
Potential of gamification in BIM training using BPMN

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Abstract

Previous research has shown positive effects of using gamification in learning environments, such as increased participation or increased motivation. These are effects that are currently lacking in small and medium-sized enterprises when it comes to dealing with BIM. In this paper, we aim to identify the potential of gamification for BIM trainings. We start by reviewing the existing body of knowledge on the implementation of BIM, analysing problem areas and highlighting the need for action with regard to training. This is juxtaposed with a systematic study of current BIM trainings in terms of content and didactic approaches. Based on the analysis, we present a framework for the use of gamification in BIM trainings including an approach for a cross-disciplinary description that reduces complexity and is comprehensible to the players in the industry using BPMN.

Keywords: BIM, BIM training, Gamification, BPMN

1 Introduction

Building Information Modeling (BIM) currently represents the main driver of digitisation in the construction industry. The improvement of the information flow of an asset over its entire life cycle offers great potential for increasing the productivity of the construction industry. In order to spread the method further within the industry, alongside technical developments, more efforts in terms of training are needed. Every year, business analysts conduct a survey on the digitisation index of various industries (techconsult, 2020). The construction industry has been at the bottom of these statistics for years. Compared to the banking, insurance and logistics sectors, the construction industry is lagging behind in the continuous use of digital information (techconsult, 2021). Although the statistics do not reflect the fragmented specifics of the construction industry, they nevertheless indicate that the construction industry has a high development potential in terms of digitisation (Meins-Becker, 2020). One of the most promising approaches for digitisation in the construction industry is the method Building Information Modelling (BIM) (Detail, 2016), which refers to the continuous use of digital information on a construction project over its entire lifecycle (ISO, 2018). Instead of documenting information with the help of paper-based workflows, using the new method, information on a construction project will be linked digitally, stopping disruptions in the information flow. The core of the method is the continuous use of digital models of the planned asset, which are accessible to all stakeholders in the construction process (Borrmann et al., 2018). The BIM method has been promoted by government initiatives and standard-setting associations for several years, however studies indicate that implementation has been slow so far. Small and medium-sized enterprises in particular have problems using the method efficiently for themselves (Bundesinstitut für Bau-, Stadt- und Raumforschung). Numerous studies on the topic of BIM show that companies lack employees with digitisation skills (Leupold, 2020), that the BIM method seems complicated and overwhelming (Helmus et al., 2018; Leupold, 2020), and that the software on offer is primarily tailored to large companies (Leupold, 2020).

1.1 Current implementation of BIM

A study among 396 municipalities in Germany showed that even in 2020, 26% of the respondents were unfamiliar with the BIM method, and another 57% had only a rudimentary understanding of the method (Ministerium für Heimat et al., 2021). A survey conducted as part of a Munich BIM trade fair revealed processes of education and training as well as change management as the greatest challenges (CAFm Ring, 2019). In 2018, 95% of craftsmen answered no to the question whether they use BIM and 47% also rejected future work with the method (Helmus et al., 2018). Companies that decide to work with the BIM method often lack BIM competence. 65% of respondents to a German bitkom study described their employees lack of BIM competence as a barrier to BIM implementation. 79% have the feeling that BIM solutions are oversized for their company (Leupold, 2020).

These figures emphasize that the BIM method, despite its recognised advantages, is not yet being used throughout the industry. For SMEs in particular there is a lack of competence to apply it, solutions tailored to their needs and incentives to use the method. Training, as part of the BIM change management process, enables employees to use the new method and builds competence (Kotter, 1996).

1.2 The concept of Gamification

An approach to design motivating trainings is gamification. The concept has been one of the popular developments in recent years, when it comes to influencing motivations and behaviors. The term gamification is derived from the word "game" and focuses on the use of game-design elements outside of traditional gaming environments. The concept of gamification has become established in recent years in industries such as marketing, HCI and healthcare for the playful design of non-game contexts (Deterding et al., 2011a). When playing, we are intrinsically highly motivated, feel flow and experience feelings of competence, social engagement and autonomy. Everyday contexts such as learning situations do not usually achieve such a level of motivation (McGonigal, 2012). The goal of gamification is to transfer the effect of games to other contexts. Game elements such as points, content unlocking or feedback loops are incorporated into other contexts to make them game-like (Deterding et al., 2011b). An example of this is the enrichment of a running app with rankings, status and competition to make the actual running more game-like and motivating (Widmann, 2015).

