure 3 shows each of these steps in detail, with a corresponding task output.

[1] Unity3D: www.unity3d.com, accessed: November, 2014.
[2] Unity Asset Store: www.assetstore.unity3d.com, accessed: November, 2014.
[3] 3D Sketchup Warehouse: 3dwarehouse.sketchup.com, accessed: November, 2014.

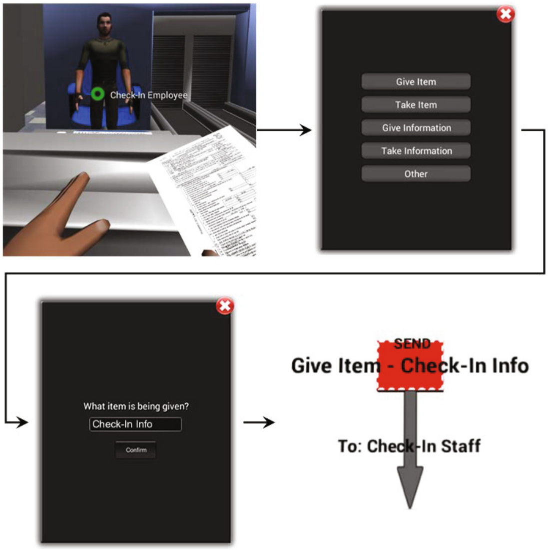

Fig. 3. Virtual world commands required to specify the handing of check-in information to airline staff

After the user has finished performing an interaction, the system will construct an S-BPM model which matches the actions which have been completed to that point[4]. This information is extracted from the virtual world using the *subject-predicate-object* approach described in S-BPM. This highlights a major benefit in using this modelling language with virtual world integration, as this task information can easily be extracted from the world data and encoded into the model quite easily. The virtual world model output for the experiment task is shown in Figure 4 below.

4 Experiment Outline

The experiment conducted in this study aimed to to identify differences in process model outputs and modelling methods between participants who use the virtual world to construct models, and participants who use a standard grammar-based modelling approach. The custom S-BPM modelling tool shown in Figure 4 was used for the comparison case in this experiment, as it allowed both tools to output the same model types and enforced a similar interface as they were designed to be used together. Participants for this study were randomly sourced from the Queensland University of Technology, Brisbane, Australia. This group was chosen as it provided sufficient statistical power to perform the proposed analyses while still having a group which could adequately play the given role for

[4] An example video showing in detail how these states, splits and joins are created can be found at https://www.youtube.com/watch?v=zezPX7do-xY

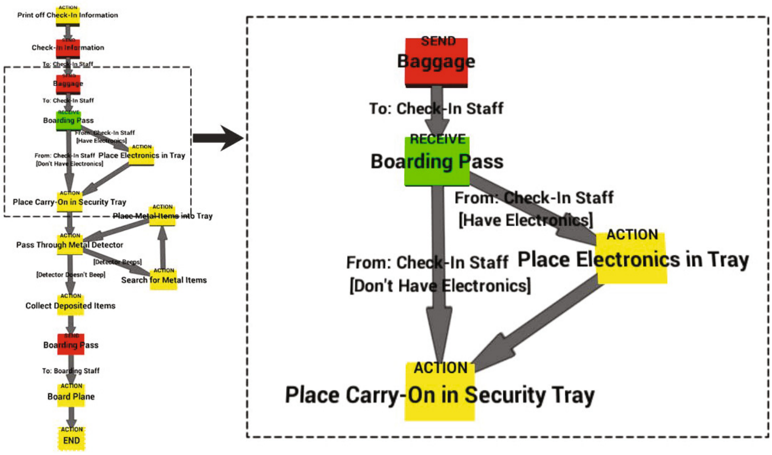

Fig. 4. Complete Virtual World S-BPM Subject-View Model for the Experiment Task. The left diagram displays a complete base model for the experimental case, with the right diagram showing a blown-up version of the dotted area.

the described process (i.e. university students are proposed as adequate proxies for people boarding a plane). Each participant was randomly assigned to one of the two test cases. In this experiment, there were three main hypotheses which were examined:

– Hypothesis 1: Users will correctly specify a larger number of task steps in the virtual world than in the S-BPM modelling tool.
– Hypothesis 2: Users will create fewer erroneous task sequences in the virtual world than in the S-BPM modelling tool.
– Hypothesis 3: Users in the virtual world will use a more consistent set of words to describe tasks than those in the S-BPM modelling tool.

There is significant theory to support the first hypothesis. While this priming effect has been shown to have positive responses in memory recall [23], the potential for eliciting procedural knowledge within a virtual world has not yet been tested. This positive effect may be attributed to situated cognition theory, which suggests that our memories are not wholely autonomous and are instead tied to the situations in which they were created [4]. As the virtual world is able to partially simulate this situation, it may trigger better memory responses then in a standard interview setting. Furthermore, lack of stakeholder engagement has been identified as a major problem during standard process construction [10]. Virtual worlds, however, have been shown to improve engagement [31], which may result in the these participants simply being more motivated to construct a correct model.

