A Theoretical Basis for Using Virtual Worlds as a Personalised Process Visualisation Approach

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Abstract. Communication processes are vital in the lifecycle of BPM projects. With this in mind, much research has been performed into facilitating this key component between stakeholders. Amongst the methods used to support this process are personalized process visualisations. In this paper, we review the development of this visualization trend, then, we propose a theoretical analysis framework based upon communication theory. We use this framework to provide theoretical support to the conjecture that 3D virtual worlds are powerful tools for communicating personalised visualisations of processes within a workplace. Meta requirements are then derived and applied, via 3D virtual world functionalities, to generate example visualisations containing personalized aspects, which we believe enhance the process of communcation between analysts and stakeholders in BPM process (re)design activities.

Keywords: Business Process Management, 3D Virtual Worlds, Process Communication

1   Introduction

Presently, Business Process Management (BPM) is recognized as a set of approaches that can facilitate business activity management [1], and its lifecycle involves four phases, which are design, configuration, enactment and diagnosis [2]. In these four phases, the communication process has been recognized as a vital component, since it is one factor, among others, that is highly related to the success of BPM projects [3].

To enhance the communication process, visual assistance approaches have been employed. Conceptual diagrams, such as BPMN [4] or ER diagrams [5], are shown to stakeholders by business analysts, when complex business environments need to be investigated. Despite these approaches, it is reported that business analysts and stakeholders often have communication problems [6-8]. This is because we cannot guarantee that every stakeholder has the necessary process diagram knowledge to understand what is being presented [9].

Recently, it has been realized that 3D virtual worlds can be applied in observational ethnography, case studies, economic markets and social networks [10]. Its richer visualization representation abilities can expand the memory bandwidth of people, allowing them to effectively process more information [11]. This strongly suggests that 3D virtual worlds could be a superior process visualization platform, enabling

people to recall and cognate about conceptual and non-conceptual content, facilitating the communication process in analysing, modelling and validating organizational structures and resource behaviours.   In addition, these visualization have the capacity for high levels of personalized configuration, providing role-based representations that enable people to easily recognize their place in a complex process system via provision of a visual context simulating their own experience [42].

As a new research area, researchers are working on BPM oriented 3D virtual world applications [12-17]. Despite the fact that these works are available and can be recognized as visualization approaches for enhancing communication approaches, theoretically based analysis works are still lacking. Theory analysis in Information Systems or BPM domains, which is conducted ahead of system developments, can provide us guidance that caters to needs in reality [18]. In other words, the lack of theory analysis may impede us in developing sophisticated 3D visualization systems in BPM in the future.

With this in mind, we in this paper propose a theory based analysis framework and utilize this framework to analyse problematic areas in communication processes, explain why problems occur, predict how to overcome these problem and suggest how to design an effective communication approach within a BPM context.

This paper is organized as follows: Section 2 discusses related work. Section 3 explores the capabilities of using a virtual world as an alternative communication approach. And at last, Section 4 concludes with a discussion of achievements, and points towards future work.

2   Related Work

In 2008, we proposed a BPM oriented virtual world application [13], where we claimed that 3D virtual worlds can be utilized as a communication approach in the BPM context. Then, we proposed an extended business animation system [12]. Following these initial efforts, other researchers have published BPM oriented virtual world applications. Perkins [14] advocates that intelligent agent systems should be integrated for demonstrating designed business plans. Chodos et al. [15] have proposed a workflow based simulation system, named MeRiTS, for professional medical training. These works have sought to visualize the operational levels of a business process environment, typically for training applications in the health domain, see Figure 1.

Figure 1 Illustrations from previous work by [19] (picture A), [14] (picture B) and [15] (picture C).

One of the major positive findings with virtual worlds has been the quantitative results showing the superior capabilities of such technologies in knowledge transfer in training scenarios [48, 49], or that they are at least equal to present physical methods [50]. This is consistent with theoretical models presenting a proposed hierarchy of simulation above other less interactive approaches, producing better learning outcomes via greater retention of information [51]. These initial, promising educational results are highly relevant to process communication issues, as such capabilities in the transfer of knowledge can be seen as overlapping with activities in process redesign requiring clear communication of process knowledge, in which there is evidence that a more human interaction oriented approach may offer better communication results. [41].