Even though the research field is still comparatively young, several studies have already proven the positive effects of gamification (Hamari et al., 2014). Hamari et al, Seaborn and Fels and Sailer investigated the effects of gamification in 58 studies in total (Hamari et al., 2014; Sailer, 2016; Seaborn and Fels, 2015). These showed predominantly positive, in 15 cases mixed results and no purely negative effects from the use of gamification. According to the investigated studies, effects that the use of gamification achieved are and not limited to (Hamari et al., 2014; Sailer, 2016; Seaborn and Fels, 2015): Engagement, motivation, commitment, fun, learning outcome, activation of previous knowledge, learning activity, performance, experience of competence, social integration, experience of autonomy, behavioural change, reasoning skills and participation.

Due to the positive experiences with gamification in other sectors, it is assumed that these can also be transferred to trainings on the BIM method. Since users in the context of BIM primarily lack the experience of competence and social engagement (Leupold, 2020), the game-like form of learning, which promotes precisely these feelings (Sailer, 2016), is considered particularly suitable for training on this topic.

2 Research method

The research objective of this study is to present a framework for the use of gamification in BIM trainings. We first conduct a systematic literature review of research on gamification in the construction industry. A second literature analysis on the current training situation examines how BIM is currently being trained. Based on the two analyses, a concept for the communication and dissemination of the idea of the gamification approach is presented within the framework of

a design science research approach. This concept aims to facilitate the application of gamification in BIM training beyond research projects and to make it accessible to more users.

2.1 Literature review of gamification in the construction industry

A literature review on gamification in the construction industry has already been conducted by Cunha Leite et al. In 2016, they concluded that there are no empirical studies in this area so far (Cunha Leite et al. 2016). In the context of this study, a literature review was conducted anew to present any possible development. For this purpose, a literature analysis according to Webster and Watson was conducted in 24 databases of the AEC field (Webster and Watson, 2002). Using the search term TITLE-ABS-KEY(GAMIF*), the databases were thus searched for word combinations of the term gamification. Journal articles and research projects were included in the analysis in addition to peer-reviewed papers.

The database search yielded 221 hits. Of these, 209 hits were excluded from the analysis. This exclusion was due to lack of reference to the construction industry (121), lack of reference to gamification (70), duplication of results (14), lack of access to the full version (3) and publication in another language (1). 12 papers were included in the analysis.

The following table shows the results of the literature review.

Table 1. Literature review on gamification in the construction industry

Source	Aim of gamification use	results	Type of study
(Cunha Leite et al., 2016)	Investigating the effect of gamification on transparency on construction sites via a design science research approach	Positive results	Case study
(Rüppel et al., 2017)	Promoting motivation for energy-efficient behaviour	No results regarding the use of gamification	Case study
(Alanne, 2016)	Overview of the state of research on gamified approaches to teaching energy-efficient construction	Positive results	Literature review
(Iria et al., 2020)	Motivating building users for an energy-efficient use of energy with a gamified mobile platform	Positive results, but no conclusions on gamification effect	Case study
(Casals et al., 2020)	Encouraging users of social housing to adopt more energy-efficient behaviour	Mixed results	Case study
(Markopoulos et al., 2015)	Literature analysis of existing gamification approaches	Little empirical research to date, but positive trends discernible	Literature review
(Hansen et al., 2017)	Stronger and facilitated involvement of the public in decision-making processes on sustainable construction	Positive results	Case study
(Irmer and Ziegler, 2019)	Increasing participation in urban research surveys through gamification	No results regarding the use of gamification	Quantitative study
(Braun, 2019)	Demonstrating gamification as a potential for urban development	Presentation of 3 projects with positive results in the use of gamification	Case study

