Improved Business Analysis by Using 3D Models

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Abstract: The use of 3D objects may enhance the requirements engineering procedures. Different approaches using 3D modelling in requirements engineering, are described in the academic literature. Furthermore, the state of research shows objectives which can be obtained by using 3D modelling. This provides a good basis to formulate a reference model which helps project managers to plan the use of 3D modelling in requirements engineering. In order to support the usage of 3D modelling in requirements engineering, a reference model is designed. This model should help project managers, to plan the usage of 3D modelling. For doing so, project managers need to know why, how and when to use 3D modelling. The findings from literature were used in combination with an experiment, to elaborate a recommendation for using 3D models in requirements engineering. The experiment was combined with a survey in a requirements engineering lecture at IU International University of Applied Sciences. The experiment shows 3D modelling by using LEGO® SERIOUS PLAY® to be a liked method. The method seems to facilitate the motivation and collaboration. However, a further pre-analysis, before using the regular LEGO® SERIOUS PLAY® method shows no significant effect, to improve the analysis. A reference model was proposed to guide the usage of 3D modelling in requirements engineering. Especially the phases of requirements elicitation and the solution design benefit from using 3D modelling techniques in this proposal.

1 INTRODUCTION

Requirements engineering (RE) seeks to facilitate the planning and understanding of upcoming software functionalities. Within RE, customers and business analysts discuss these functionalities. Business analysts try to understand the wishes of the customers and customers try to be understood. However, these understandings often struggle, because software development is such an abstract discipline. In order to facilitate the understanding, the 3D objects like LEGO® SERIOUS PLAY® and additionally technologies of 3D print should be used. With the help of 3D elements, it should be possible to extract objects that match to software functionalities / software modules, in order to help users to plan how to mix functionalities to get a working software.

Using 3D objects which describe software modules promises to facilitate the understanding. However, currently the procedures within requirements engineering are mostly based on 2D textual requirements definition. Even if using 3D objects could lead to improvements, there is no procedure, how to deal with 3D requirements descriptions. In order to allow business analysts to use 3D objects in requirements engineering, the classic processes have to be transformed to fit to 3D artifacts. This paper seeks to enhance the procedure of requirements engineering, using 3D objects. Our investigation tries prescriptive to improve the way, how requirements engineering works. By the elaboration of a reference model, we try to answer the leading question, how to integrate 3D modelling techniques in requirements engineering. In order to answer this question, the following questions have to be examined: RQ1: What is the objective, why we should use 3D modelling techniques, in requirements engineering? RQ2: Is a preparatory analysis helpful, to benefit from 3D modelling techniques? RQ3: Which activities within requirements engineering can be supported by using 3D modelling techniques? In order to answer our leading question, we first analyze related literature, seeking for methods which integrate off-the-shelf 3D bricks and 3D printings in requirements engineering. After this, we per-

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form an analysis on the meta-requirements, that has to be fulfilled by a valid reference model. The method of our investigation is described in the section ”analysis” too. In the section ”results” the created reference model will be described.

