Using games and simulations to enhance learning

F. Drevland, *NTNU*

Abstract: In recent years, there has been a significant increase in the emphasis on student-centred active learning in higher education. One effective way to enhance student engagement is through the use of serious games. Unlike traditional games, which focus mainly on entertainment, serious games are designed to achieve educational objectives such as imparting knowledge, providing interactive training, and more.

This paper shares experiences of games and simulations to enhance learning in TBA4157, "Project-Based Production," a course taught in the third year of the integrated master's program in civil engineering at the Norwegian University of Science and Technology. It highlights the effectiveness of these tools in helping students understand core theoretical concepts and in fostering long-term knowledge retention.

The insights gained from conducting digital games during the COVID-19 pandemic underscored the superiority of physical, in-person games, despite the current trend toward digitalization. The paper examines the limitations of traditional lectures and advocates for integrating games and simulations as superior teaching tools, advocating for a shift toward more interactive and engaging methods in future course delivery.

1 INTRODUCTION

In recent years, there has been a significant increase in the focus on student active learning in higher education (Idsardi, 2020; Lombardi et al., 2021). Strategies to emphasize student engagement and participation. These strategies include problem-solving, case studies, discussion, think pair share, flipped classroom, role play, quizzes, gaming, group work, simulations, and writing exercises (Chan et al., 2015; Dieguez et al., 2020; DiYanni et al., 2020; Dogani, 2023; Gosavi & Arora, 2022; Kamenetskiy, 2020; Ubabuddin, 2020) They have been found to improve academic performance, critical thinking skills, and student motivation (Dogani, 2023; Gosavi & Arora, 2022; Ubabuddin, 2020) (Dogani 2023, Gosavi 2022, Ubabuddin 2020). Despite these positive outcomes, there are still barriers to the widespread adoption of active learning, such as faculty time constraints and student resistance (Eickholt et al., 2019). However, the benefits of active learning in enhancing student engagement and learning are widely recognized, and it continues to be a key focus in higher education.

One highly effective way to enhance student engagement is through the use of serious games. Unlike traditional games, the primary focus of serious games is not solely entertainment. Instead, they aim to achieve serious goals such as imparting knowledge, providing interactive training, and much more (Condino et al., 2022). This pedagogical approach fosters student engagement by bridging the gap between theoretical concepts and practical applications, making instructional content more relatable and applicable (Kim et al., 2023).

Serious games can span any genre, utilize any gaming technology, and be designed for any platform (Kankaanranta & Neittaanmäki, 2009). In this paper, I will share my experience using serious games and simulations in the course TBA4157, "Project-Based Production," taught in the third year of NTNU's five-year integrated master's program in Civil Engineering. These games are primarialy physical analogue games played in the classroom. However, the paper also covers my experience with using digital variants of these online during COVID-19.

I start the paper by providing the course's context and background, outlining the overarching idea behind the games. I then describe four examples of games used in the course and their pedagogical roles. Afterwards, I discuss the benefits and limitations of these games. Next, I explore strategies to foster student participation and tackle practical considerations for conducting these games. I then assess the advantages and disadvantages of separating lecture and game sessions versus combining them. After

this, I reflect on my experience with digital game sessions during COVID-19. Finally, I share my vision for the course's future and games' lasting role in its development.

2 LEAN GAMES

To understand the games used in the course *TBA4157 Project-Based Production*, it is necessary first to give some background about the field to which the course belongs. It falls broadly within the field of Construction Management. Construction management is an interdisciplinary field that draws from business, engineering, and architecture (Gunderson, 2012). Although not solely engineering-based, it can be considered a branch of civil engineering.

Grimson and Murphy (2015) state, "The art of engineering is in the appropriate selection of knowledge coupled with an ability to use that knowledge in achieving an objective." This aligns with typical dictionary definitions. The Oxford English Dictionary defines engineering as "the branch of science and technology concerned with the design, building and use of engines, machines and structures." A more general version of this would be to refer to systems rather than engines, machine engineers and structure. While other branches of civil engineering deal with technical systems, such as building structural systems, in the context of construction management, the focus is on projects such as production systems. In this context, "production systems" should be understood broadly. It is not only about the production of physical facilities but also about the production of facility designs.

