Gamification and BIM

Teaching the BIM Method through a Gamified, Collaborative Approach

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Abstract –

Due to the continuous improvement in data acquisition, storage and evaluation, digital technologies are penetrating ever deeper into the operational business of the construction industry. Modern information and communication systems are at the heart of digital working methods. They encompass the factors - People, Processes and Data -, which are all decisive for successful project management. In the context of digitizing a building project, it is necessary to harmonize these factors. When implementing digitization strategies, the focus is often on finding suitable technical solutions and defining processes. However, the human factor continues to play a decisive role in the construction, as a high degree of coordination between the parties involved in the construction process is necessary in order to produce safe and functional unique buildings. In order to establish the methodology of Building Information Modeling successfully in the construction industry in the long term, it is therefore essential to involve the employees in the developments.

The human factor becomes all the more important in large construction projects, which also involve partners across national borders. The approaches to new methods, as is necessary in the case of BIM, sometimes differ greatly due to cultural differences in the international context and cause problems of understanding, even though certain software applications, for example, work perfectly. In addition, employees often experience personal inhibitions that prevent the consistent use of new methods.

The research project "BIM Game", in which partners from several European countries worked together puts the human factor in the forefront of the BIM methodology and develops new ways of communicating the basic ideas of the method already in the education of students. The project focuses on two main points: Firstly, the linking of students via a Learning Management System, which reflects the work in project rooms of a real construction project and thus promotes collaboration. On the other hand, the use of gamification - the application of game elements as known from computer games, for example - to lower inhibition thresholds and increase motivation to deal with the topic. The aim of the project is to teach future project participants how to collaborate in a digital project, rather than merely addressing technical issues. The students slip into different roles and work collaboratively and digitally on a real scenario. They do not receive feedback through classic evaluation systems such as grades, but through badges and the achievement of levels.

Keywords –

collaborative learning platform; learning management system; gamification; BIM Game; game design elements; Building Information Modeling

1 Introduction

The digitization of the construction industry is currently being driven forward primarily by the increasingly widespread use of the methodology Building Information Modeling (BIM). When talking about BIM, the acronym does not mean a software application or the mere work on a 3D model [1]. BIM describes "a collaborative working methodology that uses digital models of a building to consistently capture, manage, and transparently communicate information and data relevant to its lifecycle or to hand it over for further processing." [2] The new working methodology thus requires a holistic approach to planning, construction, operation and dismantling. For the successful implementation of the approach, in addition to suitable software solutions, a cultural change in the construction industry is required. Collaboration on a construction project must be thought of in a team-oriented way in

order to reduce interfaces and enable work in a common data environment (CDE). For this purpose, it is advisable to adapt business processes and familiar forms of cooperation [3].

Working with the BIM methodology therefore requires changes in three areas of current mode of operation. First, processes in the company must be adapted to the new methodology. In many cases, it is first necessary to identify and record the processes currently being carried out. Following this, these processes can be digitized and adapted to work with BIM. In a second step, the implementation of the newly designed processes requires the selection of suitable software offers. The most suitable offer for one's own needs must be selected from the large market for BIM software. For this purpose, prior modelling of the processes is helpful, as these can serve as a kind of demand list for the software selection. The third step that should not be underestimated is the people in the project who have to implement the new processes and use the software. Any well-considered steps in the process and software selection can lose their success if the employees are not appropriately involved in the further development. The discussion about BIM currently focuses mostly on software and processes. Important to remember ist that people traditionally shy away from change [4]. Training in BIM is therefore essential for the successful application of BIM.

There are three ways to prepare personnel for working with the BIM methodology [5]:

1. new employees with appropriate knowledge are hired and implement the specific method in the company
2. BIM skills are purchased through cooperation with external partners
3. Ones own employees are trained in the application of the specific method.

The former variant is often difficult to implement in times of a shortage of junior staff. Employees with BIM skills are in demand on the job market and are difficult to find. Apart from the costs, the purchase of external skills brings with it a certain dependency and is usually associated with trust problems. This strategy can provide an introduction to working with BIM, but it must then be possible to continue the implementation independently. The further training of one's own employees involves a certain amount of effort and requires that acceptance hurdles among employees can be overcome [6].

The BIM Game research project addresses the problem of how to prepare employees in the construction industry for working with the BIM methodology using their own resources and trains students as future employees with BIM competencies. The sluggish implementation of the BIM methodology to date also shows that training courses do not meet the demand [7]. Classical training formats can convey the new form of cooperation in theory, but training based on frontal teaching will not be able to convey practice application in detail.