Personalised process model visualization and presentation continues to be a very active area of research [42- 47]. Of particular interest is the insight that the use of iconic or pictorial representations of process activities may provide better insight into the process for a user [47]. But only preliminary evidence is available at the moment to show that this personalized view of a process actually increases understandability [47]. The question of their effectiveness is yet to be fully answered in the affirmative.

Despite the fact researchers are making efforts in such personalized visualization approaches, there is no research that we are aware of that has explored the possibility of using 3D virtual worlds as a media rich environment for personalized displays of simulated processes in BPM. Indeed, as this is a first paper on this personalized topic, there is a need to provide a theoretical analysis motivating such research. Providing such an analysis framework for BPM oriented virtual world applications can benefit system design and validation efforts. In following, we will propose our analysis framework with extensions on our previous work [20] in order to support our proposal that a 3D virtual world is a valid and effective approach to personalized process visualization, opening up a number of research directions for this topic.

3   Theoretical Support

Using an approach drawing from the theory development work of Gregor [18], we propose an analysis framework with an objective to support, in theory, the argument that a virtual world can be used to improve communication between business analysts and stakeholders in a BPM communication context, by providing a stakeholder personalised view of the process being analysed. The framework involves three major theory development components from Gregor: Analysis, Explanation and Prediction, and Design and Action.   These components are now developed in turn.

3.1   Analysis of the BPM Communication Model

Many researchers have created conceptual models and theories for describing such communication. Among these conceptual models, the one proposed by Jakobson [21], Shannon and Weaver [6] has been widely used in different areas, such as information

technology [22], software engineering [8] and media studies [23]. The common components in these two models are an information sender and receiver, information coding and transition processes, and factors that can affect the quality of information transition. They [6, 22] both believe good communication requires the sender and receiver to use the same code, while noise, as variations in the coding process, can slow down cognitive processes. The core ideas and components of their conceptual communication models can be represented in Figure 2, which has been adapted to represent communication between business analysts and other stakeholders in a BPM redesign context.
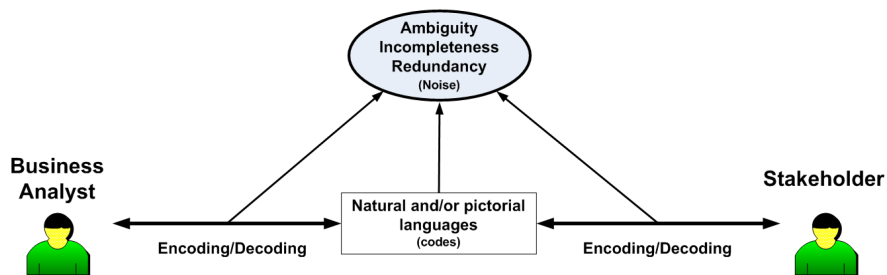

Figure 2 Illustration of a communication model within the BPM context.

In practice, the aim of the diagnosis phase in the BPM life cycle is to capture, analyse, automate and optimize present business processes. Issues such as, measuring the gap between current business processes and desired business processes, should be discussed in this phase [3, 24]. An accurate and mutual understanding between business analysts and stakeholders is therefore critical in decision making regarding process improvements [3].

On the one hand, business analysts need to gain a better comprehension of requirements and feedback from their stakeholders. This can help them design an improvement plan that suits the needs of their clients, and to continually revise the plan according to stakeholder preferences. On the other hand, stakeholders need to articulate their requirements so that business analysts can examine the validity of the newly designed business process model, to confirm that the improved and optimized business processes are appropriate, as proposed by the business analyst.

It is typical, during the design of a visualization approach, to include an analysis of the particular stakeholder tasks needing visual support [52].　We apply this approach to the analyst stakeholder interactions during a process validation activity.　During their discussions about a business process, both business analysts and operational managers are interested in a number of topics, with some of them being: the specific sequence of task events, personnel arrangements and human resource behaviours at the operational level of a business environment [25-27]. A diagram showing the communication skill set of a business analyst, and the interests of a manager or client, are represented in Figure 3, below.