Besides fitting within the umbrella of construction management, the course's main focus is lean construction—applying the lean production philosophy in the construction domain. I highlight this because there is a long and rich tradition of using games and simulations as teaching tools within lean and lean construction. I was myself introduced to this teaching approach by Professor Iris Tommelein at U.C. Berkeley when I spent a year there as an exchange student over 20 years ago. Several of the games I played back then I use in my own course today (for example, Tommelein et al., 1999). In addition to being common teaching tools for teaching lean in university settings, lean games also see significant use in the construction industry for training purposes.

Lean games are typically designed to simulate specific aspects or abstractions of production systems. They are generally played over multiple rounds, and the system design is adjusted to varying degrees between rounds. According to Rybkowski et al. (2021), this process is similar to "the type of controlled laboratory conditions that are usually found in the physical and biological sciences, where the impact of a single variable is tested and measured between rounds of play."

By experiencing the differences between various system designs, participants often have an "aha" moment that helps them grasp the underlying concepts. In the following section, I will explore this further by sharing examples of the games I use in class.

3 EXAMPLES OF GAMES PLAYED

3.1 Tennis ball game

One of the simplest games I use is the tennis ball game. Variants of this game are quite common in the lean community, although its origin is unclear. I use this game to introduce the concept of continuous improvement and Deming's Plan-Do-Check-Act (PDCA) cycle.

I divide the class into suitably sized groups of 5-10 students and have each group stand in a circle. I give one group member a tennis ball and instruct them to throw it to another group member in the circle. This process continues until the ball has been passed through all the group members. I then inform them that they have defined the process and we will measure it. I start the clock and time how long it takes for the ball to move through the entire chain. Afterwards, I ask the groups to discuss their performance and suggest improvements for the next round. This process is repeated for 2-3 more rounds.

In the first round of improvements, the group typically rearranges themselves in the circle to establish the correct sequence, instead of throwing the ball across the circle. In subsequent rounds, they make other minor tweaks, such as moving closer to one another. The whole exercise takes only about 15 minutes. Afterwards, I explain the concept of continuous improvement and the PDCA cycle using their experience as a reference before moving on to a second, slightly more advanced PDCA simulation.

3.2 Paper aeroplane standardization game

To teach students about the concept of standardization, I use a game I call the Paper Airplane Standardization Game, developed by Rybkowski and Kahler (2014). Each student receives a ruler and a sheet of paper. Once the clock starts, they have three minutes to create a paper aeroplane that is exactly seven inches long.

After the three minutes, I bring all the students out into the corridor outside of the classroom to throw their planes. We measure how far their planes fly and discuss the reasons behind the variations in distance. The students with the best-performing aeroplane then teach their designs to the others.

We then conduct another round using the standardized design. In the second round, the average distance flown is higher than in round one, and the standard deviation is lower. However, there is still considerable variation in the thrown distances. I use this to initiate a discussion about why there's still variation despite having a standardized design. The students typically identify these reasons: 1) Not being taught the standardized design well enough, 2) Different skill levels in paper folding, and 3) Significant impact of throwing technique.

From this, they understand the importance of training and the limitations of standardization based on worker skill levels. Additionally, the game serves as an introduction to lecturing on different types of standardization: standardized products, processes, and solutions.

3.3 Target Value Delivery game

Target Value Delivery (TVD) is a construction industry adaptation of Target Costing industry (Miron et al., 2015). TVD emphasizes guiding project delivery with cost and value considerations rather than assessing costs after the design is finalized (Zimina et al., 2012). In traditional projects, the owner commissions a building design based on specific requirements to fulfil a defined purpose, and costs are estimated only after the design is completed. Conversely, TVD establishes a target cost before the design process begins.

Target Value Delivery is an application of Target Costing in the construction industry (Miron et al., 2015). The main idea of TVD is to let cost and value drive the project delivery process, instead of estimating the cost after the design is finished (Zimina et al., 2012). That is, in a traditional project, the owner will commission a design of a building based on a set of requirements meant to fulfil a specific purpose. Only when the design is complete is the cost estimated. TVD works the other way around. A target cost is set before the design process starts.