2 RELATED WORK

As the need for multiple software projects starts due to the objective of digital transformation, related literature addresses the field of business change. Challenges, regarding to the digital transformation were analyzed by (Sundberg, 2019). Sunderberg explained everyone to be responsible for the success of the digital transformation (Sundberg, 2019). This emphasizes the relevance of customers for the success of development projects. Furthermore, the paper is related to investigations on software engineering. Especially research on the methodologies of requirements engineering is a relevant basis for this paper. As Nurova explains, the digitalization requires stakeholders, following a valid procedure, having the right competences and technologies as well as resources (Nurova, 2020). Within this paper, new procedures will be discussed which act on the problem of misunderstandings, as it is a common problem between stakeholders having a lack of competences (Balzert, 2008) First, this paper is related to investigations on software development. Within the field of research on software development, it is closely related to research on requirements engineering as also on ways, to improve software development. Current research shows techniques of requirements engineering to an important field of research, in order to improve software development. Bosch mentioned e.g. that software has to be more customizable, in order to fulfill the need of different customers (Bosch, 2009), p. 1. However, such customization has to be planned and techniques which facilitate the planning of adapting software could help software producers. As a consequence of projects becoming more complex and faster, techniques which enhance the visualization, like 3D modeling, become more important (Oberhauser and Pogolski, 2019). The discipline of requirements engineering is an important field of research in the context of software engineering. Balzert explains the process of requirements engineering to consist of the activities (1.) elicitation of requirements, (2.) specification, (3.) analysis, validation, and acceptance, (4.) modelling, (5.) again analysis, validation and acceptance and (6.) requirements management (Balzert, 2009), p. 444 - 445. Pandey et al. propose a process model of requirements engineering (Pandey et al., 2010). Their model contains the four main tasks ”requirements elicitation and development”, ”documentation of requirements”, ”requirements verification and validation” and ”requirement management and planning” (Pandey et al., 2010), p. 288 - 290. Their process starts with the identification of stakeholders, fitting to different groups of business-, customer- and user- sources of requirements (Pandey et al., 2010), p. 289. As part of the requirements analysis, agreement and communication are mentioned to be important activities (Pandey et al., 2010, p. 288). Commonly, the four main tasks of RE are (1.) the elicitation, (2.) the documentation, (3.) the review and acceptance and (4.) the management of requirements (Hruschka, 2014), p. 14 - 15 (Pohl and Rupp, 2015), p. 4 - 5. Similar to this, Sommerville mentions three main activities in the requirements engineering process to be (1.) the elicitation and analysis, (2.) the specification and (3.) the validation of requirements (Sommerville, 2016), p. 55. Improvements in requirements engineering which help customers to work together with software developers to plan new software, are important to face the digital transformation. As Digilina et al. explained, the labor market changes (Digilina et al., 2020). The work of employees moves from simple tasks to higher complex tasks, e.g. to solve problems (Digilina et al., 2020), p. 1237. In new work environments, creativity becomes an important skill (Digilina et al., 2020), p. 1238. Furthermore, Digilina et al. emphasize the dominance of projects as a temporary form of work (Digilina et al., 2020), p. 1237 f.. As the purpose of projects is always to fulfil new requirements, requirements engineering could become more important in the future. In order to facilitate the understanding of processes and to perform valid analysis on designed business processes, process simulations can be helpful (Rosenthal et al., 2021). Currently, the techniques of 3D modelling are widely used in order to enhance the understanding of processes. Mostly, 3D techniques were used to create virtual realities. An early attempt to use 3D virtual reality models to support manufacturing processes is described by Sankar et al (Sankar et al., 1997). Sankar et al. present a design environment (Sankar et al., 1997). An analysis of the use of virtual realities in the field of education by using different devices with *Head Mounted Displays* (HMDs) is presented by (Marougkas et al., 2022). Marougkas et al. discuss different HMD-systems for virtual realities which can be used in education, comparing their characteristics (Marougkas et al., 2022). Furthermore, Marougkas et al. investigate the use of the term ”Virtual Reality” in the field of education (Marougkas et al., 2022). The use of 3D virtual realities could facilitate the comprehension of processes. For example, Aysolmaz et al. present a 3D virtual reality approach, to improve process trainings (Aysolmaz et al., 2016). (Aysolmaz et al., 2016) describe a "generic visualization approach", which is focused on displaying the input-/outputs of every process activity within a process model. Brown describes a concept, to use 3D virtual worlds in order to facilitate the understanding of process models (Brown, 2010). In order to enhance the understandability of process models for users who are not trained in the process notion, Brown suggests using 3D modeling (Brown, 2010), p. 25). A similar approach was presented by Brown, Recker and West (Brown et al., 2011). Regarding to the understandability of process models, Brown et al. explain the benefit of 3D techniques to integrate non-verbal communication elements, like gestures in process models, to enhance its comprehensibility (Brown et al., 2011), p. 7). The communication benefits from the intuitive forms, as Brown et al. explained (Brown et al., 2011), p. 7). Especially Jagenow et al. derived interesting insights while using a 3D virtual environment to describe process models (Jagenow et al., 2022). As Jagenow et al. described, many processes lack of documentation (Jagenow et al., 2022), p. 450. As stakeholders struggle to gather correct process descriptions (Jagenow et al., 2022), p. 451, the proposed visualization of Jagenow et al. helps stakeholders to better understand processes (Jagenow et al., 2022), p. 453. Oberhauser and Pogolski present an approach, which illustrates business processes on multiple layers in 3D landscapes (Oberhauser and Pogolski, 2019). They found benefits of 3D expressions of business processes regarding to the visualization of interacting objects in space (Oberhauser and Pogolski, 2019), p. 17. Furthermore, this paper is related to research which addresses challenges in requirements engineering. One of the most important steps within requirements engineering is the elicitation of process models. Harman et al. elaborated an approach to use 3D virtual worlds to help stakeholders design process models (Harman et al., 2016). Within a virtual environment, stakeholders play to interact as usual with objects and the software captures a formal process model which fits to this interaction (Harman et al., 2016), p. 9. The interaction within a 3D virtual world accelerates the construction of process models (Harman et al., 2016), p. 23. Not only with focus on requirements engineering, Badakhshan et al. described challenges which emerge while dealing with processes. Due to interviews, Badakhshan revealed, that it is hard to ensure a similar understanding of business processes within an organization (Badakhshan et al., 2020). In order to better the situation, Badakhshan presents a tool which also improves the documentation (Badakhshan et al., 2020), which is also important in requirements engineering. This work bases on the findings of previous research, which investigates the use of 3D models to enhance requirements engineering. An early attempt of doing 3D visualization to support requirements engineering is described by (Teyseyre, 2003). Teyseyre proposed a method of formal requirements description in Z (Teyseyre, 2003), p. 47. The requirements specification would be translated to Prolog-Code (Teyseyre, 2003), p. 48. After the developer visualized the specification in a 3D world, the customer can interact with the designed 3D objects, because their behavior is formally described (Teyseyre, 2003). This procedure is a functionality in the Tool ReqViz3D by Teyseyre (Teyseyre, 2003). The use of such a visualization leads to improvements regarding to the understanding as far as cost savings in requirements engineering (Teyseyre, 2003). By using toys, representing 3D model elements, Nass et al. elaborated a method which is able to improve requirements engineering (Nass et al., 2018). Their so-called "Tangible Ecosystem Design" consists of a set of methods and tools, to facilitate the communication between stakeholders to build software services (Nass et al., 2018). Nass et al. described their workshop procedure as to (1.) define the purpose of the software ecosystem, (2.) define a concept of the customer experience and (3.) model the business processes (Nass et al., 2018). Nass Bauer and Trapp emphasize the need to design end-to-end services, which fit to the customer requirements, in context of the digital transformation (Nass Bauer and Trapp, 2019), p. 1. On the basis of their findings in (Nass et al., 2018), Nass Bauer and Trapp describe course within they taught stakeholders to create new digital services by using 3D models (Nass Bauer and Trapp, 2019), p. 3. To do so, Nass Bauer and Trapp (1.) explained the concept and then focus (2.) on the modelling of digital services, (3.) on the modelling of business flows and (4.) on the elaboration of the benefits (Nass Bauer and Trapp, 2019), p. 3 f.. Within the academic literature, much research can be found about using LEGO® SERIOUS PLAY® (The LEGO Group, 2007) in order to enhance the requirements engineering. Robert Rasmussen, who was director of research and development for the educational division of the LEGO Company in 1999, describes the collaborative effect of using LSP (Rasmussen, 2006).

With the help of LSP, teams build 3D models consisting of LEGO® bricks (Rasmussen, 2006), p. 59. The use of LSP should inspire the team to describe stories and find metaphors (Rasmussen, 2006), p. 59.

Rasmussen explains ”Once the model is built, members share its meaning and story with the rest of the team” (Rasmussen, 2006), p. 58. By using LSP the team benefits from an increased motivation (Rasmussen, 2006). Furthermore, the technique of building 3D models helps to integrate team members in the process of model construction who struggle with verbal conversations (Rasmussen, 2006), p. 60. The general process, how to use LEGO® SERIOUS PLAY® is described by (The LEGO Group 2007, p. 7 - 21). The process consists of the steps of (1.) model construction, (2.) describing the metaphors and (3.) telling a story (The LEGO Group 2007, p. 7 - 21) (Cantoni et al., 2009), p. 847. Cantoni et al. used the LSP method to create an own method which supports requirements elicitation for web development projects (Cantoni et al., 2009). Their process consists of 8 activities (Cantoni et al., 2009): (1.) introduction and set-up goals (2.) stakeholders model their own role (3.) stakeholders define the users of the web application (4.) the team models the landscape (5.) each stakeholder models the content of the web application (6.) each stakeholder models the functions of the web application (7.) the team constructs the model of the complete landscape and (8.) users, functions and content are connected (Cantoni et al., 2009), p. 848. As an advantage, the method of Cantoni et al. facilitates all stakeholders to think out-of-the-box (Cantoni et al., 2009), p. 849. Also, the LSP methodology, which consists of seven techniques combines individual- and collaborative modelling steps: (1.) stakeholder build individual models (2.) the team builds shared models, (3.) a landscape of the application will be built (4.) different models will be connected (5.) the system will be built (6.) scenarios are tested on the basis of the system (7.) guiding principles are derived (Kristiansen and Rasmussen, 2014). As LSP offers the potential to enhance the understanding, the methodology could also be used in order to enhance teaching of software engineering practices (Kurkovsky, 2015). Kurkovsky describes an experiment, in which he used detect, that using LSP helps students to remember the theoretical concepts because they practiced it (Kurkovsky, 2015). Furthermore, (Kurkovsky, 2015) emphasize the effect of LSP on the motivation (Kurkovsky, 2015), p. 218. Also, Gama describes an experiment of using LEGO® in courses to teach requirements engineering and scrum (Gama, 2019). As part of the experiment, students simulate the implementation of software by using LEGO® (Gama, 2019). Among others, the experiment compares the effect of knowing all requirements before implementation with effect of requirements to be determined during the project (Gama, 2019) , p. 291. This helps students to understand the concepts of requirements engineering as far as the risk of change-requests (Gama, 2019), p. 294 ff.. Furthermore, Gama notices positive effects, the LEGO® activity has for the teamwork of the students (Gama, 2019) , p. 294. Kurkovsky et al. used LEGO® in courses too, to teach requirements engineering practices (Kurkovsky et al., 2019). By using LEGO® the abilities of students to solve problems and the skills for interpersonal communication are trained (Kurkovsky et al., 2019), p. 223. Using LEGO® facilitates students to move ”their thinking beyond concrete conceptualizations to abstract”, as Kurkovsky et al. described (Kurkovsky et al., 2019), p. 223. Furthermore, in order to teach students, the challenges of requirements engineering, related to the communication of requirements details between multiple stakeholders, Scialdone and Connolly describe a teaching method on the basis of LEGO® SERIOUS PLAY® (Scialdone and Connolly, 2021). The use of 3D models in requirements engineering decreases the importance of verbal communication (Scialdone and Connolly, 2021), p. 7.