So far, communication theories [6, 22] have been used to analyse the communication roles of business analysts and stakeholders, and the code forms they

utilize. It can be said that business analysts and stakeholders alternatively play the role of message sender and receiver in the communication process.
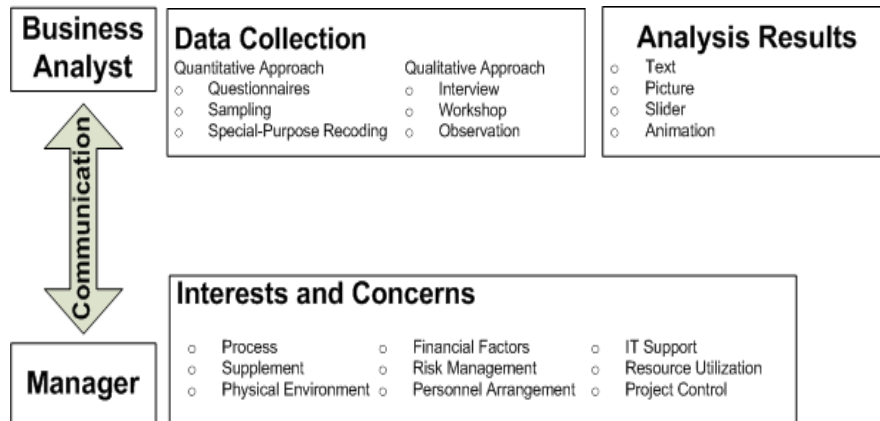

Figure 3 Illustration of the main information concerns of business analysts and managers.

From this previous research, two major conclusions can be reached. One, stakeholders cannot always represent their understanding and thoughts about business activities in a well structured way [7]. Their goal may not be clearly defined and a variety of unexpected factors can influenced their satisfaction with meeting results [28]. Two, the visual codes used by business analysts inevitably interfere with cognitive processes in the readers. To understand the visual codes requires a cognitive process within the stakeholder, to work on the conceptual model representations. The success of the cognitive process relies on long term memory that contains prior knowledge about the conceptual model, such as abstract model grammars and terminologies [8]. In practice, it cannot be expected that visual code readers, in particular the domain specialists, have such prior knowledge [9]. This has resulted in the common experience that conceptual models puzzle domain specialists. In part, this is due to the their inability to align the abstracted representation with their own personal and experiential understanding of the business process being discussed.

3.2 Explanation and Prediction

In the following, conjectures related to cognitive theories [11, 29-31] are made to explain why the noise occurs in the communication process and predicts what measures can reduce the noise to promote the efficiency of the communication process.

Explanation - Figure 4 represents information processes in the human brain, known as the Human Process Model (HPM) [32].
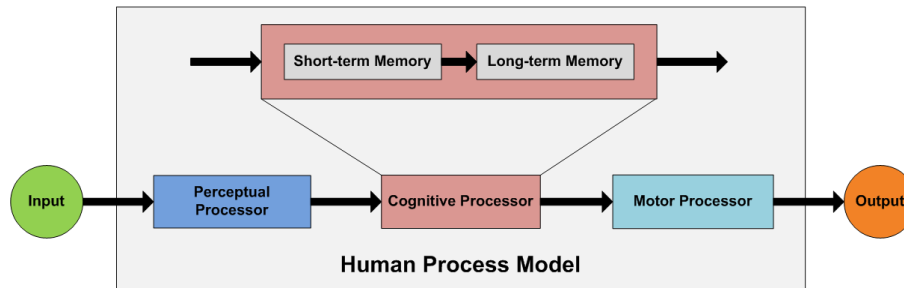
Figure 4 Illustration of the Human Process Model that is adapted from [32]. The model describes the procedure that humans use to process information.

The Perceptual Processor models how people sense input information, such as a process model in a graphical representation. Sense organs, such as eyes and ears, receive input information, which will be passed to the Cognitive Processor.

The Cognitive Processor in the model, analyses the input information by utilizing short-term memory, which is a temporary storage area loaded with a stream of input signals. It is believed that the loading capability of such working memory is important in both verbal and visual information processing [33, 34].

Long-term memory permanently stores some prior knowledge. The amount of knowledge determines how a human responds to the input information [35]. If prior knowledge is relevant to the input information, the motor processor will receive positive indications, enabling a human to take a correct action. Otherwise, the motor processor will receive negative indications, giving an irrelevant or wrong answer.

With reference to this model of information processing, it can be said that the cognitive processor plays an important role in problem solving [29, 36]. In the context of this research, it can be said that the performance of communication between business analysts and stakeholders is dependent on this same cognitive process.

Therefore, a reverse argument can be made; the increase of loading capability in the short-term memory and presence of prior knowledge in the long-term memory can optimize and improve the cognitive processes involved, potentially improving communication between stakeholders in a meeting.