To teach the students the fundamental principles of TVD, I use a TVD game developed by Rybkowski et al. (2016). The game is played over two rounds. The objective is to build a tower using a variety of available materials (spaghetti, straws, cocktail skewers, marshmallows, and tape). In the first round, the students are only told that "The Owner wishes to design and build a tower that is 2 feet tall (approx. 60 cm), that is capable of holding a marshmallow at the top, and that is no more than 2 inches out-of-plumb. The tower must be constructed with supplied materials and must be free-standing (i.e. cannot be taped to a table)", and are given frees access to use any of the available materials as they see fit.

In round one, students usually produce a tower similar to the one shown in Figure 1, which is typically sturdy but over-engineered. After round one, I reveal the cost of the materials used in their tower. Before the second round, we discuss setting a target cost using the Target Value Design (TVD) methodology, though the specifics are not crucial in the context of this paper. The main goal for round two is for the students to build the tower as inexpensively as possible while still meeting the requirements, often resulting in a very minimalistic tower that barely stands long enough for inspection, as shown in Figure 2.

In our subsequent discussion, some students typically point out that the exercises are unrealistic, arguing that a real-life project would never be built with such poor quality. I respond that this depends entirely on the needs and requirements of the client. If someone wants a tent for a weekend garden party, you would not build them a concrete bunker that could withstand a nuclear bomb. Furthermore, nothing in the design brief said anything about quality.

Beyond teaching the fundamental concepts of Target Value Design (TVD), the game also emphasizes the importance of always considering the client's needs and requirements. It emphasizes the critical role of understanding costs, be they monetary or environmental (like greenhouse gas emissions), in making well-informed decisions. Additionally, it demonstrates how having cost targets and insight into construction costs can significantly influence designers' decision-making processes. This insight naturally leads to discussions about strategies for ensuring this knowledge is readily accessible in projects, such as through early contractor involvement.