3 ANALYSIS AND METHOD

In order to create a reference model to use 3D modelling techniques in requirements engineering, it has to be analyzed, why, how and when to use 3D modelling techniques. These questions are directly related to the three research questions *RQ1* (=why), *RQ2* (=how), *RQ3* (=when). The analysis of related work in section 2 shows requirements engineering to be a well-defined procedure. The activities of requirements engineering are widely documented. Also, procedures, how to use 3D modelling techniques are described within the literature. Furthermore, the objectives that could be fulfilled by using 3D modelling techniques are discussed in the state of research. However, business needs a holistic plan for the integration of such concepts. In order to find such a holistic plan, the project manager needs to know the strengths and weaknesses of different concepts, for the integration of 3D modelling in requirements engineering. Mainly, the project manager has to decide for what purpose 3D modelling techniques should be used (*RQ1*), if the use of 3D modelling techniques should be prepared (*RQ2*) and which activities benefit from 3D modelling techniques (*RQ3*). Premise of this work is the assumption, that findings from our use of LEGO® SERIOUS PLAY® in our experiment are applicable for 3D modelling in general. The activities, to be supported by 3D modelling techniques, can be collected on the basis of findings from research. Therefore, *RQ3* will be answered conceptually deductive (Wilde and Hess, 2006), p. 7 - 14. Wilde and Hess describe the use of conceptually deductive analyses to be design orientated (Wilde and Hess, 2006), p. 7 - 14. A reference model will be designed, that simplifies the reality (Wilde and Hess, 2006), p. 7. The reference model should be a theoretical construct that facilitates the formulation of statements (Fettke and Loos, 2004), p. 10. Following (Chmielewicz, 1994), Fettke and Loos explain the way to describe reference models as a terminological instrument, which helps to classify a set of terms within a specific spatio-temporal system (Fettke and Loos, 2004), p. 10.

Figure 1: 3D print and models of brick elements representing transportation, compatible to LEGO®, own design created by using AutoCAD 2023 for MAC OS, a product of the Autodesk Inc.

In order to answer *RQ1* and *RQ2*, a combination of an experiment and a survey will be performed. Within this experiment, a subset of methods and findings from research (see section 2) will be tested, in order to answer the research questions. Therefore, the answer to *RQ1* and *RQ2* will be derived by using behavioral science (Wilde and Hess, 2006), p. 3. The qualitative results from the experiment and the survey will be analyzed quantitatively, by using statistical tests (Wilde and Hess, 2006), p. 8. The experiment was performed within a lecture in the requirements engineering module of study, at IU International University of Applied Sciences in Hamburg. The lecture was visited by 18 bachelor students, being in their 3rd semester. The group of students consists of 5 students, studying informatics and 13 students studying business informatics.

All students are parallel employed in companies, to collect practical experiences as part of their study. The students already know methods of requirements elicitation, requirements specification and the construction of system models by using UML before the experiment is performed. Furthermore, all students are already trained in the implementation of software applications, using the object-oriented programming language JAVA. The class was separated in two groups, one group being the subject team (ST, Group 1), the other being the control group (CG, Group 2). Separating a course into two groups can lead to difficulties of communication between these groups, which impacts on the results (Kurkovsky et al., 2019), p. 223. To decrease this risk, the control group has a special room. The study group and the control group both become divided into 3 sub teams. The students form teams on their own preferences. This should ensure a good collaboration. Each team gets a set of three requirements, described in text form, having different levels of difficulty. Approximately, the first requirement takes 30 minutes to be analyzed, the second requirement takes 40 minutes to be analyzed and the third requirement takes 20 minutes for its analysis. Therefore, the experiment takes 90 minutes in total. Furthermore, each team gets a bag of bricks, being part of a LEGO® SERIOUS PLAY® Window Exploration Bag. Each bag has more than 50 LEGO® bricks. All teams had the possibility to get some more bricks if they wanted. Before the experiment started and after the experiment was performed, some questions were asked using the web service of (Mentimeter, 2023). The students were asked if they had experience with LEGO® SERIOUS PLAY® and if they think that 3D modelling will facilitate requirements engineering. Just one student already had experience with LEGO® SERIOUS PLAY®. After the experiment, all students were asked to evaluate the technique of 3D modelling as being part of requirements engineering. The lecture ended with a discussion, comparing the findings from literature with the experiences from using LEGO® SERIOUS PLAY® in practice in the lecture. Before the practical part of the experiment started, all students were introduced to the state of research, regarding to 3D modelling of requirements by using LEGO® SERIOUS PLAY®, see section 2. Especially, the basic steps of modelling, building metaphors and storytelling (The LEGO Group 2007, p. 7 - 21)(Cantoni et al., 2009), p. 847 were thought and illustrated. Within the experiment, all teams have to use LEGO® SERIOUS PLAY® in this way to analyze the requirements. After the requirements are analyzed, all students should design an UML class diagram and an UML activity diagram to describe a valid solution, fulfilling the requirement. The three sub teams of students, being in the subject group, have to do a short pre-analysis, additionally. This pre-analysis forces the students to collect some notes, regarding to the objective, the procedure, the pre- and postconditions and the problems and preventions. After the experiment was finished, the results of each of the 6 sub-teams were collected.