Prediction - According to cognitive load theory [30], humans have limitations in processing information, that is, humans usually can process seven, plus or minus two items without context [11]. This is a bottleneck with regards to communication improvement and optimization. Miller [11] states that one possible solution for communication improvement is to increase the loading capability of the short-term memory of the receiver, arousing prior knowledge in the longer-term memory to achieve better performance.

In BPM consultation practice, tools and techniques, such as individual or group interviews, questionnaires, conceptual models, workshops and prototypes, aim to achieve better communication [26, 28, 37]. These tools and techniques provide people with a wide range of communication methods, such as, for example, representations of business process scenarios and user participation in their development.

The conjecture of this research is that more personally configurable tools and techniques can increase the loading capability of the short-term memory and arouse prior knowledge in the longer-term memory, consistent with the arguments of Miller [11]. For example, an accurate visualization about the working environment can arouse the prior knowledge of a stakeholder. Many stakeholders work in a real environment, not a conceptual space. They are very visually familiar with their working environment. A personalised visualization of their working environment can provide them with a representation in a "hands-on" manner that simulates real artefacts in real spaces. This enables them to make comments according to their work experience.

Moody concludes that this "hands-on" manner is a form of semantic transparency [8]. Such a transparency provides the real meaning and appearance of conceptual models. People can directly infer information in the conceptual model from the operational representation of the conceptual models in a simulated workplace.

Indeed, these visualization capabilities can be combined and employed to inform an individual or group interview, questionnaire, conceptual model, workshop and prototype [26, 28, 37]. Therefore, these visualization capabilities can be recognized as meta-requirements for communication improvement and optimization, increasing the loading capabilities of the short-term memory to arouse prior knowledge in the longer-term memory.

3.3   Effective Communication Approach Design

An appropriate Design and Action Theory can guide us to systematically and scientifically design a better communication approach [18]. Two design theories proposed by Markus et al. [38] and Wall et al. [39] state that system A can meet the meta-requirements for developing another system B, then system A can be adapted to facilitate the development of system B. Guided by such design theories [38, 39], the following sections will investigate the features of a 3D virtual world and then discuss the feasibility of utilizing 3D virtual worlds to satisfy previously mentioned meta-requirements.

Virtual world features can be used to create BPM oriented visualization applications, satisfying communication meta-requirements we have identified, facilitating the BPM Communication Model. The supporting relationship between aforementioned meta-requirements and features of a virtual world application are represented in Table 1, followed by a discussion about how meta-requirements instantiated within 3D virtual worlds can be used to enhance communication between business analysts and stakeholders.

Table 1 Discussion of the relationship between meta-requirements and virtual world features.

Meta-requirements	Virtual World Features
Entity Representation	Geometry Representation
Physical Environment	Geometry Representation
User Participation	Interaction and Collaboration, Avatar

Prototype Demonstration	Geometry Representation, Functional Configuration, Avatars, Behaviour Modelling
Information Display	Functional Configuration, Information Visualization
Human Resource Behaviour	Avatar, Behavioural Modelling

This process has driven the design of our series of process model simulations and visualisations that can be focused on a particular role within an organization. The visualisations are based on an agent-based system we have developed to simulate control and resource workflow patterns [20]. The agents are provided work using a role-based push approach from a business process system. We now detail the meta-requirements for such communication, and how this has motivated the virtual world visualization design. In particular, we focus on how this can personalize a visualization to assist understanding by a stakeholder. A series of selected features [40] and capabilities are now analysed. In each case, the examples referenced are those shown in Figure 5, which illustrates a hospital admissions process we have visualized in a virtual world[1].

Figure 5 Example personalized virtual world process visualisations. Firstly, the 2D HUD (a) is a representation of the running instance of interest, with its state highlighted using red annotations showing the present status of activities for the process model at a global scale. The second (b) is a resource-aligned representation providing a role-oriented view of the tasks being specifically performed by the simulation agent within the view.

Entity Representation - business analysts typically use 2D shapes constrained by visual grammars to abstractly represent real objects, in particular, to describe the relationships between tasks and state transitions between tasks [4]. In the visualisations shown below, the YAWL process modeling grammar is used to annotate the scene to provide process model information. We show two examples of this annotation, via a 2D Heads Up Display (HUD) and a resource centric overhead display. This relates the abstract process activities to a specific operational environment, with agent representations of specific roles, to increase insight.