2 Idea of the BIM Game

The idea of the BIM Game is therefore to rethink training in the field of BIM. Instead of classical lectures, the aim is to teach the method in the cooperative collaboration that the BIM methodology demands. The BIM Game research project, led by gip Besancon, is a cooperation of various universities, colleges, training centers and software companies from five European countries (University of Wuppertal, Jade University of Applied Sciences Oldenburg, Lycee du Bois Mouchart France, Universided de Castilla la Mancha, Université de Liège, datacomp, Pôle énergie Franche Comté). The aim of this inter-European cooperation is to find a common understanding of the BIM methodology and to teach the methodology to students, trainees and experienced professionals in a fun, collaborative way using real-life examples and projects. Regarding the preparation of personnel for working with the BIM methodology it addresses the first and third option. Students should acquire the ability to use BIM in a targeted manner in professional practice in order to establish them as sought-after actors and partners in business and society. Through the involvement of experienced experts, people who are already established on the labour market also learn the superordinate or specific use of BIM.

Playful learning is the most intuitive form of learning that people know. Even at a very young age, new skills are learned through play and adaptation to new challenges is tested [8] [9]. Only with increasing age does learning become less and less playful. The fact that adults still like to play is shown, among other things, by the high user numbers of online games across all ages and genders[10]. The BIM Game makes use of this natural play instinct and thus provides a higher motivation to deal with the topic of BIM and increases the participants knowledge about it. The method behind this is called gamification. Gamification stands for the transfer of typical game design elements into non-game contexts [11]. The goal of gamification is to make everyday training situations, which have nothing to do with games, more interesting by enriching game design elements such as a narrative, avatars, levels, points or badges. The goal is to achieve a change in behaviour and an increase in motivation [12].

Beyond the increase of motivation during the training, the project uses gamification to increase learning effects through the activation of long-term memory. “If you

want to explain something to someone else, you must first understand it yourself, e.g. have read or heard it. Whoever tries out or applies something already links the entire course of events with the actual information, which is why the result is anchored more firmly in the brain as if he had only observed the same result in someone else" [13] This effect is achieved by actively absorbing information through multiple cognitive channels (seeing, applying and experiencing) during the game and by incorporating repetition effects of specific thematic areas throughout the total game. This is to be realized by an active and collaborative processing of application-related building scenarios in an environment embedded by computer game elements. This way of gathering information increases the willingness to learn and lowers the barriers to dealing with the complex topics of the holistic BIM work methodology. The goal is to encourage self-study in a playful way.

2.1 Practical implementation of the project

Between 2016 and 2019, 10 events were organised as part of the BIM Game, which introduced students, trainees and experienced professionals to the BIM methodology in the described collaborative, playful way. Each of these events followed a basically identical structure. To ensure practical relevance, the BIM methodology was taught using scenarios from real professional practice. These scenarios were enriched with game design elements to create a collaborative, playful and motivating learning atmosphere. Figure 1 shows the game design elements integrated in each scenario:

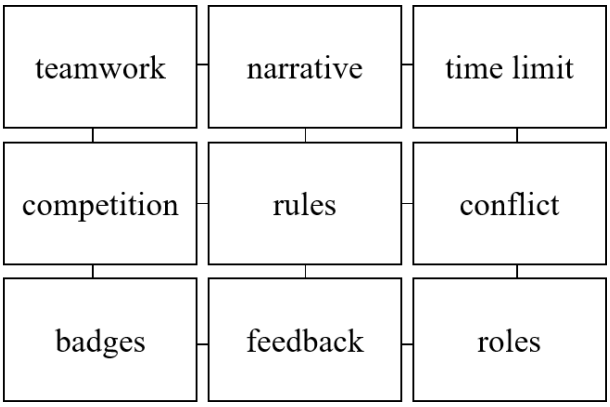

Figure 1. game design elements of scenarios used in the BIM Game

The **narrative** is always based on a scenario of a real construction project. The scenarios correspond to situations from different life cycle phases of a construction project. To classify the scenarios, six life cycle phases from project development to project operation have been defined. This ensures that participants learn that the BIM methodology goes beyond application examples in the planning phase and is relevant for the entire life cycle of a building. The design of the scenarios allowes them to be played through within one day. Depending on the group and event, they can be shortened or extended to half a day or two days by shortening or adding to the task. The content of all scenarios is based on the BIM guidelines ISO 19650. In order to be able to respond individually to the previous knowledge of the different user groups of the BIM Game, each scenario was designed with a unique task and a different focus as well as with different levels of difficulty. All scenarios were developed primarily with the goal of understanding the roles and their tasks in a multinational collaboration in order to strengthen teamwork in an international construction process.