These results are qualitative, showing different designs to fulfil the requirement. In comparison with a sample solution, which fulfils the given requirement, all answers were evaluated. For each diagram it was analyzed how much the design of the student team matches to the sample solution. The achieved percentages of the different groups are analyzed statistically, in the next section. Also, the accuracy of the pre-analyses of the subject teams was analyzed and evaluated in percent, subjectively. The statistical analysis was done by using (Microsoft® Excel® 2019). Especially the functions in the Analysis ToolPak being part of (Microsoft® Excel® 2019) were used. The web service of (Mentimeter, 2023) offers a function to obtain the results of the survey in a .xlsx file, compatible for (Microsoft® Excel® 2019).

4 RESULTS

The experiment and the survey were conducted on January, 16th 2023. First, the students were asked three questions via the web service of (Mentimeter, 2023):

- *Q1*: Did you play with LEGO® when you were a child? (Possible answers: Yes, No and NULL)
- *Q2*: Have you already used LEGO® SERIOUS PLAY®? (Possible answers: Yes, No and NULL).
- *Q3*: Do you think, 3D modelling will facilitate requirements engineering? (Possible answers: Yes, No, Unsure, NULL)

Each student answered the questions anonymously. The value NULL means, a participant has not given an answer. The total number of collected answers shown in the classroom and the concept of LEGO® SERIOUS PLAY® was explained. As described in the previous section, all students were divided into 6 sub teams, 3 in subject group and 3 in control group. Each team gets three fictitious requirements to be analyzed:

- *Req.1*: a system that can be used by medical practices, to register recipes at the health insurance, to prevent fraud with counterfeit receipts.
- *Req.2*: a system that can be used by a manufacturer of furniture, who has a forest and wood management on his own, to plan the production of individual ordered furniture.
- *Req.3*: a system that can be used by the coach of a football team, to plan tournaments (travel, strategy) and to document them.

The requirements were shortly described in German language: *Req.1* in 60 words, *Req.2* in 58 words and

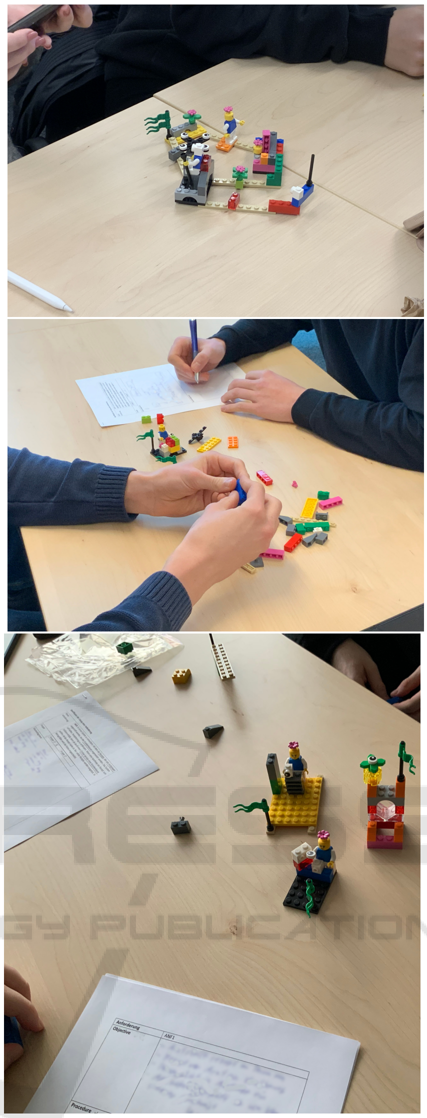

Figure 2: Impressions of the experiment, partially photos edited with (GIMP 2.10.24).

Req.3 in 43 words. After the experiment was conducted, the students were asked to answer again 5 questions by using (Mentimeter, 2023):

- *Q4*: Which group do you belong to? (Possible answers: Group 1, Group 2 and NULL)
- *Q5*: Did you have fun, using the technique? (Possible answers: -5 to +5 points, -5 = Absolutely not! and +5 = Yes, definitively!)
- Q6: Could you imagine to use the technique in practice? (Possible answers: -5 to +5 points, -5 = Absolutely not! and +5 = Yes, definitively!)
- *Q7*: Did the technique facilitate the development of a solution model? (Possible answers: -5 to +5

points, -5 = Absolutely not! and +5 = Yes, definitively!)

- *Q8*: Do you have any comments? (all textual answers are possible)

Requirements	Average Preparation
Req.1	16,67%
Req.2	11,67%
Req.3	6,67%

	Average Result (mean)	
Requirements	UML class model	U ML activity diagram
Req.1	65,00%	81,67%
Req.2	50,00%	50,00%
Req.3	52,50%	23,33%

	Average Result (mean)	
Requirements	UML class model	UML activity diagram
Req.1	56,67%	80,00%
Req.2	36,67%	56,67%
Req.3	46,67%	36,67%

	Average Result (mean)	
Requirements	UML class model	UML activity diagram
Req.1	73,33%	83,33%
Req.2	63,33%	16,67%
Req.3	58,33%	63,33%

Figure 3: Average results, describing the experiment.

All questions were asked in German language. Furthermore, the meaning of the questions was explained in the lecture. Asking Q4 was necessary, because the survey via (Mentimeter, 2023) is anonymous. In order to assign the results to the subject group (=Group 1) or the control group (=Group 2), the participants were asked to enter their group number in the survey. All 18 students accessed the survey within Mentimeter. Due to the webservice of (Mentimeter, 2023), a unique number was assigned to each participant (ID 1 to ID 18). The survey came the following results:

- *Q1*: 16x Yes; 1x No; 1x NULL
- *Q2*: 1x Yes; 16x No; 1x NULL
- *Q3*: 12x Yes; 0x No; 4x Undecided; 2x NULL
- *Q4*: 9x Group 1; 7x Group2; 2x NULL
- *Q5*: 16 answers, 2x NULL; Overall: mean=3,937 & median=4,000 ; within group 1: mean=3,777 ; within group 2: mean=4,142
- *Q6*: 16 answers, 2x NULL; Overall: mean=0,375 & median=0,500 ; within group 1: mean=0,000 & median=-0,500 ; within group 2: mean=0,857 & median=2,000
- *Q7*: 16 answers, 2x NULL ; Overall: mean=0,688 & median=1,000 ; within group 1: mean=0,777 & median=0,500 ; within group 2: mean=0,444 & median=1,000
- *Q8*: 11 answers, 7x NULL; 4x positive comments without further explanation; 1x comment tends to be negative; 1x comment was not interpretable ; 1x comment explains the technique has enhanced the creativity; 4x comments make proposals for the application of the method (use more LEGO® bricks; use for large teams ; helpful to build class models ; use to stimulate communication).

The analysis of the experiment compared the UML class diagram and the UML activity diagram for each requirement with a sample solution. The result of each team was scored with a percentage value. For the subject teams, the accuracy of the pre-analysis was alse scored with a percentage value.

