

<sup>1</sup> Gregor  
Grunwald<sup>2</sup> Jan Yoshio  
Kawasaki<sup>3</sup> Tobias Hanke<sup>4</sup> Jonathan  
Eidam

## Robotic Process Automation to Increase Teaching Efficiency in Higher Education



**Abstract:** - Digitalization is advancing and changing our world, and with it the whole economy. Universities must meet this changing demand with new training offers. The AUFLADEN (Charging) project, funded by the Stiftung Innovation in der Hochschullehre, is developing new training formats for students involved in construction planning, predominantly students of architecture and civil engineering. One of the questions of the research project and the subject of this article is whether and how Robotic Process Automation (RPA) can be integrated into teaching as a learning tool to support students specifically and individually in learning software applications through automation. For this purpose, so-called self-learning knowledge Nuggets were developed. RPA makes it possible to have operating steps carried out computer-aided, a technology that is becoming popular to simplify recurring work processes. By slowing down this automation process, the user can study and imitate necessary steps. In a case study it is determined whether better learning results can be achieved by this training method. The results are that the learning speed increases and the teaching effort decreases. This encourages the use of automation technology to free teaching from method teaching and to use the precious teaching time for higher learning targets.

**Keywords:** education, robotic process automation, RPA, self-learning, UI-Path, building information modeling, BIM.

### I. INTRODUCTION

The push for digital transformation in the construction industry has been gaining momentum worldwide, as governments and private enterprises alike recognize the potential for increased efficiency and cost savings that can be achieved through the implementation of digital technologies. The shift towards digital planning has not only transformed the way buildings are designed and constructed, but has also opened up new opportunities for collaboration and innovation within the industry.

As a result, there is a growing need for education and training programs that can equip the next generation of construction professionals with the skills and knowledge required to navigate this new digital landscape. Universities are therefore taking up the challenge by developing innovative training programs, such as the BIM Game offered by the Jade University of Applied Sciences in Oldenburg, Germany.

The BIM Game provides participants with a unique and engaging way to learn about Building Information Modeling (BIM) and its application in digital planning. By simulating an architectural design competition, the game challenges interdisciplinary teams to work together to build more digitally and collaborate more effectively. Participants learn how to communicate on a 3D model, organize themselves and their design processes in a digital work platform, and acquire the basic digital planning skills needed to succeed in today's rapidly changing construction industry. Overall, the BIM Game represents an exciting new approach to education and training in the construction industry, one that is aligned with the growing demand for digital transformation and the need for professionals who are equipped to thrive in a rapidly changing technological landscape. As the industry continues to evolve, it is clear that innovative programs like the BIM Game will play an increasingly important role in shaping the future of construction and design.

#### A. BIM Nuggets

The BIM Nuggets developed for the BIM Game offer a comprehensive and interactive learning experience for participants. Designed to explain complex tools and processes, BIM Nuggets are self-learning formats that focus on specific topic areas. These Nuggets consist of various components, including video tutorials, click tutorials, exercises and sample solutions, and quiz questions.

The video tutorials provide an in-depth explanation of various BIM use cases, enriched with additional information and step-by-step instructions for implementing the corresponding software application. The mouse is superimposed schematically to record clicks required for the application, and keyboard shortcuts are also displayed. The workflow is explained via voice recording, making it easier for users to follow along. These video tutorials are designed to prepare users for the BIM Game by providing them with a solid foundation in the necessary skills and knowledge.

Click tutorials, on the other hand, are PDF-based reference works that provide learners with a condensed format of the required steps. These tutorials are particularly useful as a memory aid during the BIM Game, as they offer a quick and easy reference

<sup>1,2,3,4</sup> Jade University of Applied Sciences, German, <sup>[1]</sup>gregor.grunwald@jade-hs.de, <sup>[2]</sup>jan.kawasaki@jade-hs.de, <sup>[3]</sup>tobias.hanke@jade-hs.de, <sup>[4]</sup>jonathan.eidam@student.jade-hs.de

guide to help participants navigate the various tools and processes.

Exercises and sample solutions are also included in the BIM Nuggets, helping learners apply the knowledge they have acquired through self-study and test it before participating in the BIM Game. These exercises are designed to help participants master the most important applications and workflows, enabling them to perform better in the BIM Game.