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[1] Videos of visualizations are available at: https://www.youtube.com/watch?v=m6Losma61-U

Physical Environment - in a 3D virtual world, a complex and realistic environment can be built up from basic geometries. Key physical objects related to processes and roles are depicted in the images as a basis for the visualization. In the case of our example, relevant medical equipment, beds, hospital rooms, administration desks, amongst other items, are physically modeled in order to provide a representation of a familiar working environment, personalizing the visual to match the actual workplace of a viewer.

Human Resource Behaviour - observers can obtain insight into the position level, nature of work, interpersonal relationship, intention and characteristics of a observed person performing work activities via their appearance [14, 25]. In a 3D virtual world, avatars or agents can be created that accurately model the work behaviour of people in reality. In the example shown, tasks have been allocated to agents according to a role model within the process, with their commensurate visual behaviours.

Prototype Demonstration - business analysts can use some visualization approaches, such as a configurable simulation, to demonstrate a prototype [26, 28, 37]. Such visual assistance is an essential component of requirements elicitation and analysis, enabling business analysts and stakeholders to discuss unforeseen situations that may happen in their work. In a virtual world, a prototype can clearly demonstrate human resource behaviour, enabling stakeholders and business analysts to observe characteristics of the business plan via interactions between agents and objects in the virtual worlds. In a similar vein to a configurable process simulation, the examples below demonstrate, using agents, each role within a process as a separate case running in parallel. This capability is illustrated in our examples by the images of multiple avatars moving through the environment.

User Participation - users of virtual worlds can log into a virtual world from a remote place with a software client. The users who log into the virtual world will be represented as avatars, providing people with communication engagement. The darker avatar in each image in the examples, is logged in remotely to the server, and can thus view the simulation as it is performed. Even a side-by-side analyst and stakeholder meeting can benefit from this interaction, as the logged in avatar provides an in-world gesturing device.

Information Display - information may be loosely classified as qualitative and quantitative. These types of information reflect the temporal state of the business environment. Representations of this information can, amongst other things, provide people with insight into the workload of human resources and utilization rates of non-human resources. Our examples show, via a HUD, the display of the current state of the process model case being visualized, or resource centric information regarding the state of each agent in the simulation.

4   Conclusion

In this paper, a theoretical analysis framework has been proposed for solving problems in communication between business analysts and stakeholders. Firstly, it has utilized communication theories [6, 21] to identify the main components of communication between business analysts and stakeholders. Then, cognitive theories [11, 29, 30] were used to explain why the performance of the communication process can be negatively affected by more abstract process model grammars, presently being used. Meta-requirements for communication improvement and optimization were identified. Finally, features of 3D virtual worlds were analysed, forming a mapping of their key features to communication requirements, showing how the features of a virtual world can be combined to assist the validation techniques used by a business analyst.

Specific examples from a hospital virtual world we have implemented were used to illustrate the use of virtual worlds for personalized views. In particular, the views can be personalized to the operational view that a stakeholder has of their work. Personal aspects of the visualisations are: physical location, agent role representations, process state information overlays and interaction modes. According to design theories [38, 39], the conclusion is that a virtual world can be potentially used as an effective approach to support the communication process between business analysts and stakeholders, by providing a highly personalized view of the process being executed.

This work is preliminary in nature, and has only begun to investigate possible approaches to providing 3D personalized visualisations. In future work, we will design an evaluation framework, which is based on the discussion in this paper, to evaluate the presented visualization approaches. In addition, the visualization interfaces will be updated to reflect the latest approaches to 2D personalized visualization [42], providing intuitive filtering and display approaches for a more fine-grained personalized experience of 3D process model information.

References

1. Brocke, J. v., Rosemann, M. (eds.): Handbook on Business Process Management: Strategic Alignment, Governance, People and Culture. Springer Verlag, Heidelberg (2010)
2. van der Aalst, W.M.P., ter Hofstede, A.H.M., Weske, M.: Business Process Management: A Survey, BPM 2003. LNCS, vol. 2678, pp. 1--12. Springer, Heidelberg (2003)
3. Trkman, P.: The critical success factors of business process management. International Journal of Information Management, 30(2), 125--134 (2010)
4. Wohed, P., van der Aalst, W.M.P., Dumas, M., ter Hofstede, A.H.M., Russell, N.: On the Suitability of BPMN for Business Process Modelling, BPM 2006. LNCS, vol. 4102, pp. 161--176. Springer, Heidelberg (2006)
5. Davies, I., Green, P., Rosemann, M., Indulska, M.,Gallo, S.: How do practitioners use conceptual modeling in practice?. Data & Knowledge Engineering. 58(3), 358--380 (2006)