Much of the theory for the second hypothesis aligns closely with the first. If participants in the virtual world are primed to remember more information about the process, they are also likely to remember the sequence in which steps are executed. In addition to this, research has shown that training participants with images and videos resulted in better task ordering then text based descriptions [32]. This suggests that being able to view aspects of the environment clearly is critical. A virtual world provides the next logical step for this, allowing participants to achieve much greater levels of presence through interaction with the environment [8]. Furthermore, having the participants role-play the process within the world also provides much greater spatial awareness. If a participant was to enter an airport, pass the security checkpoint and then have to backtrack to the front desk to pick up their boarding pass, they are much more likely to notice their mistake then a participant who did not visually see this issue.

The third hypothesis once again draws heavily on memory recall stated earlier [23]. As the participants are given a short description of the task beforehand (as a series of annotated images), it is primarily testing their ability to remember the keywords used and apply them in their descriptions. Furthermore, this also tests the participants ability to apply these words consistently. The goal is that by have participants associate keywords with objects in the environment, they will continue to use those same words throughout the task. Additionally, it is expected that participants in the virtual world will better remember the original images when primed by similar environments within the world. This may allow them to more accurately recall the original keywords used in the description.

4.1 Modelling Scenario

For this experiment, participants used their assigned tool to describe all of the actions which may be necessary in boarding an airplane for a short domestic flight. To limit the scope of potential responses, participants were asked to only consider tasks occurring after they had already arrived at the airport and before they boarded the plane. To assist in normalising knowledge of the process, participants were given a series of real world images showing each of the core steps involved in the process alongside text based descriptions of the corresponding actions. This task priming technique has been used successfully in other studies which examine the ability of a stakeholder to model a task [24]. Examples of described tasks include:

– Collecting a Boarding Pass
– Handing Baggage to Airport Check-In Staff
– Placing Carry-On Luggage into Security Trays

In addition to the core process tasks, participants were also encouraged to include any *additional* tasks (without removing or reordering existing steps) that they would normally perform when boarding an airplane. This was done to better identify whether participants were primed by past experience in the process, or simply by the task that had been explained.

4.2 Participant Training

Despite the development of both elicitation tools targeting process stakeholders, it is unrealistic to expect that they can be easily operated without any training, background knowledge or outside assistance. To counter this issue, participants were provided with basic training on their assigned tool in the form of an annotated video. As both tools require different forms of training, however, this factor needed to be controlled. This was done by ensuring both videos had the exact same play length (four minutes) and covered identical topics. Furthermore, a 7-point Likert-scale item was included in the questionnaire which asked participants to rate how well they believed they had been trained for the task to further control for any differences which may have existed in the training videos.

5 Results

Participants were randomly assigned to one of the two conditions, with each condition having 32 participants. There were two dropouts in the S-BPM treatment which needed to be replaced. The average age of this cohort was 21.2 (SD = 2.9), with a gender distribution of 45 males and 19 females. The level of prior process modelling knowledge was quite low, with an average response of 1.9 on a seven-point Likert scale (SD = 1.27). Perceived understanding of the airport boarding process was quite high, with an average response of 5.2 (SD = 1.4). Of the 64 respondents, 38 reported that they had boarded an airplane sometime during the year. Finally, participants in the virtual world reported moderate virtual world exposure, with an average response of 4.3 (SD = 2.4). As multiple tests of significance are performed below, a Bonferonni correction has been applied to keep the family-wise error rate to 0.05. In total, 8 individual univariate tests were performed with a revised significance level of 0.00625.

5.1 Hypothesis 1: Tasks Remembered

The first hypothesis aimed to evaluate whether participants in the virtual world would remember a larger number of task steps than those given an S-BPM modelling tool. In the evaluation off this hypothesis, three main measures were considered: the number of base explanation steps recalled, the number of additional steps added and the total number of overall steps. Results from these tests showed that participants in the virtual world remembered a larger number of base tasks (M = 11.22, SE = 0.26) than the S-BPM tool (M = 9.03, SE = 0.31), $t(62) = 5.37$, $p < 0.0001$, r = 0.56. Participants in the virtual world also produced models with a larger number of additional task steps (M = 2.19, SE = 0.32) than the S-BPM tool (M = 0.84, SE = 0.21), $t(62) = 3.54$, $p = 0.0008$, r = 0.41. Finally, the overall number of task steps was also higher in the virtual world (M = 13.41, SE = 0.50) than the S-BPM tool (M = 9.88, SE = 0.38), $t(62) = 5.58$, $p < 0.0001$, r = 0.58.