Teamwork is an important part of all scenarios, since BIM projects are never implemented by one person alone, but are always in interdisciplinary teams that have to get along well with each other. Each team member is assigned the **role** of a participant that he or she is not familiar with from the usual project business. An architect, for example, slips into the role of a craftsman, a planning engineer into that of a facility manager. This is intended to create more understanding for the project partners' views of a project. Another aspect of teamwork is **multinational cooperation**. Participants of different nationalities are always mixed so that cooperation with foreign partners, communication in English and the adaptation of different approaches to problems are trained.

Each scenario and each subtask must always be processed within a certain time limit. This simulates the tight schedules of real construction projects and puts the participants under time pressure, which makes cooperation with the project participants indispensable.

For each scenario the participants are given **rules** in the task definition. These can also deliberately contain **conflicts** that need to be resolved within the team and, if necessary, in communication with other participants.

The entire BIM Game and thus also the participation in the individual scenarios is designed as a **competition**. The individual teams compete against each other in the fight for the overall victory. In addition, **badges** are awarded e.g. for the most sustainable project. Winning is always connected with a reward. Extensive **feedback** is given for all teams on the work they have done, which should prepare them for further work with the BIM method.

The central element for the implementation of the scenarios is a digital platform based on common data environments (CDE) from construction projects. The participants process the scenarios completely online

using the platform. They are given the opportunity to communicate via chat functions, files can be stored and exchanged, appointments can be planned and notifications send to others. In order not to prefer a commercial provider of CDE, an open source offer was tailored to the needs of the project. The Learning management system (LMS) nextcloud has been adapted to come close to working in a CDE (see Figure 2).

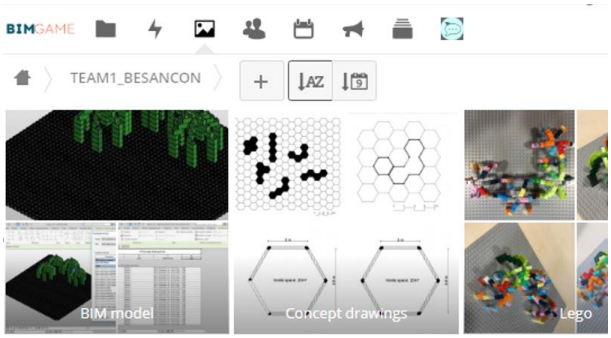

Figure 2. Extract from the data management area of the platform

The platform serves as a basis and link point for all steps in the scenario processing. The task is provided via nextcloud and all further task parts are organised, processed and completed by the participants via the platform. This set up also made it possible, when organising an event in France, to integrate participants from Spain and Poland who were not on site.

2.2 Example of a scenario

In order to bring closer what exactly a scenario looks like, an example is presented below. In November 2018, 13 students in the field of architecture and civil engineering took part in the described scenario, working in three groups.

In order to bring building product traceability and the application of BIM on the construction site closer, a construction site was simulated in the scenario using Lego bricks. These enabled both a design for a building to be produced and the design to be implemented on the "construction site" within one day. The participants worked through the scenario in the roles of client, BIM manager, architect, engineer, craftsman and supplier. A team of architects and engineers had to develop a design in compliance with budget and sustainability requirements (different stones = different properties). This was implemented "on the construction site". With the help of a BIM viewer, the construction workers could view the design on a tablet and implement it accordingly. Using RFID tags on the individual bricks, the progress of the construction work could be monitored by scanning the tags during installation, then creating an as-built model and tracing the building products in the finished building.

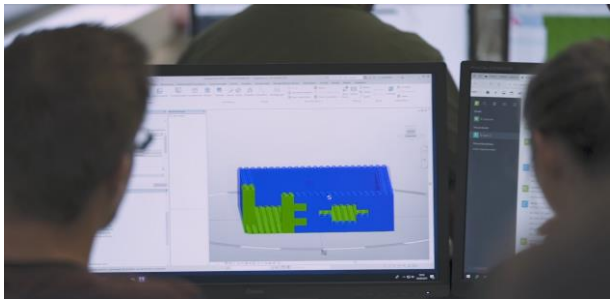

Figure 3. a participant working on the 3D model

The client also acted as a jury in the scenario, evaluating the results and giving feedback to the groups on their solutions (see Figure 4).

Figure 4. client giving feedback to the groups

2.3 Evaluation of events

Selected events were evaluated to continuously improve the scenarios and to check whether the way of teaching the BIM methodology is successful. The evaluation method was based on questionnaires that the participants answered after the scenarios were completed. Over a period of one year and within the framework of four different scenarios, a total of 50 participants were surveyed. The items of the questionnaire were designed as multiple choice questions. Non-symmetrical answer scales were used to avoid an accumulation of neutral answers.