Team		Requirement			Grading		
Team TID	Group GN	Shortcut of requirement REQ	Effort REQE	Difficulty REQE	Quality of preparation QPA	Quality of class diagram QCD	Quality of activity diagram QAD
ST1	1	Req.1	30	3	20,00%	90,00%	60,00%
ST1	1	Req.2	40	5	10,00%	60,00%	80,00%
ST1	1	Req.3	20	2	30,00%	50,00%	50,00%
ST2	1	Req.1	30	3	10,00%	30,00%	80,00%
ST2	1	Req.2	40	5	0,00%	20,00%	60,00%
ST2	1	Req.3	20	2	0,00%	20,00%	20,00%
ST3	1	Req.1	30	3	70,00%	50,00%	100,00%
ST3	1	Req.2	40	5	60,00%	30,00%	30,00%
ST3	1	Req.3	20	2	10,00%	70,00%	40,00%
CG1	2	Req.1	30	3	0,00%	90,00%	100,00%
CG1	2	Req.2	40	5	0,00%	80,00%	40,00%
CG1	2	Req.3	20	2	0,00%	85,00%	60,00%
CG2	2	Req.1	30	3	0,00%	70,00%	50,00%
CG2	2	Req.2	40	5	0,00%	80,00%	0,00%
CG2	2	Req.3	20	2	0,00%	30,00%	30,00%
CG3	2	Req.1	30	3	0,00%	60,00%	100,00%
CG3	2	Req.2	40	5	0,00%	30,00%	10,00%
CG3	2	Req.3	20	2	0,00%	60,00%	100,00%

Figure 4: Experiment data.

4.1 Answer to RQ1

The objective, why to use 3D modelling in requirements engineering, could first be answered on the basis of the findings from literature. 3D modelling techniques like LEGO® SERIOUS PLAY® offering a playful environment, to analyse requirements {citeCantoniBotturiFareBolchiniDavide2009, p. 847. Using 3D models within requirements engineering could improve communication (Teyseyre, 2003), p. 45. (Scialdone and Connolly, 2021) and the creativity (Rasmussen, 2006), p. 61, (Cantoni et al., 2009), p. 847, (Kurkovsky et al., 2019), p. 218. Rasmussen explains the use of LEGO® SERIOUS PLAY® reduces costs and increases the quality of products (Rasmussen, 2006), p. 58. Using techniques, like LEGO® SERIOUS PLAY® is fun, helps us to think out-of-the-box (Kurkovsky, 2015), p. 218, (Scialdone and Connolly, 2021), p. 6. The results from the survey and the experiment shows, that participants had fun, using the technique LEGO® SERIOUS PLAY®

(93,75%, see Q5). Most of the participants think, using 3D modelling will facilitate requirements engineering (85%, see Q3). However, about 43,75% of the participants could not imagine to use the technique in practice (see negative records in *Q6*). 50% of the participants could imagine to use 3D modelling techniques in practice (see *Q6*). With regard to the outcome, in *Q7* the participants answered on an average that using 3D modelling has just a slight positive effect on the development of solution models. 56,25% of the participants see the development of a solution model to be facilitated by the use of 3D modelling techniques. 31,25% of the participants do not see the use of 3D modelling to facilitate the creation of UML solution models. Two participants (21,5%) scored the effect 3D modelling has on the solution model to be 0, means anywhere between positive and negative. On the basis of this findings, we recommend to use 3D models mainly in order to facilitate the communication and the collaboration. Furthermore, the findings show 3D modelling to have a positive impact on the motivation.

4.2 Answer to RQ2

The use of LEGO® SERIOUS PLAY® is already guided by different principles / processes, which are described, e.g. by (Rasmussen, 2006), (Cantoni et al., 2009). The experiment examines the effect, an additional pre-analysis has on the quality of the solution design. In order to guide the pre-analysis, a simple meta-process is designed, called O4P. O4P requests the modeler to define the (O) objective, the (P) procedure for the solution, (PP) pre- and post-conditions of the procedure and (PP) problems and preventions. Within the experiment, students which belong to the subject group had to perform this O4P before using LEGEO® SERIOUS PLAY® as usual, see (Rasmussen, 2006) (Cantoni et al., 2009). In order to answer the question *RQ2*, a regression analysis will be performed. The regression analyzes the effect, the quality of preparation (QPA) has on the quality of the UML models, describing the solution (QCD + QAD). The regression analysis revealed the covariance to be 0,00106, the correlation coefficient to be 0,01196 and the adjusted coefficient of determination to be -0,13317. The t-Test shows the residual variance to be 0,2097 and the standard error to be 0,45793. The value of the t-Statistic is 0,4512. Compared with T being 2,11991, there is no statistic significant impact, QPA has on QCD+QAD. A project manager, who wants to know how to use 3D modelling in requirements engineering, should focus on the standard principles / guidelines which are already established. An additional pre-analysis, which goes beyond these standard procedures, has no significant positive effect.

4.3 Answer to RQ3

The literature review shows requirements engineering to be a well-defined phase within the software engineering discipline. Harman et al. explained that elicitation of processes is a collaborative task which requires communication between multiple stakeholders, normally (Harman et al., 2016), p. 4. Brown concludes 3D models to facilitate the communication between different stakeholders on process models (Brown, 2010), p. 31. Stakeholders IT-competence is an important success factor, to realize software projects (Nurova, 2020). (Nurova, 2020). Also(Nass et al., 2018) mentioning the consumers experience has to be considered. Regarding to the visualization of business processes, Oberhauser and Pogolski show the benefit of using layers within cubic structures (Oberhauser and Pogolski, 2019), p. 4 - 8). Pandey et al. explain requirements management to be a continuous activity (Pandey et al., 2010, p. 290). A procedure, that supports the use of 3D models in requirements engineering has to be flexible, fitting to different needs in different companies. As requirements engineering is a collaborative activity which strongly depends on the communication with customers, the experience of the customer should be considered by the method. Furthermore, a valid reference model has to support the basic activities, requirements engineering consists of. As described in sections 2, all activities of requirements engineering are described within the literature, e.g. by (Balzert, 2009) (Hruschka, 2014) (Pohl and Rupp, 2015) (Sommerville, 2016). The basic activities of requirements elicitation, solution design and documentation (Balzert, 2009) (Hruschka, 2014) (Pohl and Rupp, 2015) (Sommerville, 2016) could be defined as main steps. Furthermore, a setup activity should be added as basic step within requirements engineering to initialize the business analysis. Within a literature, often the communication and management of requirements are seen to be separate activities (see section 2). However, in practice, each activity requires an amount of management and also of communication. E.g. writing a documentation needs a plan and control, as it is the task of the management. Furthermore, the documentation has to be communicated, e.g. to find mistakes in the documentation or to reconcile it. Consequently, the four activities (I) preparation, (II) requirements elicitation, (III) solution design and (IV) documentation have a (1.) management dimension, they have a (2.) communicative dimension and (3.) they have a constructive dimension. Within the constructive dimension, all activities have to realize a practical output, that has to be constructed, e.g. like the written specification document or the list of collected requirements. This model of requirements engineering has to complement with facilities, to create or use 3D models. Different types of customers, distinguished on the basis of the experience of the customers, require different proceedings. For each activity in each dimension and for each type of the customer, companies are able to choose between different procedures. Next to basic procedures that belong to requirements engineering, e.g. like brainstorming, companies are able to use procedures which base on 3D models. Such 3D-Modelling-Procedures (3DMPs) are creative steps, having a high degree of communication. They risk to lose the focus on the objective of requirements engineering.