5.2 Hypothesis 2: Task Ordering

The second hypothesis in this experiment stated that the virtual world participants would be less likely to place tasks in an incorrect order than their S-BPM counterparts. To evaluate this hypothesis, the average number of incorrectly ordered tasks was considered. Results from this test showed that participants in the virtual world placed fewer tasks in an incorrect order (M = 0.19, SE = 0.07) than participants in the S-BPM modelling tool (M = 0.72, SE = 0.16), $t(62) = 3.09$, $p = 0.0003$, r = 0.37.

5.3 Hypothesis 3: Consistent Naming

The third hypothesis in this experiment stated that participants in the virtual world would be more consistent with their naming conventions. To evaluate this, the total number of distinct words used by participants has been examined, both as an absolute value and as a ratio of unique words to total words used - also known as *lexical density* [21]. Texts with lower lexical densities are considered to be easier to understand. Furthermore, if the overall wording pool from participants contains fewer unique words, this may suggest that participants are referring to actions and objects more consistently with their naming. Results from these tests show that participants in the virtual world used a smaller set of unique words to explain the process (M = 38.15, SE = 4.25) than those using the S-BPM tool (M = 67.92, SE = 5.11), $t(62) = 4.48$, $p < 0.0001$, r = 0.49. Comparing lexical density shows a similar affect, with participants in the virtual world having much lower lexical density scores (M = 0.24, SE = 0.01) than those in the S-BPM tool (M = 0.41, SE = 0.02), $t(62) = 7.38$, $p < 0.0001$, r = 0.68.

The results from this test indicate a noteworthy effect, with participants in the virtual world constraining their grammar more heavily than participants in the S-BPM modelling tool. To verify that this result did impact on their task labeling, an analysis of frequent words has also been performed. The below table shows how the virtual world resulted a larger count of consistent word usage for each item than the 2D S-BPM modeller, eg. Boarding Pass (49 VW vs 28 2D S-BPM).

Table 1. Most Frequent Word Choices by Treatment Case

Expected Name	Virtual World Tool	2D Modelling Tool
Boarding Pass	Boarding Pass (49), Ticket (4)	Boarding Pass (28), Ticket (16)
Metal Items	Metal Items (11), Metal Objects (9)	Metal Items (4), Metallics (2)
Carry-On	Carry-On (19), Bag (8)	Bag (9), Carry-On (7)
Metal Detector	Metal Detector (30), Scanner (1)	Metal Detector (8), Scanner (6)

This analysis shows that when referring to a specific object, participants in the virtual world more commonly use the same naming style, while participants in the S-BPM modelling tool had a much more evenly distributed spread of responses. Note that this effect occured even for the *Boarding Pass* and *Carry-On* items, despite the names of these objects never appearing within the world.

5.4 Model Construction Time

In addition to the hypotheses stated above, the time taken to construct these models was also a value of interest in this study. Results from this test measuring the total seconds required to fully construct a model showed that participants in the virtual world constructed their models faster (M = 377, SE = 30.80) than those in the S-BPM modelling tool (M = 668, SE = 57.41), $t(62) = 4.47$, $p < 0.0001$, r = 0.49.

5.5 Model Alterations

The final factor which was considered in this experiment examined the method behind how users arrived at their final process model. From the beginning of the modelling session, participants may perform actions which they later consider to be incorrect. This could result in wording changes, task reordering or task deletions. For this analysis, the combined total of each of these values has been considered. The results of this test showed that participants in the S-BPM tool made more modifications to their model (M = 0.81, SE = 0.23) than those in the virtual world (M = 3.38, SE = 0.45), $t(62) = 5.10$, $p < 0.0001$, r = 0.54.

6 Discussion

The result of the first and second hypotheses in this experiment closely match the expected results. It does appear that the virtual world did prime user memory and enables participants to remember the overall process structure more clearly. This closely matches with theoretical literature which suggests that providing a user with an environment encourages them to think about tasks specific to that environment [26]. The result from the third hypothesis is quite interesting. Despite participants in the virtual world using more overall words to explain their models, their choice of words was more concise, having a lexical density approximately half that of the S-BPM participants. Concise and consistent naming is of great importance when either analysing a group of models for similarities, or trying to merge multiple views into a single process [5]. If descriptions are not consistent, analysts may not recognise that these varying action descriptions correspond to the same task.

The analysis investigating the time taken to construct the final output models is also of great interest. A major concern noted in earlier experiments was that it may become too time consuming for participants to model complex processes using the virtual world [14]. In particular, the time required for users to move about the world and interact with objects was considered to be a risk with this approach, as stakeholders are often unwilling to spend copious amounts of time constructing their models [10]. This experiment, however, suggests that the virtual world users were able to construct their models much faster than those in a 2D S-BPM modelling tool. The larger number of model changes made by the S-BPM treatment may be a factor in this result, but further analysis is needed to determine exactly where this time was spent.