Finally, questions are included in the BIM Nuggets to reflect on and consolidate what has been learned. These quizzes serve as a self-check and help participants evaluate their understanding of the material.

All of the BIM Nuggets are available digitally to participants for self-study and can be accessed at any time via a website (Fig.1). While primarily intended for the preparation and qualification of the BIM Game, the Nuggets can also be used as a reference and reminder during the game. Overall, the BIM Nuggets offer an effective and engaging way for participants to learn and apply the skills and knowledge needed to succeed in the modern construction industry.



Figure 1. project website– Source: own figure [1]

### B. Project funding

The creation of the training format with corresponding learning platform and content in the form of BIM Nuggets is a project funded by “Stiftung Innovation in der Hochschullehre” that run for a period of two years. The foundation's goal is to enable innovation in teaching and learning at universities. [2]. The funded project is called "AUFLADEN" (in English: Charging). An excerpt of the project description follows, read at [3].



Figure 2. Logo of the Foundation – source [2]

The journey into the digital future of construction requires ideas, time, courage and energy. The education and training laboratory for digital design and construction is the place to bundle energy and knowledge to participate in the digital transformation. The aim of the project is to create a suitable training concept for teaching BIM, the didactic preparation of the learning content and the scientific evaluation of the new concept. The knowledge gained from this should help to improve the university's teaching offer, promote the standardization of the teaching offer and provide impulses and suggestions throughout the university. The project is aimed at students of degree programs along the entire value chain of the construction and real estate industry, in particular prospective architects, civil engineers and specialist planners. The project serves to close the gap between beginners and advanced BIM users, to pick up students who are still seeking access to the topic, and to involve everyone in the digital transformation.

### C. Literature

There is a growing body of literature on the use of BIM games as a tool for teaching BIM skills. Sanchez et al. conducted a study to investigate the effectiveness of the BIM Game as a training tool, and found that it was an effective way to teach BIM skills [4]. Similarly, Alanne investigated the effects of the BIM Game on participant motivation and found that it was an successful tool for increasing participant motivation [5]. A study by Pütz et al. found that the BIM Game not only increased participant motivation, but also helped participants to improve their understanding of BIM and its application in practice [6]. These findings suggest that the BIM Game is a useful tool for teaching BIM skills, and can help to improve participant knowledge and motivation.

The BIM Game has been the focus of several interdisciplinary Erasmus+ projects. In one such project, which took place between 2015 and 2018, the BIM Game was organized as part of an Erasmus+ project [7]. This project aimed to promote the

use of BIM in higher education and professional practice and the BIM Game was used as a key tool for achieving this goal. Currently, the BIM Game is being further developed [8,9,10] and is implemented into the ongoing Erasmus+ project "Digital DECATHLON" [11].

The AUFLADEN project aims to develop innovative digital tools for teaching and learning. The project seeks to develop innovative digital tools that can enhance the learning experience and foster engagement among students, while also promoting the acquisition of essential skills and knowledge. The BIM Game is being used as a key component of this effort. Overall, the literature suggests that the gamification aspect of it is an effective tool for teaching BIM skills, and can help to improve participant motivation and understanding of BIM and its applications. With ongoing development and further research, the BIM Game has the potential to play an increasingly important role in BIM education and training.

#### D. Self-Learning Courses

T Sanchez et al. develops a methodology for the implementation of BIM and game engines for improving the online learning experience for construction design courses in higher education. They demonstrate "the positive perception from the students." [12]. Similarly, Sa Tsai et al. reported improved understanding of BIM modeling processes through the use of self-paced BIM learning courses [13]. In addition to these studies, Poirier et al. "directs towards a new concept of Classroom 4.0, which will act as a bridge between Industry 4.0 and Education 4.0—hence devising a conceptual model of the holistic learning educational ecosystem." [14]. This approach was found to be particularly effective for adult learners, who may have different learning needs and preferences than traditional students.