5 DISCUSSION

After the experiment and the survey were finished, the results were discussed with the students. The students were asked about their evaluation of findings from literature. Within the discussion, the students agreed to the following statements from literature, regarding to LEGO® SERIOUS PLAY® (LSP):

- Using LSP is fun, helps us to think out-of-the-box (Kurkovsky, 2015), p. 218, (Scialdone and Connolly, 2021), p. 6.
- Using LSP enhances the creativity (Cantoni et al., 2009), p. 847
- LSP offers a playful environment, to analyse requirements (Cantoni et al., 2009), p. 847
- LSP facilitates the learning (Kurkovsky, 2015), p. 217, (Gama, 2019), p. 296.
- The insights obtained by using LSP are sustainable, because of the haptic nature of the technique (Kurkovsky, 2015), p. 217, (Gama, 2019), p. 296.
- The teamwork and the communication were enhanced by using LSP (Kurkovsky, 2015), p. 214, (Gama, 2019), p. 294, (Rasmussen, 2006), p. 60.

One student especially emphasizes the effect, described by (Rasmussen, 2006), p. 60, that LEGO® SERIOUS PLAY® helps to integrate those students, ”who don´t normally share what they are thinking”, as explained by Rasmussen (Rasmussen, 2006), p. 60.

However, in the discussion, the students explained LEGO® SERIOUS PLAY® to be not suitable in all situations at their valuation. In communication with hanseatic clients, being very conservative, the use of techniques like LSP could be seen to be ”too hip”, as the students explained. However, in total the students think that LEGO® SERIOUS PLAY® is a valuable technique which could be helpful in practice.

Currently, 3D models are not used everywhere in requirements engineering. A reference procedure, which helps to integrate the usage of 3D models in requirements engineering, could guide the usage of 3D methods. However, the findings from the experiment suggest a reference model to be valuable if it does not limit the freedom of 3D modelling approaches too much. The given answers to Q5 show that students in group 2 had more fun with using LSP (mean 3.78 in group 1 compared to 4.14 in group 2, see section 4). Also the answers to Q6 show that students in group 2 have a higher agreement to use LSP in practice (mean 0.86 in group 2 compared to 0.00 in group 1, see section 4). A reference model which guides the methods application, without increasing the effort to use the method, could be valid to support the practice of 3D modelling techniques in requirements engineering.

6 CONCLUSION

Requirements Engineering could be improved, by using 3D objects. By printing 3D objects for individual software functionalities, customers could better plan how to integrate these modules to build a new system. However, currently, requirements engineering is mostly based on 2D textual descriptions. In order to use 3D objects, the procedures in requirements engineering has to be adapted. This paper presents a reference model for new requirements engineering processes which integrate 3D printing technologies. The state of research shows 3D modelling to be a reasonable technique, supporting requirements engineering. Experiences with playful methods (Knauss et al., 2008), using LEGO® (Cantoni et al., 2009) or Playmobil® (Nass Bauer and Trapp, 2019), (Nass et al., 2018) show how to use 3D modelling in requirements engineering. Using 3D modelling promises to facilitate the communication (Teyseyre, 2003). (Scialdone and Connolly, 2021), increases fun and creativity (Kurkovsky, 2015), p. 218, (Scialdone and Connolly, 2021), p. 6, (Cantoni et al., 2009), p. 847 and helps to integrate all team members in the construction of a solution for complex ideas (Rasmussen, 2006) (Kurkovsky, 2015). Furthermore, LSP as an 3D modelling technique, has the potential to improve the quality and speed of decision making and leads to faster and better implementations, as Rasmussen explains (Rasmussen, 2006), p. 58. Using LEGO® as a technique to teach concepts of requirements engi-

Layer 1: Management

	I) set-up	II) requirements elicitation	III) solution design	IV) documentation
Level 0: Basic	-define phases -project planning -set up workspace	-define priority categories - organize 3D modelling workshops - handle change requests	-demonstrate business case solution -measure the fulfillment of the objectives	-define release process
Level 1: Business User	-determine vision	-multiple playing-workshops -define objective	-plan high-adjustable platform design	-step-by-step cooperation
Level 2: Key User	-determine objectives	-focused discussion-meetings	-plan cooperative software-design-process	-solution-based cooperation
Level 3: Experts	-set up acceptance criteria	-little number of coordination-meetings	-plan test-cases	-cooperative-collaboration

Layer 2: Communication/Agreement

	I) set-up	II) requirements elicitation	III) solution design	IV) documentation
Level 0: Basic	-contract formulation -set up release procedure	-define glossary -define 3D objects	-agreement on the results of the construction	-agree on documentation format
Level 1: Business User	-understand customers language	-taking customer´s perspective -business to 3D transformation	-agreement on possibilities of further changes	- documentation of decisions and their emergence
Level 2: Key User	-define degree of assistance	-functionality-discussion -process to 3D transformation	-agreement on processes	- documentation of the agreed service
Level 3: Experts	-define formal language	-technical objective formulation -service to 3D transformation	-agreement on core-functionalities	- description of the solution

Layer 3: Construction

	I) set-up	II) requirements elicitation	III) solution design	IV) documentation
Level 0: Basic	-set up concept document	-set up backlog -3D model construction	-model quality assurance	-define document structure -documentation of the 3D model
Level 1: Business User	-define business symbols	-role playing games -experience customers job	-business models -3D business game	-story telling
Level 2: Key User	-collect experience reports	-model-discussion-cycle	BPMN process model -3D process model	-business design
Level 3: Experts	-request for CRS (Lastenheft)	-create FDS (Pflichtenheft)	UML system models -3D service integration model	-functional documentation

Critical step   Normal step   Simple step   Using 3D models

Figure 5: Layered reference model, created with (Microsoft® Word 2019).