7 Limitations and Threats to Validity

As this was primarily an exploratory study which aimed to generate some preliminary data on the use of virtual worlds in the scope of task elicitation, the results presented come with certain limitations. All virtual worlds are not equal, the level of detail in the environment, user controls and the level of interaction within the world have the potential to greatly affect the observed outcome. To develop rigorous claims about the efficacy of virtual worlds for elicitation, these results need to be replicated within other environments. Furthermore, this work evaluated the two interfaces against a single business process. The results obtained may have varied greatly if participants were exposed to a different process, particularly one which was not as spatial as the airport scenario. There are also limitations in this study with regards to the modelling language chosen. In this work, the S-BPM modelling language was chosen as the comparative case, but the grammar exposed to participants in the 2D modeller treatment may impact on the number of tasks participants are able to specify. As this experiment involved the use of two distinct tools, there was the potential for usability differences to impact on the results discovered. To try and control for this, a software usability questionnaire [18] consisting of several seven-point Likert scale questions was provided to participants with analysis revealing no significant differences between the overall usability scores in the virtual world (M = 5.65, SE = 0.12) and the 2D S-BPM modelling tool (M = 5.56, SE = 0.10), $t(62) = 0.62$, $p < 0.53$. This does not mean that no differences in usability were present, but does suggest that the observed differences were more likely caused by the modelling approach to which they were exposed. Finally, as the training videos given to the two user groups also had differences, it is possible that one group was trained better than the other. In an attempt to control for this, participants were asked to rate how well they believed they were trained for the given task, with similar responses being observed in both the virtual world (M = 6.09, SE = 0.18) and S-BPM modeller (M = 6.25, SE = 0.13), $t(62) = 0.71$, $p = 0.48$. Despite this, there is still the potential that differences in the training videos may have impacted on the results obtained.

In addition to these limitations, there are certain threats to the ecological validity of these findings. The participants were generally quite young, with many coming from a technology background and reporting previous virtual world usage. This suggests that while the virtual world cohort in this experiment may have found the tool easy to use, the target audience of expert process stakeholders may not have this same background. Additionally, participant knowledge of the process was normalised by providing them with a summary of the tasks before they began. While this approach has been used previously when looking to prime novice modellers [24], it does result in the outcome potentially being influenced by the participant's ability to recall short-term information, rather than commonly repeated actions. This issue was partially controlled by asking participants to provide additional information not included in the task description, but it nevertheless did prime participants with knowledge they may not otherwise have recalled.

8 Related Work

Process elicitation is tremendously important and difficult at the same time. Process elicitation methods comprise workshops, interviews, and process modeling by domain experts (top-down) as well as process discovery based on mining techniques (bottom-up). Several novel top-down approaches have been recently proposed. Some of these methods aim to extend current techniques by providing stakeholders with tangible modelling interfaces to assist in visualisation [11], with further work integrating these interfaces directly into existing modelling tools [19]. In [17], an alternate approach to process elicitation (BPME) based on to-do lists and combining content analysis and process mining is described. In particular, based on the to-do lists, the individual views of the process participants are derived in terms of process models. These individual process models are then to be integrated into the process model that reflects the overall business process. This method is extended to the BPMEVW method by using a complementary virtual world approach [5]. Specifically, the meta data that is necessary to integrate the individual process models can be enriched by the virtual world context, e.g., exploiting information on shared resources. Other virtual world applications in this scope have also been examined, with an aim to improve remote collaborative modelling by allowing modellers to use natural gestures (such as pointing or waving), which would not be possible in a standard tool [22].

9 Conclusion and Future Work

The results from this study have highlighted several key areas of interest. In particular, they suggest that virtual worlds do provide an effective platform for stakeholder knowledge elicitation. In addition to requiring little outside assistance, the results also suggest that users were able to remember a larger amount of process tasks and place tasks in correct order more often than in the 2D S-BPM modeller. This result holds much significance as accurate knowledge elicitation and model generation is critical for quality analysis to be performed. Additionally, results also suggest that stakeholders are able to fully construct these models much faster in the virtual world than they could using a standard modelling approach. This study also indicates that the large virtual world time construction barriers have been reduced significantly with the introduction of freely available development tools and pre-built assets. Full 3D virtual environments can easily be constructed in a matter of hours, with participants being able to operate and efficiently complete tasks with little formal training and no outside assistance.

As this is the first empirical evaluation which has been performed with regards to virtual world potential in process elicitation, there is a significant amount of work which still needs to be done. While the results from this study indicated that a virtual world tool is effective at priming user memory, further research needs to be conducted to determine the ecological validity of these results. In particular, evaluating the effectiveness of this world when used by expert stakeholders would be the logical next step in the evaluation of this approach.

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