Overall, these studies suggest that self-learning courses and other digital teaching methods are effective for teaching BIM skills. By combining self-directed learning with virtual simulations and other interactive tools, students can gain a deeper understanding of BIM modeling processes and develop the skills needed to succeed in the field of civil engineering and construction. As such, self-learning courses and digital teaching methods are likely to play an increasingly important role in BIM education in the years to come.

## II. ROBOTIC PROCESS AUTOMATION

While there is a significant body of literature on the use of self-learning courses for a range of different educational software, there is currently little research specifically focused on creating self-study courses with UI-Path and the use of robots. However, UI-Path is a highly suitable tool for creating effective self-learning courses. For example, UI-Path is an intuitive and user-friendly software that is specifically designed to automate repetitive tasks. This makes it an ideal tool for creating step-by-step tutorials and interactive learning modules that can guide learners through complex software processes. In addition, UI-Path provides a range of built-in features and tools that are designed to support effective training and development, including detailed analytics and reporting capabilities that can be used to track learner progress and identify areas for improvement.

#### A. UI Path

UiPath is one of the leading software platforms for Robotic Process Automation (RPA), a popular tool that allows organizations to automate mundane and repetitive tasks (Fig.3). With UiPath, one can create software robots or "bots" that perform a range of tasks, including data entry, invoice processing, and customer service.

UiPath uses a visual drag-and-drop interface (Fig.4) that allows users to create automated workflows without needing to write code. The software also has a robust library of pre-built activities and connectors, making it easier to integrate with other systems and applications.

UiPath can be used in a variety of industries, including construction business, and manufacturing, to improve operational efficiency, reduce errors, and free up people to focus on higher-level tasks.

Overall, UiPath is a tool to streamline operations and increase productivity through process automation. The goal is to increase the efficiency of recurring work processes and to relieve people from routine tasks.



Figure 3. UI Path Logo – source: [15]

UiPath allows users to create software "robots" capable of performing a wide range of tasks automatically. These robots can extract data from Excel spreadsheets, insert it into databases, classify documents, and even answer emails automatically.

But UiPath's capabilities extend beyond these simple tasks, and it can also be used to automate processes in CAD programs and other software relevant to the BIM method.

To start recording a work process within a CAD application, users first need to download and install UiPath Studio. Once installed, they can begin the recording process to capture all mouse movements and keystrokes performed in the CAD

application. The recorded processes are then saved as a robot workflow file in the UiPath Studio software.

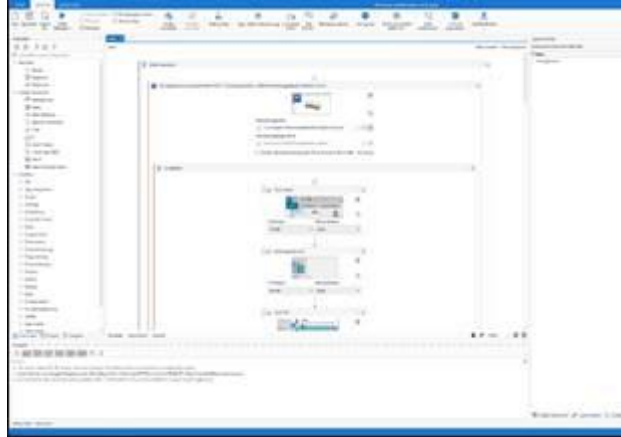


Fig.4 Classic structure of the UI Path user interface, with a menu bar at the top with all commands, on the left in the column a selection menu of all available process steps, a center Workspace with the currently edited process, Right: Properties panel. Bottom: Output information for feedback when the program is executed.

The robot workflow file can be uploaded to UiPath's Orchestrator platform, where the desired playback speed can be set. This allows the process to run slowly and traceably on the learner's computer, providing a step-by-step guide for following and viewing the process.

Overall, UiPath is a tool for automating work processes even in CAD applications and providing a way to record and playback these processes as instructions. As more organizations and educational institutions adopt UiPath for training and development programs, it is likely that we will see even greater applications of the software in the years to come.

#### *B. Use case: IFC Export*

Exporting IFC files from Revit program is a good example of how RPA automations can simplify complex processes. The IFC export feature in Revit is difficult to use as it navigates users through multiple menus, submenus and settings. With UiPath Studio, this process can be automated through simple interactions with the Revit program. The process is recorded and is therefore repeatable and, as described later, comprehensible for the user thanks to the possibility of playing the recording slowly and thus learning how to carry it out by watching the necessary work steps repeatedly.