neering, shows its potential to improve students' perception of abstract concepts (Kurkovsky, 2015), p. 223. In order to use 3D modelling in requirements engineering, project managers have to find answers regarding to the organization of the methods used. The research questions aim to describe why to use 3D modelling (*RQ1*), how to practice 3D modelling (*RQ2*) and when to do 3D modelling in requirements engineering (*RQ3*). A reference model, that facilitates the use of 3D modelling in requirements engineering has to answer these questions. In order to answer *RQ1* and *RQ2* an experiment was performed in combination with a survey and a discussion of findings from literature. During the experiment, different groups had to use 3D modelling to analyze requirements. The work of the groups differs in the amount of pre-analysis, done before the use of 3D modelling. The analysis of the effect, the pre-analysis has on the outcome of the groups, helps to answer *RQ2*. The survey and the discussion aim to identify benefits, that can be realized by using 3D modeling. This helps to answer *RQ1*. The analysis of the results from the survey and the experiment confirm, 3D modelling to be a valuable technique, facilitating the motivation and collaboration. By using a regression analysis, the data obtained from the experiment shows a pre-analysis to not have a significant effect on the outcome. The usage of 3D modelling techniques can be recommended, in order to facilitate the communication and motivation, mainly in the activities of requirements elicitation and the solution design. Further investigations may be focused on the extended integration of 3D printing in order to create specialized 3D model elements, to be used in requirements engineering. If companies print their own 3D models, representing specialized services of the companies business (like a specific way of transportation as depicted in figure 1), the creation of metaphors (Cantoni et al., 2009) could be enhanced. However, as LEGO® SERIOUS PLAY® is well-known, it has to be analyzed, how to combine individual created 3D models and LEGO® SERIOUS PLAY®. By doing so, the benefits of both approaches might be realized.

REFERENCES

Aysolmaz, B., Brown, R., Bruza, P., and Reijers, H. (2016). A 3D Visualization Approach for Process Training in Office Environments. In Debruyne, C., Panetto, H., Meersman, R., Dillon, T., Kühn, e., O'Sullivan, D., and Ardagna, C. A., editors, *On the Move to Meaningful Internet Systems: OTM 2016 Conferences. Confederated International Conferences: CoopIS, C&TC, and ODBASE 2016*, pages 418–436. Cham, Switzerland: Springer LNCS 10033. DOI: 10.1007/978-3-319-48472-3_24 .

Badakhshan, P., Geyer-Klingeberg, J., El-Halaby, M., Lutzeyer, T., Lembo, A., and Gabriela, V. (2020). Celonis Process Repository: A Bridge between Business Process Management and Process Mining. In van der Aalst, W. M. P., vom Brocke, J., Comuzzi, M., Di Ciccio, C., García, F., Kumar, A., Mendling, J., Pentland, B., Pufahl, L., Reichert, M., and Weske, M., editors, *BPM-D 2020. BPM 2020 Best Dissertation Award, Doctoral Consortium, and Demonstration &*

Resources Track. CEUR Workshop Proceedings. Vol. 2673. https://ceur-ws.org/Vol-2673/paperDR01.pdf.

Balzert, H. (2008). *Lehrbuch der Softwaretechnik. Softwaremanagement*. Heidelberg: Spektrum Akademischer Verlag, ein Imprint von Springer, 2nd edition.

Balzert, H. (2009). *Lehrbuch der Softwaretechnik. Basiskonzepte und Requirements Engineering*. Heidelberg: Spektrum Akademischer Verlag, ein Imprint von Springer, 3rd edition.

Bosch, J. (2009). From Software Product Lines to Software Ecosystems. In McGreger, J. and Muthig, D., editors, *Proceedings of the 13th International Software Product Line Conference (SPLC2009)*, pages 111–119. Carnegie Mellon University, The Software Engineering Institute.

Brown, R., Recker, J., and West, S. (2011). Using Virtual Worlds for Collaborative Business Process Modeling. *Business Process Management Journal, Emerald Group Publishing Limited*, 17(3):546–564. DOI: 10.1108/14637151111136414, file = F.

Brown, R. A. (2010). Conceptual Modelling in 3D Virtual Worlds for Process Communication. In Link, S., editor, *The proceedings of the Seventh Asia-Pacific Conference on Conceptual Modelling (APCCM 2010)*, volume 110, pages 26–32. CRPIT.

Cantoni, L., Botturi, L., Faré, M., and Bolchini, D. (2009). Playful Holistic Support to HCI Requirements Using LEGO Bricks. In Kurosu, M., editor, *Human Centered Design, HCD 2009*, volume 5619, pages 844–853. Berlin, Heidelberg, DE: Springer, LNCS DOI: 10.1007/978-3-642-02806-9_97.

Chmielewicz, K. (1994). *Forschungskonzeptionen der Wirtschaftswissenschaft*. Schäffer-Poeschel, Stuttgart, 3rd edition.

Digilina, O. B., Teslenko, I. B., and Abdullaev, N. V. (2020). Prospects and Problems of Digitalization of the Labor Market in Russia. In *Proceedings of the 2nd International Scientific and Practical Conference "Modern Management Trends and the Digital Economy: from Regional Development to Global Economic Growth" (MTDE 2020)*, volume 138, pages 1237–1240. Atlantis Press SARL (Advances in Economics, Business and Management Research). DOI: 10.2991/aebmr.k.200502.205.

Fettke, P. and Loos, P. (2004). Referenzmodellierungsforschung - Langfassung eines Aufsatzes. In Loos, P., editor, *Working Papers of the Research Group Information Systems & Management. ISYM - Information Systems & Management*. Johannes Gutenberg Universität Mainz. Paper 16. https://www.econbiz.de/archiv/mz/umz/winformatik/referenzmodellierungsforschung.pdf.

Gama, K. (2019). An Experience Report on Using LEGO-based Activities in a Software Engineering Course. In *SBES'19: Proceedings of the XXXIII Brazilian Symposium on Software Engineering*, pages 289–298, New York, USA. Association for Computing Machinery (ACM). DOI: 10.1145/3350768.3353817.

Harman, J., Brown, R., Johnson, D., Rinderle-Ma, S., and Kannengiesser, U. (2016). Augmenting Process Elicitation with Visual Priming: An Empirical Exploration of User Behaviour and Modelling Outcomes. *Information Systems, Elsevier Ltd.*, 62:242–255. DOI: 10.1016/j.is.2016.01.005.

Hruschka, P. (2014). *Business Analysis und Requirements Engineering. Produkte und Prozesse nachhaltig verbessern*. Carl Hanser Verlag, München.

Jagenow, A., Speck, A., Windrich, M., Öksüz, E., and Pulvermüller, E. (2022). Business Process Modeling in a Virtual 3D World. In Fujita, H., Watanobe, Y., and Azumi, T., editors, *New Trends in Intelligent Software Methodologies, Tools and Techniques. Proceedings of the 21st International Conference on New Trends in Intelligent Software Methodologies, Tools and Techniques (SoMeT_22)*, pages 450–459. IOS Press (=Frontiers in Artificial Intelligence and Applications). Vol. 355. DOI: 10.3233/FAIA220274.

Kimball, S. and Mattis, P. and the GIMP develompent team (2021). GIMP 2.10.24, Version 2.10.24, Revision 3, GNU Image Manipulation Programm. https://www.gimp.org/downloads/.