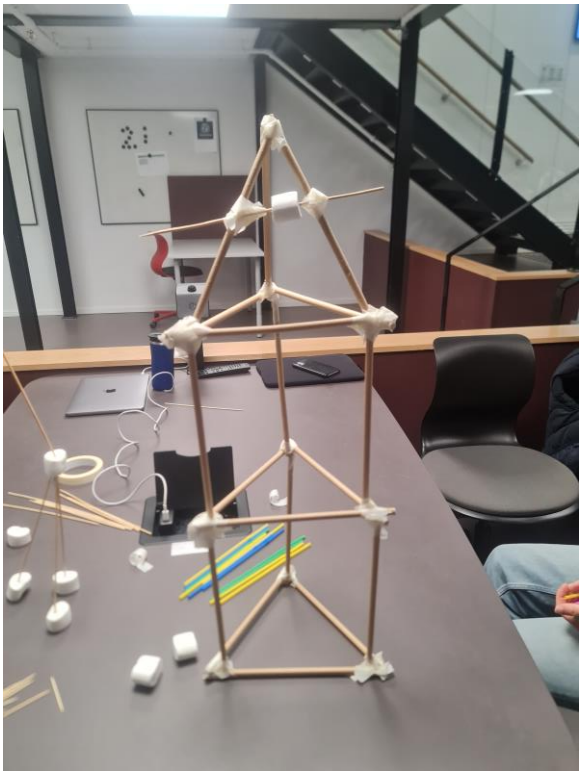

Figure 1 Example of round 1 tower

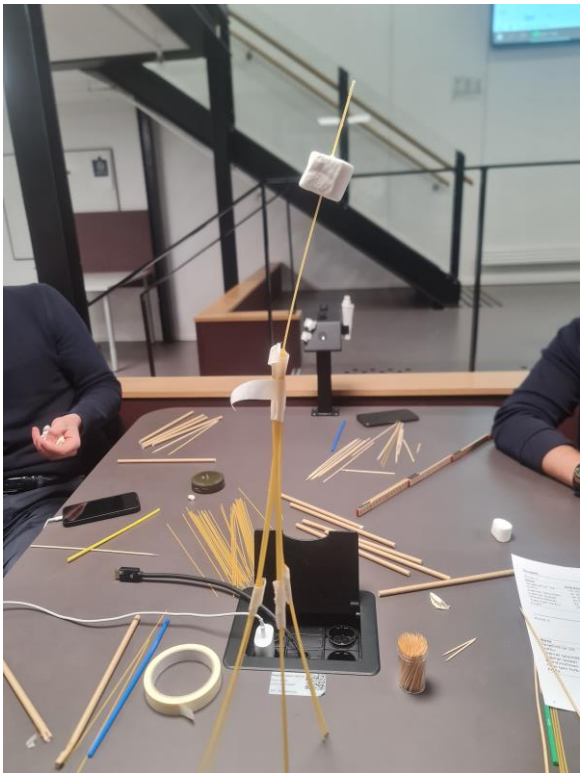

Figure 2 Example of round 2 tower

3.4 Villego

Villego is a simulation meant to teach the Last Planner System (LPS), a production planning and control methodology that is very common in the construction industry.The simulation is based on teams of 6-14 participants constructing Lego buildings, with the particpants divided into different roles. (Project manager, trade contractors and data collectors). (Warcup & Reeve, 2014). The simulation has two rounds. The first round relies on a traditional planning and control approach, and the second round uses LPS methodology.

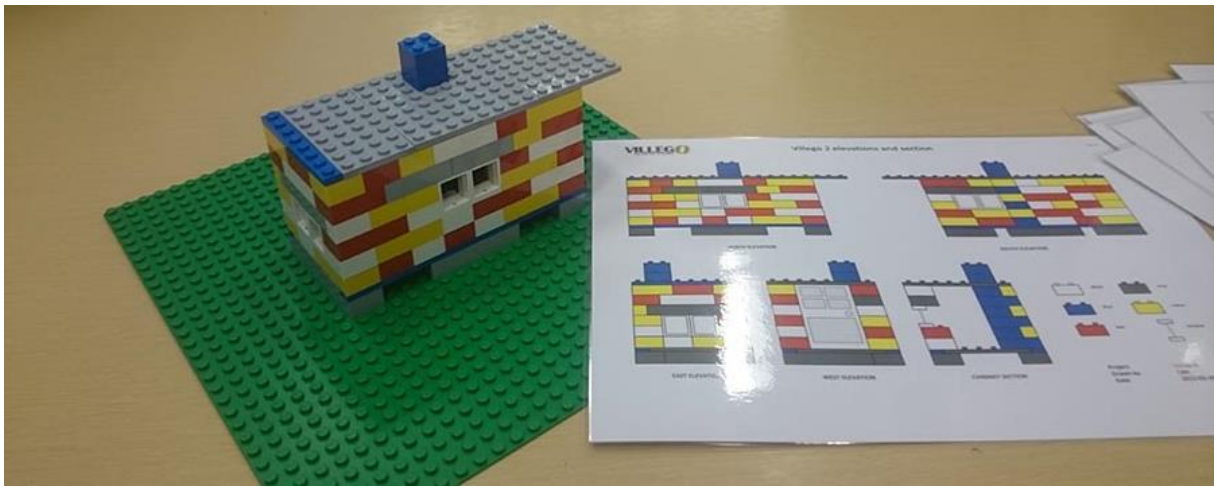

Figure 3 Lego Villa

In both rounds, the objective is to construct a Lego villa as quickly as possible, with the nominal schedule set at 10 minutes. Within the simulation, 10 seconds equals one workday, and one minute represents a six-day workweek. The construction site consists of a green Lego baseplate alongside a marked-off area on the floor where students stand while building. Only the students in the trade contractors areroles allowed to participate in the actual building of the villa, and they can only place bricks of their assigned colour. Additionally, no more than two people are allowed on the site simultaneously.

Before round one, the students have approximately 20 minutes to plan their work however they choose. The clock then starts, and the construction begins. During this phase, a gong sounds every 10 seconds (each simulated workday), signalling the data collectors to record the workers on-site. This data is used to calculate labour costs and note material waste and safety violations, such as more than two people on-site or not wearing a hard hat (cap).

In round one, students typically use more than meetings, double the nominal time allotment. Once the costs are calculated, it becomes clear that everyone has lost money. We then discuss why things went wrong, and I provide additional observations, such as people being on-site without clear tasks. Students often mention feeling that the process was chaotic and lacked transparency,, and that they had no real idea what they should be doing and when.

Round two introduces the LPS (techniques of pull-planning and weekly work planning. Pull-planning involves starting with the final task, such as placing the chimney on the roof, and working backwards to plan the preceding tasks. The students use colour-coded post-its on the wall, each colour representing a different trade contractor. They note the task details on the post-its, including what to build, on which level, and the required bricks. Once satisfied with the task sequence and timing, I start the clock for round two.