6. Shannon, C., Weaver, W.: The Mathematical Theory of Communication. University of Illinois Press, Chicago (1963)
7. Sadiq, S., Indulska, M., Bandara, W. Chong, S.: Major Issues in Business Process Management: A Vendor Perspective, In: 11th Pacific-Asia Conference on Information Systems:Managing Diversity in Digital Enterprises (PACIS 2007), pp. 40--47. (2007)
8. Moody, D.: The "Physics" of Notations: Toward Scientific Basis for Constructing Visual Notations in Software Engineering. IEEE Transactions On Software Engineering. 35(6), 756-779 (2009)
9. Khatri, V., Vessey, I., Ramesh, V., Clay, P., Park, S.: Understanding Conceptual Schemas: Exploring the Role of Application and IS Domain Knowledge. Information Systems Research, 17(1), 81-99 (2006)
10. Bainbridge, W.: The Scientific Research Potential of Virtual Worlds. Science. 317(5837), 472-476 (2007)
11. Miller, M.: The magical number seven, plus or minus two. Psychological Review, 63, 81-97 (1956)
12. Brown, R., Rasmussen, R.: Virtual Environment Visualisation of Executable Business Process Models, In: Rao, R. (ed.) Virtual Technologies for Business and Industrial Applications : Innovative and Synergistic Approaches. pp. 68--88. IGI Global Press, Hershey, USA (2010)
13. Brown, R., Cliquet, F.: Communication of Business Process Models via Virtual Environment Simulations. BPTrends. 12(9), 1--7 (2008)
14. Perkins, K.: Workflow Simulation in a Virtual World, Master Thesis in Computer Science and Computer Engineering Department. University of Arkansas: Fayetteville, (2001)
15. Chodos, D., Stroulia, E., King, S.: MeRiTS: Simulation-Based Training for Healthcare Professionals. Studies in health technology and informatics. 163, 125-131 (2011)
16. Betz, S., Eichhorn, D., Hickl, S., Klink, S., Koschmider, A., Li, Y., Oberweis, A., Trunko, R.: 3D representation of business process models. In: MobIS, pp. 73--87. (2008)
17. Eichhorn, D., Koschmider, A., Li, Y., Sturzel, P., Oberweis, A., Trunko. R.: 3D support for business process simulation, In: 33rd Annual IEEE International Computer Software and Applications Conference, COMPSAC'09, vol. 1, pp. 73--80. (2009)
18. Gregor, S.: The Nature of Theory in Information Systems. MIS Quarterly, 30(3), 611-642 (2006)
19. Brown, R., Rasmussen, R., Baldwin, I., Wyeth, P.: Design and implementation of a virtual world training simulation of ICU first hour handover processes. Australia Critical Care Journal. 25(1), 178-187 (2012)
20. Guo, H., Brown, R., Rasmussen, R.: Virtual worlds as a model-view approach to the communication of business processes models. In: *CEUR Workshop Proceedings*. (2012)
21. Jakobson, R.: Closing statement: Linguistics and Poetics, in Style, In: Language, T.A. Sebeok (ed.), pp. 350 - 377. MIT Press, Cambridge (1960)
22. Hollnagel, E., Woods, D.: Joint Cognitive Systems: Foundations of Cognitive Systems Engineering. CRC Press, Boca Raton (2005)
23. Manovich, L.: The language of new media. The MIT Press, Cambridge (2001)
24. Nah, F., Lau, J., Kuang, J.: Critical factors for successful implementation of enterprise systems. Business Process Management Journal. 7(3), 286-296 (2001)
25. Lewis, M., Slack, N.: Operations Management: Critical Perspectives on Business and Management. Routledge, New York (2003)
26. Reid, R., Sanders, N.: Operations Management. Wiley, New York (2009)
27. Voss, C., Tsikriktsis, N., Frohlich, M.: Case research in operations management. International Journal of Operations & Production Management. 22(2), 195-219 (2002)
28. McConnell, S.,: Rapid Development: Taming Wild Software Schedules. Microsoft Press, Redmond (1996)
29. Newell, A., Simon, H.: Human Problem Solving. Prentice Hall, Upper Saddle River (1972)