Knauss, E., Schneider, K., and Stapel, K. (2008). A Game for Taking Requirements Engineering More Seriously. In *Third International Workshop on Multimedia and Enjoyable Requirements Engineering - Beyond Mere Descriptions and with More Fun and Games (MERE'08)*, pages 22–26. IEEE Computer Society. DOI: 10.1109/MERE.2008.1.

Kristiansen, P. and Rasmussen, R. (2014). *BUILDING A BETTER BUSINESS USING THE LEGO® SERIOUS PLAY® METHOD*. John Wiley & Sons, Inc., Hoboken, New Jersey.

Kurkovsky, S. (2015). Teaching Software Engineering with LEGO Serious Play. In *Proceedings of the 2015 ACM Conference on Innovation and Technology in Computer Science Education, ITiCSE'15*, pages 213–218. New York, USA: Association for Computing Machinery (ACM). DOI: 10.1145/2729094.2742604.

Kurkovsky, S., Ludi, S., and Clark, L. (2019). Active Learning with LEGO for Software Requirements. In *Proceedings of the 50th ACM Technical Symposium on Computer Science Education. SIGCSE'19*, pages 218–224. New York, USA: Association for Computing Machinery (ACM). DOI: 10.1145/3287324.3287444.

Marougkas, A., Troussas, C., Krouska, A., and Sgouropoulou, C. (2022). Virtual Reality in Education: Reviewing Different Technological Approaches and Their Implementations. In Krouska, A., Troussas, C., and Caro, J., editors, *Novel & Intelligent Digital Systems: Proceedings of the 2nd International Conference (NiDS 2022)*, volume 556, pages 77–83. Cham, Switzerland: Springer Nature Switzerland AG (=Lecture Notes in Networks and Systems). DOI: 10.1007/978-3-031-17601-2_8.

Mentimeter (2023). Mentimeter AB. Tulegatan 11, SE-113 86 Stockholm Sweden. https://www.mentimeter.com.

Microsoft Corporation (2019a). Microsoft® Excel®. Office Home & Business 2019. Version 2212.

Microsoft Corporation (2019b). Microsoft® Word. Office Home & Business 2019. Version 2212.

Nass, C., Trapp, M., and Villela, K. (2018). Tangible Design for Software Ecosystem with Playmobil®. In *Revisiting the Life Cycle. Proceedings of the 10th Nordic Conference on Human-Computer Interation*. New York, USA: Association for Computing Machinery (ACM). DOI: 10.1145/3240167.3240278.

Nass Bauer, C. and Trapp, M. (2019). Tangible Ecosystem Design – Developing Disruptive Services for Digital Ecosystems. In *CHI'19 Extended Abstracts. Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems*. New York, USA: Association for Computing Machinery (ACM) (=Advancing Computing as a Science & Profession). DOI: 10.1145/3290607.3298819.

Nurova, O. (2020). Actual Problems of Digitalization in the Field of Industrial Safety Management. In *Proceedings of the 1st International Scientific Conference "Legal Regulation of the Digital Economy and Digital Relations: Problems and Prospects of Development" (LARDER 2020)*, volume 171. Atlantis Press (=Advances in Economics, Business and Management Research). DOI: 10.2991/aebmr.k.210318.036.

Oberhauser, R. and Pogolski, C. (2019). VR-EA: Virtual Reality Visualization of Enterprise Architecture Models with ArchiMate and BPMN. In Shishkov, B., editor, *Business Modeling and Software Design. 9th International Symposium, BMSD 2019*, volume 356. Cham, Switzerland: Springer (=Lecture Notes in Business Information Processing). DOI: 10.1007/978-3-030-24854-3_11.

Pandey, D., Suman, U., and Ramani, A. (2010). An Effective Requirement Engineering Process Model for Software Development and Requirements Management. In *Proceedings. Second International Conference on Advances in Recent Technologies in Communication and Computing. ARTCom 2010*, pages 287 – 291. IEEE Computer Society. DOI: 10.1109/ARTCom.2010.24.

Pohl, K. and Rupp, C. (2015). *Basiswissen Requirements Engineering. Aus- und Weiterbildung nach IREB-Standard zum Certified Professional for Requirements Engineering Foundation Level*. Heidelberg: dpunkt.verlag GmbH, 4th edition.

Rasmussen, R. (2006). When You Build in the World, You Build in Your Mind. *Design Management Review (dmi:review). Oxford, UK: Wiley-Blackwell*, 17(3):56–63. Reprint #06173RAS56. DOI: 10.1111/j.1948-7169.2006.tb00053.x.

Rosenthal, K., Ternes, B., and Strecker, S. (2021). Business Process Simulation on Procedural Graphical Process Models. *Business & Information Systems Engineering. Springer*, 63(5):569 – 602. DOI: 10.1007/s12599-021-00690-3.

Sankar, J., Connacher, H. I., and Lyons, K. W. (1997). Virtual assembly using virtual reality techniques. *Computer-Aided Design. ELSEVIER Ltd.*, 29(8):575–584. DOI: 10.1016/S0010-4485(96)00094-2.

Scialdone, M. and Connolly, A. J. (2021). The Building Blocks of Requirements: A LEGO©-Based Activity for Introducing Requirements Engineering and the System Development Lifecycle. In *Proceedings of the EDSIG Conference*, volume 7. Washington DC, USA: ISCAP (Information Systems and Computing Academic Professionals). No. 5582.

Sommerville, I. (2016). *Software Engineering*. Harlow: Pearson Education Limited, 10th edition.

Sundberg, L. (2019). If Digitalization is the Solution, What is the Problem? In Kaya, T., editor, *Proceedings of the 19th European Conference on Digital Government ECDG 2019*, pages 136–143. Reading, UK: Academic Conferences and Publishing International Limited.

Teyseyre, A. R. (2003). 3D Requirements Visualization. *JOURNAL OF COMPUTER SCIENCE AND TECHNOLOGY (JCS&T)*, 3(2):45–51. Postgraduate Office, School of Computer Science, Universidad Nacional de La Plata.

The LEGO Group (2007). LEGO SERIOUSPLAY™. Imaginopedia for Skills Building. Brochure. LEGO Company. published on the website of SeriousPlayPro.com is a non-profit community at URL: https://seriousplaypro.com/wp-content/uploads/2016/10/Imaginopedia_LSP_Brochure.pdf. accessed 2023-01-14.

Wilde, T. and Hess, T. (2006). Methodenspektrum der Wirtschaftsinformatik: Überblick und Portfoliobildung. Arbeitsbericht Nr. 2/2006, Institut für Wirtschaftsinformatik und Neue Medien der Ludwig-Maximilians-Universität München (LMU). Hess, T. (Hrsg.). https://www.wim.bwl.uni-muenchen.de/download/epub/ab_2006_02.pdf, access 2021-08-30.