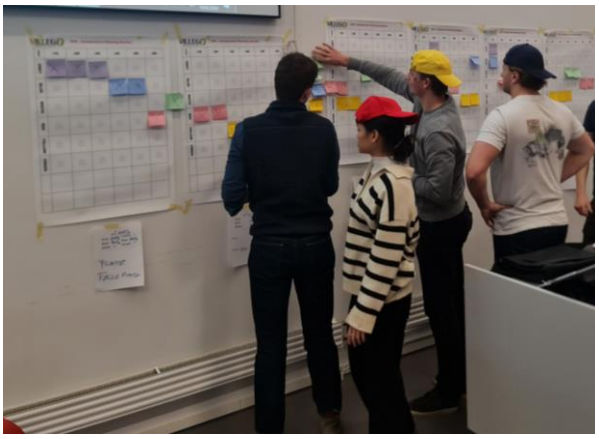

Figure 4 Pull planning

Figure 4 Construction in progress

A key difference in round two is that the clock does not run continuously. Instead, it stops after each minute (one simulated work week) for a weekly work planning meeting. In these meetings, students calculate the Percent Plan Complete (PPC)—the percentage of tasks planned for the week that were fully completed. If the PPC is less than 100%, students discuss the reasons and devise improvement actions. They then adjust their plans for the upcoming week as needed, based on incomplete tasks from the previous week, tasks already completed ahead of schedule, or adjustments for overly ambitious or conservative planning.

This cycle of building and weekly work planning continues until the project is completed, which is always significantly faster than in round one. Most groups finish building in around five minutes, though some have completed it in just over three minutes.

Afterwards, we engage in a discussion to reflect on the students' experiences, contrasting both rounds of the game. We also discuss how well the simulation mirrors a real-life construction project, highlighting the differences and similarities.

4 BENEFITS AND LIMITATIONS

There are several reasons why I choose to use these games. One reason is that I believe in student-active learning in general. Perhaps the most significant is that, based on my experience, they are excellent at facilitating long-term knowledge retention. This insight comes not only from my own experience of playing such games at Berkeley at the start of the millennium but also from feedback given by my former students. When I meet them years after graduation, they often highlight these games as being particularly memorable and impactful. In other words, these games have been effective in ensuring the long-term retention of core concepts, enabling students to internalize them rather than just memorize them for exams.

I believe there are several reasons why this is the case. Firstly, the games offer multichannel learning, which involves using different media to enhance learning (Mukhopadhyay, 2001), often incorporating audio, visual, and tactile modalities (Fadeev, 2021). Another reason the games are so helpful is that they are concrete and provide anchor points for learning. The students in my class typically have little or no practical experience in construction projects, so much of the course content can feel abstract and hard to relate to.

While I've found success using other strategies to provide anchor points, like sharing stories and examples from the construction industry, nothing compares to the physical experience these games provide in solidifying students' understanding of key concepts and principles. The hands-on experience brings theoretical concepts to life in a way that other teaching methods cannot match.

However, it is important to note that games are excellent for some purposes but are not equally effective for others. Rybkowski et al. (2021) compared lean games to lab experiments, where one variable is adjusted each round to observe the impact. In my experience, this approach works well for teaching concepts and principles but is less effective for teaching specific tools or methods like the Last Planner System (LPS).

Although Villego is intended as an LPS simulation and is the most complex and time-consuming game I run, requiring a full four-hour session, it still doesn't fully capture all aspects of LPS. To provide students with a more comprehensive understanding of LPS, I now have them use the system to plan their own work throughout the semester, as detailed in Drevland (2022). I have adopted a similar approach when teaching other tools and methods rather than concepts and principles.

5 GETTING THE STUDENTS TO SHOW UP

I have been successfully using these kinds of games for 15 years. However, starting around 2016, I noticed a decline in student participation in these sessions. While some of this could be attributed to scheduling conflicts with other courses, it mostly appeared that students did not find the games sufficiently relevant to exams. This lack of attendance troubled me. I can understand students choosing to read the course material rather than attend my lectures, but there is no substitute for the experience of playing these games.

Recognizing the value of these sessions for students' learning and long-term knowledge retention, I knew I had to do something to incentivize attendance. At the time, the course relied on a traditional exam that accounted for 100% of the final grade. Initially, I tried incorporating exam questions related to the games played in class, but this did not yield satisfactory results.