Two aspects were particularly important for the project: Do the participants like the way the method is communicated via collaborative, playful methods and do the participants get a good, lasting impression of the BIM methodology in a short time?

76% of the participants stated that they had gained a good insight into working with the BIM methodology. For the remaining participants, technical problems, e.g.

poor Internet connection, were the main reason why they did not get the desired insight into the methodology. The learning method about collaborative scenarios was positively evaluated by 90% of the participants (see Figure 5).

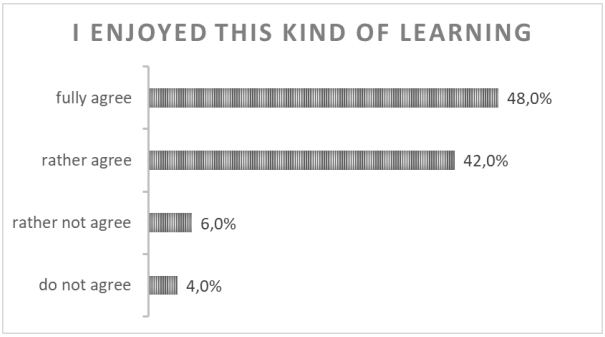

Figure 5. satisfaction of participants with the kind of learning

78% said they had fun and were motivated during the scenario. The idea of competition with other teams motivated 96% of the participants. The gamification method, which has rarely been used in construction training, would be used more frequently by 94% after the BIM game (see Figure 6).

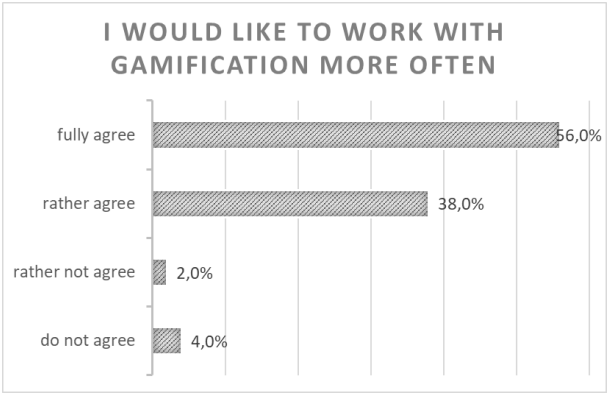

Figure 6. preference of the participants to work with gamification more often

Since it is not only the unique pleasure of teaching that is important for successful application of the BIM methodology, the participants were asked to give their opinion on the durability of what they had learned. More than 70% of the participants stated that they expected the learning content to be more durable than with traditional learning methods. A further 16% rated the durability the same, regardless of the learning methods. The verificaton whether the BIM methodoligy was understood in the context of the scenarios was not done via the questionnaires, but was ensured by presenting the results to the jury.

3 Findings

The study shows that success with the BIM Game has been achieved both in terms of learning the BIM methodoligy and the fun of learning. In comparison to their usual learning settings, the participants were more motivated and felt that they had fun. The playful, collaborative design was also able to help them gain a good insight into working with the BIM methodology and consolidate what they had learned in the long term.

In addition to the positive results of the study, the potential was revealed to make corresponding scenarios more effective in the future. For a digital working method such as BIM, a corresponding equipment of software and hardware is an absolute prerequisite in the learning context. If problems with software or hardware occurred during the events, the positive feedback from the participants decreased. Many training centres and universities have a lot of catching up to do in this area in order to prepare their trainees and students for working life.

Language barriers prevented even more successful results from the participants despite all digitisation. Although collaboration is largely based on technical systems, the simple factor of whether or not participants can talk about complex problems with their counterpart is still an issue that should not be neglected. For a common language on the subject of BIM across national borders, there is also a lack of standardization in the field of BIM. With their understanding of the methodology, each partner works in proprietary systems that inhibit collaborative work. The ISO 19650 standard indeed provides initial guidelines in the direction of standardization, but remains shallow and does not provide enough details to help in the daily work with BIM in the operative business.

4 Conclusion

The study conducted in the context of the BIM Game project shows that alternative learning methods are positively accepted and their application should be further pursued. The implementation of the collaborative working method within the learning phase ensures long-term learning outcomes.

The use of gamification motivates learners to deal with the subject matter more intensely and to get involved with the topic.

5 Suggestions on further research

Within the BIM Game a limited number of game design elements was used. The team was careful in using game design elements to avoid overloading the scenarios.

For future scenarios the use of additional game design elements would be useful, as well as an investigation of how the individual elements work. There has been little research on this so far.

Further information on the project can be found on www.bimgame.eu. The project was co-funded by the Erasmus+ Programme of the European Union.

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