(Knigge, 2018)	Improving public relations in urban development processes through gamification	No empirical evaluation, positive effect recognisable	Pilot project
(BBSR, 2018)	Analysis of the benefits of gamification for the generation of knowledge on urban development	Analysis of several process examples with positive result tendencies	Research project
(Drakoulis et al., 2018)	Changing the behaviour of public transport users with the help of gaming incentives	No results regarding the use of gamification	Case study

Of the 12 analysed hits, 8 show positive results, 4 did not explicitly assess the effect of gamification. The low number of hits and the results from Table 1 indicate that gamification has hardly been empirically investigated in the construction industry so far. However, some projects in the construction industry have recognised the potential of gamification and applied the concept to the training of BIM. The research projects BIM Game (Pütz et al., 2020) and BIMcert (BIMcert, 2021) are particularly worthy of mention here. Other projects also use the concept of gamification, but in contexts that are not directly related to BIM trainings (BIM4VET, 2021; BIMplement, 2021; BIMzeED, 2021; NET-UBIEP, 2018). The use of gamification showed positive results in the trainings related to these projects. This highlights the potential of gamification to be used successfully in trainings on BIM and other topics in the construction industry.

2.2 Literature review of current training on BIM

In order to compare the potential of gamified BIM training with the current training situation, we conducted a literature review of the current range of BIM training courses on the example of the German training market in March 2021.

The non-profit organisation buildingSMART is currently striving to standardise BIM training. Within the framework of the Professional Certification Programme, both the training courses offered and the BIM competences become more comparable and easier to assess (buildingSMART Deutschland, 2021). Training providers can have their courses certified via a certificate programme and issue participants with an official certificate of BIM basic knowledge (buildingSMART Deutschland, 2021).

For the literature review, all training providers listed by buildingSMART Germany were evaluated. In addition, search engines were used to search for training offers with the search strings "BIM*Training". In a first step, 81 offers were recorded for the analysis. These were then reduced by offers that refer to pure software training or have no specific reference to the BIM method. In the subsequent analysis, 78 offers were included. On the basis of the information on websites and flyers, these were examined with regard to the content conveyed and the didactic approach. The following table summarises the result of the analysis.

Table 2. training offers on BIM

Training concept	Source	frequency	percentage
Lectures/ presentations	(Akademie AKNW, 2021; Akademie der Ruhr-Universität, 2021; alfatraining, 2021; Allplan, 2021; Architektenkammer Berlin, 2021; auxalia, 2020; Bayerische Ingenieurkammer-Bau, 2021; BIM Institut, 2020; Build Informed, 2021; BWI-Bau, 2021; CADsys, 2021; Contelos GmbH, 2021; DBC Consulting, 2021; DIN Akademie, 2021; EIPOS, 2021; FH Erfurt; Formitas, 2021; GSP Network GmbH, 2021; Hochschule Karlsruhe	N=58	71,6 %

	- Technik und Wirtschaft, 2021; HTWK Leipzig, 2021; IK-Bau NRW, 2021; Jundi Schrade Baumeister, 2021; Mensch und Maschine Software, 2021; MTS-Akademie, 2021; planify, 2021; Technische Universität München, 2021; TerraMeta 3D Laser Service, 2020; TU Dresden, 2021; TÜV Rheinland, 2021; TÜV Süd, 2021b; VDI Wissensforum, 2021a; Weiterbildung an der Hochschule Biberach, 2021)		
Project work	(Akademie der Ruhr-Universität, 2021; alfatraining, 2021; BIM Institut, 2020; FH Erfurt; VDI Wissensforum, 2021c)	N=5	6,1 %
Tutorials	(EIPOS, 2021; Mensch und Maschine Software, 2021; Weiterbildung an der Hochschule Biberach, 2021)	N=3	3,7 %
Web-based-Learning/E-Learning	(Akademie der Ruhr-Universität, 2021; Architektenkammer Sachsen, 2021; Bauhaus Weiterbildungsakademie Weimar, 2021; BIM Institut, 2020; EDUBIM-Campus, 2021; HOCHTIEF ViCon GmbH, 2021; Mensch und Maschine Software, 2021; Technische Universität München, 2021; TÜV Süd, 2021c; VDI Wissensforum, 2021b)	N=10	12,35 %
Serious business game	(VDI Wissensforum, 2021b)	N=1	1,2 %
n. s.	(ASSMANN BERATEN + PLANEN, 2021; BIM Schule, 2021; Borgmann, 2021; DUSCHL INGENIEURE, 2017; HafenCity Universität Hamburg, 2021; Hochschule München - Fakultät Bauingenieurwesen, 2021; inovi gmbh, 2021)	N=8	9,88 %