After further reflection, I realized the course focused too much on rote memorization and regurgitation. I decided to overhaul the assignments and evaluation scheme, shifting from individual memorization to having student groups apply knowledge in realistic scenarios and ultimately ending with a portfolio assessment. The full scope of these changes is beyond this paper (some aspects are documented in (Drevland, 2022). However, regarding the games and simulations, I made attendance of at least four out of seven workshops mandatory and required students to write a one-page reflection note after each workshop. These reflections are included in the final portfolio assessments, accounting for 40% of the final grade.

This approach has been effective. It has not only motivated students to show up but also encouraged them to actively reflect on what they are observing and experiencing during the sessions.

6 PRACTICAL CONSIDERATIONS

While I find these games to be excellent teaching tools, their feasibility is limited by some practical constraints:

6.1 Room Attributes

To run these games effectively, a suitable room is essential. Some individually-centred games, like the paper aeroplane standardization game, can be managed in traditional lecture halls. However, most games I conduct require small groups around tables. For classes smaller than 40 students, my university has many flat lecture rooms with movable tables and chairs that are suitable. For larger classes, I depend on getting one of the few lecture halls designed for active learning. Fortunately, I have been able to secure such rooms when requested, but I still feel anxious around the semesterly room allocation announcements. Failing to secure a suitable room would undermine my entire teaching approach..

5.2 Facilitator Capacity

All the games I run require some level of facilitation, including dividing the class into groups, distributing materials, explaining rules, ensuring adherence to those rules during play, and facilitating discussions between rounds. The number of facilitators needed depends on the game, but typically, I can manage a maximum of 25-30 students on my own. For larger classes, the course's student assistants help with facilitation.

6.2 Available Equipment

Many games have minimal equipment needs. For instance, the tennis ball game only requires cheap tennis balls, and the paper aeroplane games need blank sheets, printed rulers, and a measuring tape. However, some games, particularly those based on LEGO, can be expensive. For example, Villego is a commercial product, and each kit, serving 7-14 students, costs €1,400. I currently have two kits, allowing me to run a maximum of 28 students through the simulation at once. Therefore, even with sufficient room and facilitators to run parallel simulations, I am limited by the equipment. This necessitates conducting at least two Villego sessions each time the course is taught. Since each Villego session lasts 4 hours, extra sessions add significant extra time consumption and create a challenge in scheduling the course.

7 COMBINING LECTURES AND GAMES

Over the years, I have debated whether to separate lectures and gaming sessions or to combine them. A combined approach involves giving a short lecture, running the games (possibly interspersed with brief lectures between rounds), and then wrapping up with more lecturing.

I have concluded that the combined approach is better. It makes the lectures less monotonous for students; instead of listening to me for two 45-minute sessions, they get to engage in activities. Also, closely linking lecture material to the tactile experiences gained from the games enhances their learning

and retention. This is especially beneficial for students who do not regularly attend lectures. While they could read the course literature instead, many tend to skip that, so getting them to attend these sessions would significantly improve their learning.

Despite considering the combined approach superior, practical constraints often lead me to separate lectures and gaming sessions. Some games, like Villego, take too long for this approach to be feasible. Although it would work in a continuing education setting as part of a full-day event, it's difficult to fit it into a regular university course. Getting a four-hour block for the simulation is challenging enough.

Another constraint is room allocation. Half of my class hours are in traditional lecture halls unsuitable for games, so I have to stick to lectures for those sessions to maintain a feasible class schedule.

8 RUNNING GAMES THE DIGITAL DOMAIN

On March 11, 2020, the World Health Organization officially recognized COVID-19 as a global pandemic (Rybkowski et al., 2021). By that point, the virus had spread to more than 110 countries. Within weeks, universities and businesses around the world transitioned to online or hybrid formats, primarily facilitated by digital platforms like Zoom and Microsoft Teams. Lean Construction educators and consultants around the globe found themselves with a bit of a conundrum: How to run games and simulations online.

One of these was a German lean construction consultant, Annett Schöttle, who reached to me and 20 other experienced lean simulation users in the global lean construction community, asking how we could find a way to run simulations when everything was online (A. Schöttle, personal communication, March 2020). Zofia Rybkowksi at Texas A&M University stepped up and organized what would become a weekly global online lean simulation testing group named APLSO (Administering and Playing Lean Simulations Online). APLSO aimed to create a safe space for testing interactive online simulations so lean educators could maintain high-quality instruction despite social distancing (Rybkowski et al., 2021).