Figure 5a shows how UI Path first selects the program to use and launches Revit and with three clicks automatically activates the IFC export function (Fig. 5b-d). All steps run directly on the learner's computer without his intervention being necessary as long as unattended bots are running. UiPath Studio also offers the possibility to program attended bots. These are designed to run on the user's screen and require real-time monitoring and user interaction. For example, in the case of exporting an IFC file from Revit, a attended bot can ask the user for the name of the file (Fig. 6), followed by a prompt for the file location (Fig. 7). In the case shown, the user can choose one of the three locations (Desktop, Documents, or Downloads) without having to browse the documents menu. The program saves the selection and incorporates the specification into the automation process, saving the user valuable time. Unattended bots can run in the background without user input, making them ideal for automating repetitive and time-consuming processes. In the context of exporting IFC files from Revit, an unattended bot can be programmed to run at a specific time or after a specific trigger. He can then export the IFC file without any user intervention and save it to a predetermined location.

From the above text, we can deduce that RPA tools like UI Path intervene and control the usage of software, thus providing an effective solution to automate repetitive and time-consuming processes. Especially in complex processes like exporting IFC files from Revit program, RPA tools can help users not only to simplify these processes and save time and resources but in addition to learn how to execute these processes. This is how the RPA tools help to create a machine-human learning process.

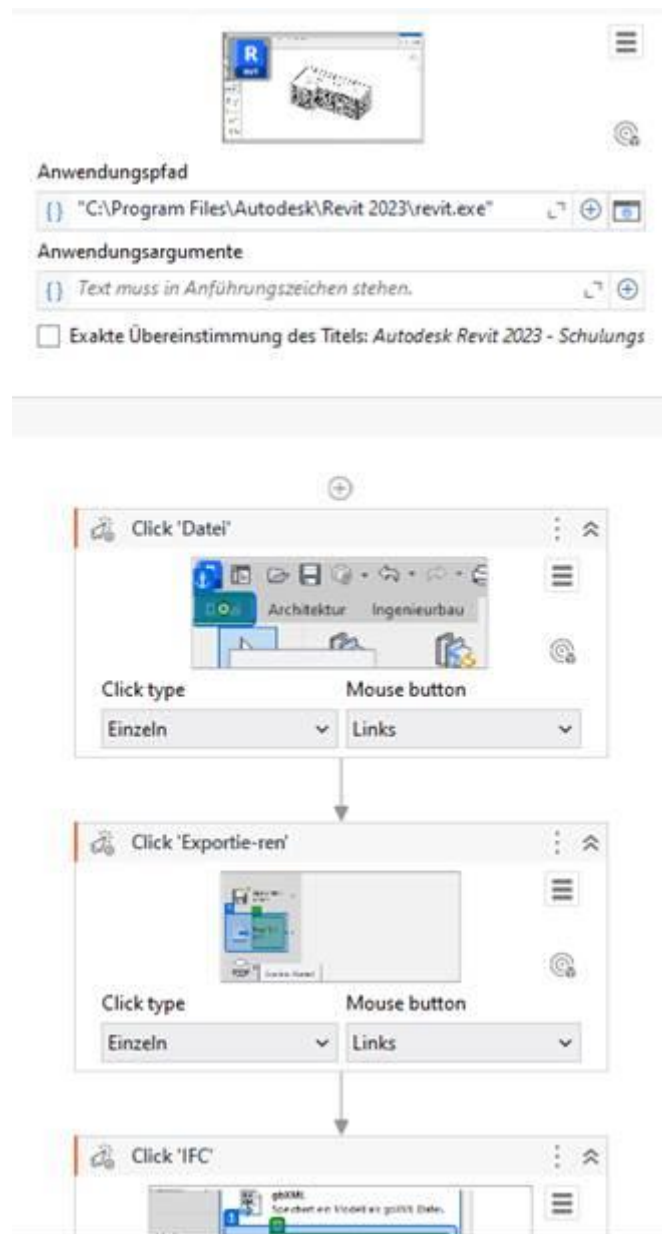


Fig.5a-d UI Path first selects and starts the program to be used and automatically starts the IFC export function by three clicks – source