Of the 78 training offers analysed, 34 are certified via buildingSMART. 9 others teach content similar to the buildingSMART certificate without having it certified. The remaining 35 providers train BIM basics with a different focus.

In the course of the corona pandemic, the range of online trainings grew strongly. 63 percent of the providers offer online training. In many cases, the online training corresponds to a delivery of the previous face-to-face training via web conferencing tools. This is the case with 71 per cent. Some providers supplement this offer with documents for self-study. This is the case in 7 percent. Only 10 providers offer e-learning programmes that are not based on web conferencing. 5 of the offers are based on the same e-learning programme, which is offered by the providers in their own corporate design. Gamification is not mentioned or described as a form of delivery in any of the offers. However, one provider offers a serious business game (VDI Wissensforum, 2021b) and four providers refer to multiple choice (Akademie der Ruhr-Universität, 2021; Architektenkammer Sachsen, 2021; EDUBIM-Campus, 2021; TÜV Süd, 2021a).

In summary, the analysis shows that BIM training currently takes place primarily via classic formats such as lectures. The positive results on the use of gamification in BIM trainings from research projects have not yet had an impact on training offers. Gamification is currently not a relevant didactic concept for BIM training. The two literature analyses show that the construction industry has not yet exploited the potential of gamification. Instead, BIM is communicated via classic, old-fashioned formats. There is great potential here to provide approaches for the use of gamification in BIM training with the help of the framework, presented in the following section.

3 Framework for the use of BPMN for gamification approaches

The literature analysis reveals two aspects: on the one hand classic formats dominate in BIM training and the concept of gamification has not yet been applied. On the other hand, the potential has already been recognised in research projects and applied in this context (BIMcert, 2021; EDUBIM-Campus, 2021, 2021; Pütz et al., 2020). A transfer of the training concepts from the research projects into certified and commercially offered BIM training courses has not yet taken place. Gamification is a very complex concept that combines elements of game design, motivational psychology, behavioural change and the requirements of the application context (Morschheuser et al., 2018). Creating such a concept requires careful planning. For the application in the building industry, which is not a gamification expert, it needs a way to communicate this concept and make it transferable. The aim of this study is to present a concept for this communication approach.

3.1 Previous research work

An approach for communicating gamification concepts is provided by Morschheuser et al. with their gamification notation based on the Business Process Modelling notation (BPMN). (Morschheuser et al., 2015). BPMN is a graphical notation for modelling and documenting processes (BPM&O, 2020). The use of BPMN is available free of charge and offers a uniform communication between different actors. BPMN combines simple semantics with sufficient detail (Affinis, 2019). In the construction industry, BPMN is already used in the context of BIM for BIM process modelling and as a standardised ISO standard (Borrmann et al., 2015). The basic principles of the notation and the advantages of its application are therefore already known within the industry.

In their notation extension, Morschheuser et al. take up the advantages of BPMN for clear communication and a uniform understanding of processes and use this to achieve a standardisation of gamification at process level through a specification of process patterns (Morschheuser et al., 2015). In this way, the communication and transfer of gamification concepts is facilitated. With their notation, Morschheuser et al. were able to demonstrate an easier understanding of how gamification works and a reduced time required for the presentation of gamification concepts (Morschheuser et al., 2015).

The following figure shows the notation extension of Morschheuser et al. on the example of the game design element points.