30. Chandler, P., Sweller, J.: Cognitive Load Theory and the Format of Instruction. Cognition and Instruction. 8(4), 293-332 (1991)
31. Flugel, J.: The psychology of clothes. AMS Press, New York (1976)
32. Card, S., Moran, T., Newell, A.: The Model Human Processor: An Engineering Model of Human Performance. In: Handbook of Perception and Human Performance, K. R. Boff, L. Kaufman, & J. P. Thomas (eds.), vol. 2. pp. 1–35, Wiley, New York (1986)
33. Caplan, D., Waters, G.: Verbal working memory and sentence comprehension. Behavioural And Brain Sciences. 22, 77-126 (1999)
34. Lohse, G.: The Role of Working Memory in Graphical Information Processing. Behaviour and Information Technology, 16(6), 297-308 (1997)
35. Kosslyn, S.: Graphics and Human Information Processing. American Statistical Association. 80(391), 499--512 (1985)
36. Sweller, J.: Cognitive Load During Problem Solving: Effects on Learning. Cognitive Science. 12(2), 257--285 (1988)
37. Cadle, J., Paul, D., Turner, P.: Business Analysis Techniques 72 Essential Tools for Success. British Informatics Society Ltd, Chippenham (2010)
38. Markus, M., Majchrzak, A., Gasser, L.: A Design Theory For Systems That Support Emergent Knowledge Processes. MIS Quarterly. 26(3), 179--212 (2002)
39. Walls, J., Widmeyer, G., Sawy, O.: Building an Information System Design Theory for Vigilant EIS. Information Systems Research. 3(1), 36-59 (1992)
40. Burdea, G., Coiffet, P.: Virtual Reality. Wiley, New York (2003)
41. Kock, N., Danesh, A., Komiak, P.: A discussion and test of a communication flow optimization approach for business process redesign. Knowledge and Process Management. 15(1), 72--85 (2008)
42. Bobrik, R., Reichert, M., Bauer, T.: View-based process visualization. In: BPM 2007. LNCS vol. 4714, pp. 88--95, Springer, Heidelberg (2007)
43. Leoni, M., van der Aalst, W., ter Hofstede, A.: Visual support for work assignment in process-aware information systems. In: BPM 2008. LNCS vol. 5240 pp. 67--83, Springer, Heidelberg (2008)
44. Zhao, X., Liu, C., Sadiq, W., Kowalkiewicz, M.: Process view derivation and composition in a dynamic collaboration environment. In: Proceedings of the OTM 2008, Confederated International Conferences, 2008, Part I, 82-99.
45. Koschmider, A., Song, M., Reijers, H.: Advanced social features in a recommendation system for process modeling. Business Information Systems. 21, 109—120 (2009)
46. Koschmider, A, Reijers, H. and Dijkman, R. Empirical Support for the Usefulness of Personalized Process Model Views, In: Computer Science Industry Multi Conference 2012 MKWI 2012, D. Christian, M. Field, S. (eds.) (2012).
47. Kolb, J., Hübner, P., Reichert, M.: Automatically Generating and Updating User Interface Components in Process-Aware Information Systems. In: 20th International Conference on Cooperative Information Systems (COOPIS2012), (2012) (In Press)
48. Jarvis, S., de Freitas, S.: Evaluation of an immersive learning programme to support triage training. In: Games and Virtual Worlds for Serious Applications, VS-GAMES'09, pp. 117--122. (2009)
49. O'Leary, S., Hutchins, M., Stevenson, D., Gunn, C., Krumpholz, A., Kennedy, G., Tykocinski, M., Dahm, M., Pyman, B.: Validation of a networked virtual reality simulation of temporal bone surgery. The Laryngoscope. 118, 1040--1046, (2008)
50. Dev, P., Youngblood, P., LeRoy Heinrichs, W., Kusumoto, L.: Virtual worlds and team training. Anesth Clin. 25, 321--336 (2007)
51. Dale, E.: Audiovisual methods in teaching. Holt, Rinehart and Winston, New York (1969)
52. Sedlmair, M., Meyer, M., Munzner, T.: Design Study Methodology: Reflections from the Trenches and the Stacks. IEEE Trans. Visualization and Computer Graphics. 18(12), 2431--2440 (2012)