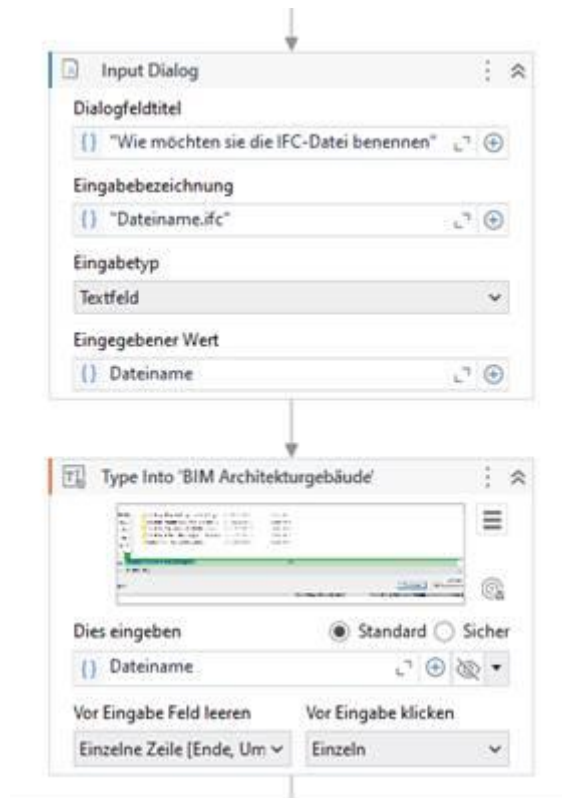


Fig.6 Query and prompt the user how to name the IFC file

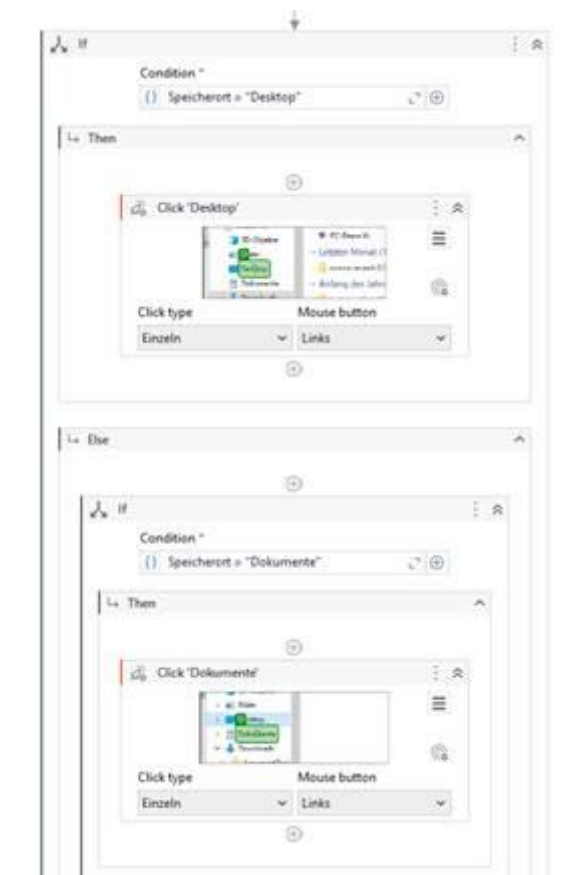


Fig.7 Case distinction when querying the storage location

### C. RPA as a learning tool

Now such automation, as described in the IFC export example above, can be used for more than just process execution. It is also possible to slow down the recorded process in order to be able to understand all the necessary steps. In this way, the recorded process becomes a tutorial for students trying to learn and run the program themselves. This is done by building a delay function into UI Path Studio. This slows down the processes. The delay function can be adapted to the learning speed of the students. It is also possible to display info boxes with further explanations and prompt the user to continue playing the next process steps. Optionally, a mouse and keyboard visualization is added to the recording, which is possible via broadcaster software such as OBS-Studio [x]. OBS is a free and open source program used for recording and live streaming videos. It is widely used to broadcast or record content.