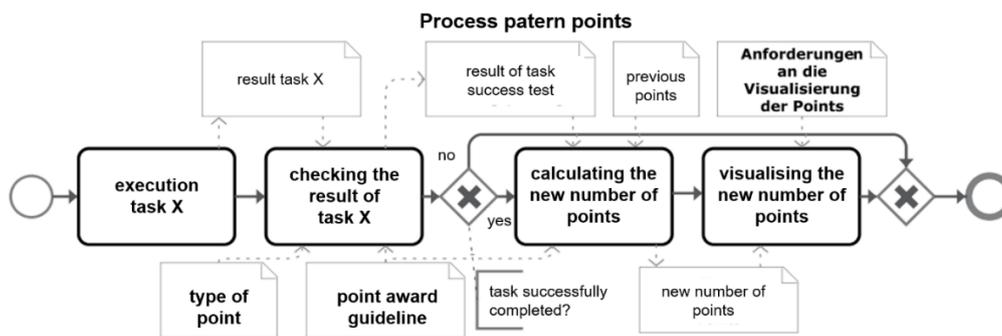


Figure 1. Excerpt from the BPM notation expansion according to Morschheuser et al.

3.2 Further development of the concept

The framework of Morschheuser et al. is currently limited to the use of five game design elements. The notation presents the game design elements points, rewards, badges, leaderboard and level in the BPM notation (Morschheuser et al., 2015). A complete enumeration of game design elements is not possible. However, lists of game design elements from the gamification literature include far more than these 5 elements (for references see e.g. (Blohm and Leimeister, 2013; Werbach and Hunter, 2012; Wood and Reiners, 2015; Zichermann and Cunningham, 2011)). The framework according to Morschheuser et al. therefore only allows a limited source for

communication on gamification. An extension of the concept is intended to make it usable for communication in the construction industry and the adoption of gamification concepts.

For this purpose, we extended the concept in two ways: on the one hand, further game design elements were added, and on the other hand, the modelled gamification concept was related to the content of the training course. Thus, the linking of gamification elements with training content can be illustrated, promoting an easier understanding and simplified communication of gamification approaches.

3.2.1 Design science research approach

Morschheuser et al.'s framework was further developed in a design science research approach. The concept was created, tested and revised in three design cycles. The application tests were carried out as part of the DigIT_Campus research project (DigIT_Campus, 2021). In workshops with N=8 participants, the concept was discussed and continuously improved. The workshops were conducted with experts in didactics and BIM training. Thus, their diverse expertise could increase the quality of the framework.

3.2.2 Framework

The framework includes BPMN process patterns for 24 game design elements, which allow to visualise the operation of an implemented game design element. Each game element is represented with the help of its own icon to be quickly visually recognizable. Figure 2 shows examples of these icons.



Figure 2. BPMN icons for game design elements

The elements were selected based on an analysis of the most frequently listed game design elements in the gamification literature. Figure 3 illustrates the design of a gamification process using the example of the game design element quest.

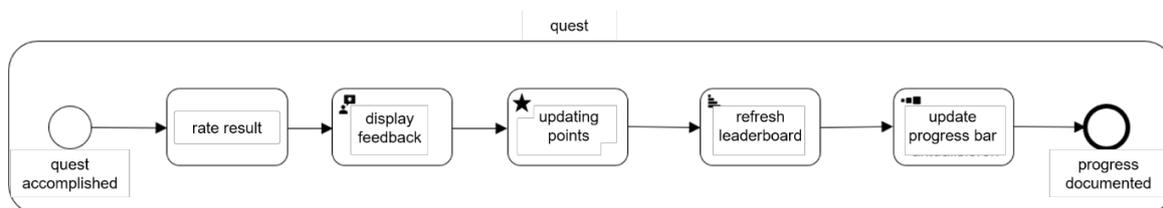


Figure 3. BPMN process pattern quest

Based on the process patterns for game design elements, a link is created between the gamification processes and the training content. This is achieved as follows:

The certified content according to buildingSMART is first broken down into individual topic blocks and presented as an activity in a swimlane. In the second step, the implementation of the contents in the training is shown in another swimlane. Here, it comes into play, for example, whether a topic is taught through a lecture, a learning video or group tasks. A third swimlane then shows how the gamification elements are applied to this content and its implementation. If a quest is used as a game design element, the framework allows for a graphic abstraction of the content to which this quest is linked and how the content was conveyed. For example, there could be a quest on the definition of BIM that was presented via a learning video. For better readability, the following figure only shows an excerpt from the corresponding BPMN diagram. The complete framework can be downloaded here: <https://biminstitut.uni-wuppertal.de/de/forschung/download-bereich.html>

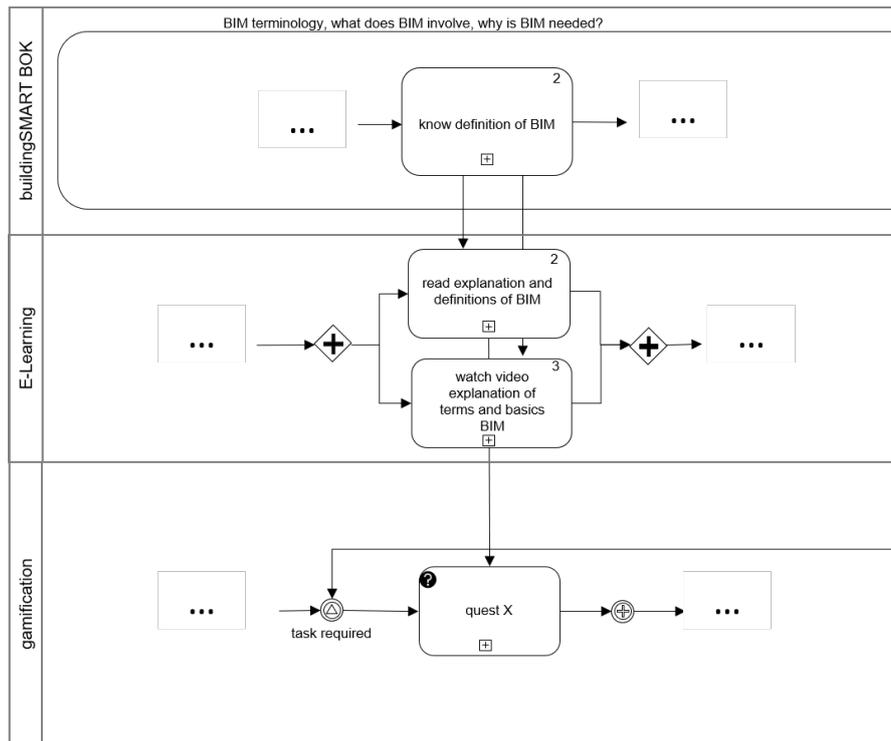


Figure 4. exemplary excerpt of the communication framework

Following this approach, the gamification mechanisms within trainings are mapped graphically and presented in a way that is easy to understand even for people inexperienced with gamification. Depending on the needs, game design elements can be added or replaced to suit the requirements of the individual training. Use cases for the framework are, for example, the description of a gamified BIM trainings for providers who have not worked with gamification so far but would like to offer such a training. These can be both from companies in the economy or training providers. For them, the concept can be easily explained with the help of the framework.

4 Conclusion

The aim of this study is to present a framework for the communication of gamification concepts. This contributes to the improvement of BIM trainings, meeting the challenges enterprises of the construction industry face when implementing BIM. The study offers an overview of the current research on gamification in the construction industry and the current training situation. The findings indicate the achievement of positive result tendencies using gamification in trainings in the context of research projects. A transfer of these approaches to commercial training has not yet occurred. The presented framework helps to communicate the idea of implementing gamification and transfers it to other trainings. Thus, we contribute to a simplified application of gamification. The framework has proven to be effective in the development cycles and in the application of a DigIT_Campus training.

5 Recommendations for further research

Further work is required to investigate the utility and effectiveness of the framework in a larger application context. We recommend the development and analysis of case studies using the framework. In addition, the framework can be continuously extended to further game design elements to represent the complex concept of gamification even more precisely. The analysis of the effect in trainings would offer further valuable insights for the application of gamification in BIM trainings.

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