It is important to understand that the execution of the recorded script is not only a guide, but that the application is actually running on your own computer. This means, in the case of IFC export, that the resulting IFC file is actually created and is physically present on the user's hard drive. This ensures that the work step works in any case and that a partial result (on which the further work steps may be based) is error-free. Regardless of whether the user understands the work process and can carry it out himself. For this purpose, however, good instructions have been created with the recording, which makes it easy for the user to study and try out the work steps in peace.

## III. DISCUSSION AND CONCLUSION

### A. Exchange of ideas

The use of RPA (Robotic Process Automation) and automation tools like UI Path Studio have revolutionized the way we approach complex and repetitive tasks. As discussed in the previous text, the automation of the IFC export process in Revit is a good example of how RPA can simplify and streamline complicated workflows.

One interesting aspect of RPA is the ability to use recorded processes as tutorials for learning how to use different software applications. By slowing down the recorded process and adding explanations and prompts, students and new users can easily learn how to carry out the task themselves, step-by-step. This approach can save time and effort, as it allows learners to acquire new skills more quickly and easily than traditional learning methods.

Moreover, the fact that the actual software application runs on the user's computer during the execution of the recorded script ensures that the resulting output is physically present and error-free. This means that even if the user is not completely familiar with the process, they can still produce reliable and accurate results.

However, there are also potential drawbacks to the use of RPA and automation tools. One main concern is that students relying too heavily on automation and become too dependent on the automated process without truly understanding the underlying concepts or steps involved. This can lead to a situation where students simply go through the motions of running the automation without actually learning anything new or gaining any real skills. In such cases, students may be able to generate the desired output, but they may not be able to troubleshoot issues or make modifications to the process when necessary. Therefore, it is important to strike a balance between using automation to simplify complex processes and ensuring that users still gain an understanding of the steps involved and can troubleshoot issues when necessary.

Another concern is the potential for errors or malfunctions in the automation process. Thus, it is important to ensure that the automation process is thoroughly tested and properly implemented to minimize the risk of errors or other negative outcomes. Overall, the use of RPA and automation tools like UI Path Studio has the potential to greatly improve learning especially as self-learning courses in higher education.

### B. Key findings

UiPath offers a powerful tool for automating work processes and creating effective training and development programs, with potential benefits for students dealing with construction planning such as civil engineering and architecture.

- Using UiPath to create learning tutorials can improve the efficiency of training.
- With robotics, the processes are not simply recorded, but all the steps are performed on the user's own computer
- concrete results are available after the process run, so that further work can be done with these files.
- The process can be repeated or run through more slowly for better understanding.
- Creating learning tutorials with UiPath can save time and reduce training costs.
- UiPath-based learning tutorials are more interactive and personalized than traditional training methods.
- UiPath-based learning tutorials can be used as reference tools.

The learning successes will be measurable as soon as the next BIM Game events are held.

### C. Conclusion

The results of the study show that using UiPath to create learning tutorials can be an effective way to improve training. In particular, processes can be recorded efficiently by performing all steps on one's own computer. As a result, concrete files can be available after the process run, which can be further processed. Furthermore, UiPath-based learning tutorials are more interactive and personalized than traditional training methods and are suitable as reference tools.

Overall, the results of this study, as well as other studies [16-23], provide motivation to increase the use of automation technologies such as RPA for training purposes. They are motivating and effective methods to improve training, increase its quality and connect the learning environment with current technologies.

## REFERENCES

- [1] <http://www.wissen-aufladen.de>, under construction
- [2] <https://stiftung-hochschullehre.de/>  
last accessed 2023/05/07
- [3] <https://stiftung-hochschullehre.de/projekt/AUFLADEN/>  
last accessed 2023/05/07
- [4] Sanchez, B., Ballinas-Gonzalez, R., & Rodriguez-Paz, M. X. (2022, March). BIM and game engines for engineering online learning. In *2022 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1467-1472). IEEE. Heins, C., Grunwald, G., Helmus, M. (2021) Gamification and BIM - The didactic guidance of decentralised interactions of a real-life BIM business game for higher education. ISARC 2021 Conference Paper, 38th International Symposium on Automation and Robotics in Construction, November 2021, DOI: 10.22260/ISARC2021/0126
- [5] Kari Alanne (2016) An overview of game-based learning in building services engineering education, *European Journal of Engineering Education*, 41:2, 204-219, DOI: 10.1080/03043797.2015.1056097
- [6] Pütz, C., Heins, C., Helmus, M., & Meins-Becker, A. (2020). Gamification and BIM: Teaching the BIM method through a gamified, collaborative approach. In *ISARC. Proceedings of the International Symposium on Automation and Robotics in Construction* (Vol. 37, pp. 272-277). IAARC Publications.
- [7] <https://epale.ec.europa.eu/en/content/bim-game-new-learning-method-better-cooperate-building-industry>, last accessed 2023/05/07
- [8] Heins, C., Grunwald, G., Helmus, M.: Gamification and BIM - The didactic guidance of decentralised interactions of a real-life BIM business game for higher education. ISARC 2021 Conference Paper, 38th International Symposium on Automation and Robotics in Construction, November 2021, DOI: 10.22260/ISARC2021/0126
- [9] Grunwald, G., Heins, C.: (2022) BIM Game: a testing ground for specifying, modeling, evaluating and visualising information in IFC formats. ICCEA 2022 Conference Paper, 5th International Conference on Civil Engineering and Architecture
- [10] Bhat, V., Grunwald, G., Hanke, T.: (2023) "Understanding BIM through a Simulation Game - Case study of Indian Students subjected to this course". ISARC 2023 Conference Paper, 40th International Symposium on Automation and Robotics in Construction
- [11] Website „digital Decathlon“, <https://www.jade-hs.de/unsere-hochschule/fachbereiche/architektur/forschung/digital-decathlon/>, last accessed 2023/05/07
- [12] Sanchez, B., Ballinas-Gonzalez, R., & Rodriguez-Paz, M. X. (2022, March). BIM and game engines for engineering online learning. In *2022 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1467-1472). IEEE.
- [13] Sa Tsai, M. H., Chen, K. L., & Chang, Y. L. (2019). Development of a project-based online course for BIM learning. *Sustainability*, 11(20), 5772.
- [14] Koul, S., & Nayar, B. (2021). The holistic learning educational ecosystem: A classroom 4.0 perspective. *Higher Education Quarterly*, 75(1), 98-112
- [15] UI-Path, <https://www.uipath.com/> last accessed 2023/05/07
- [16] Anagnoste, S. (2017, July). *Robotic Automation Process-The next major revolution in terms of back office operations improvement*. In *Proceedings of the International Conference on Business Excellence* (Vol. 11, No. 1, pp. 676-686).
- [17] Lasso-Rodríguez, G., & Gil-Herrera, R. (2019). Robotic Process Automation Applied To Education: a New Kind of Robot Teacher?. In *ICERI2019 Proceedings* (pp. 2531-2540). IATED.
- [18] Ferreira, N. F., & Machado, J. T. (2000). RobLib: an educational program for robotics. *IFAC Proceedings Volumes*, 33(27), 563-568.
- [19] Le Clair, C., UiPath, A. A., & Prism, B. (2018). The Forrester wave™: robotic process automation, Q2 2018. *Forrester Research*, 1-24.
- [20] M. Araneta and S. Kapoor, "Robotic Process Automation in Asia/Pacific Financial Services: Key Learnings from 10 Early Adopters," IDC Perspective, 2018
- [21] S. Müller, B. Bergande and P. Brune, "Robot Tutoring: On the Feasibility of Using Cognitive Systems as Tutors in Introductory Programming Education: A Teaching Experiment," in ECSEE'18 Proceedings of the 3rd European Conference of Software Engineering Education, Seon, Bavaria, 2018
- [22] C. Fernandez-Llamas, M. A. Conde, F. J. Rodríguez-Lera, F. J. Rodríguez-Sedano and F. García, "May I teach you? Students' behavior when lectured by robotic vs. human teachers," *Computers in Human Behavior*, vol. 80, pp. 460-469, 2018
- [23] Ivanov, S. H. (2016, June). Will robots substitute teachers?. In *12th International Conference "Modern science, business and education"* (pp. 27-29).