Through my involvement with the APLSO group, I gained enough knowledge and insights to either adapt or replace many of the games I use in class into a digital format for the fall semester of 2021. The experience from that semester was mixed. While running such games online is possible, there are significant challenges and drawbacks, which I will delve into further in the following sections.

8.1 Format

The game sessions, like regular lectures, were conducted through Zoom. After explaining the game, the students were divided into groups and sent to Zoom breakout rooms, returning between rounds and at the end for plenary discussions. Zoom was the primary communication platform for both plenary sessions and group interactions. However, a different platform was needed to host the game content and serve as the game boards.

In the APSLO group, we experimented with different types of software to use as game boards. A key insight was that using unfamiliar software could lead to much time wasted learning the interface. Physical post-it notes require no instructions, but digital equivalents in unfamiliar software often do. Ultimately, we found that Google Slides worked best as a simulation tool. Its user interface is familiar to most people, and it allows several groups to be hosted in one slide deck, with each group having its own slides and a common set for reporting results.

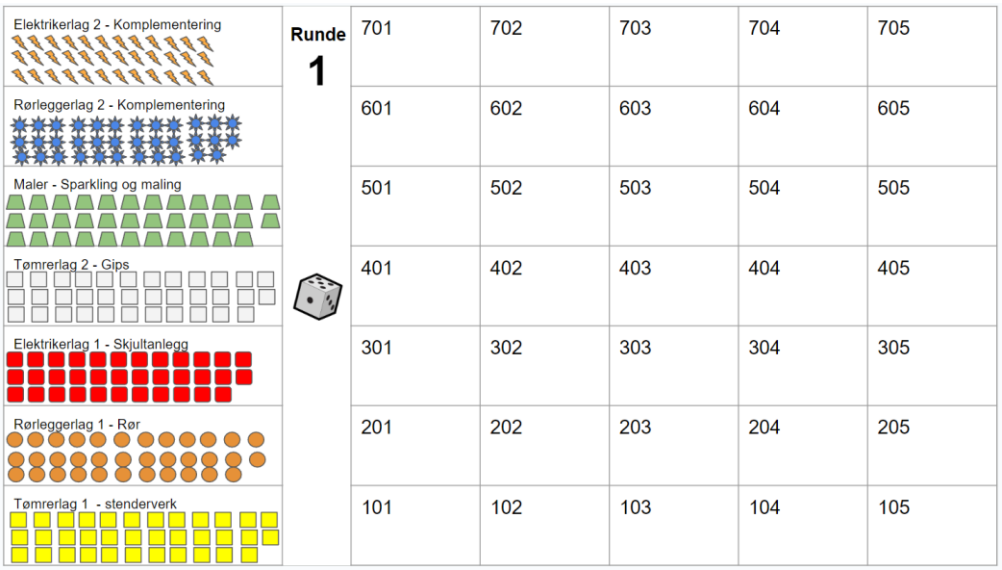

Figure 6 Example of game board in Google Slides

8.2 Facilitation

Facilitating the online versions of the games was much more challenging than their physical counterparts. In a classroom setting, I can easily oversee 5-6 groups at once, while online, managing three was challenging. While I could observe the state of all the groups' game boards in the shared Google Slides deck, I had to enter their Zoom breakout rooms and listen in to understand what each group was doing. In contrast, in a classroom setting, I can easily spot issues by glancing across all the groups and listening to their background conversations.

8.3 Time consumption

The class time required for an online game was greater than for its physical counterpart, primarily due to technical issues. Challenges include setting up and navigating Zoom breakout rooms, explaining and understanding the user interface, dealing with microphone and speaker issues, and managing connectivity problems. These factors significantly increase the time consumption compared to physical games.

8.4 Loss of tactile experience

One of the significant advantages of games and simulations is their ability to enable multichannel learning. However, the tactile experience offered by digital games is notably less impactful than that of their physical counterparts. Clicking a mouse to build a virtual spaghetti tower can't compare to the hands-on experience of manipulating spaghetti and other materials to build a real one.

8.5 Intra-group communication

During the COVID years, many people found that online meetings worked well, especially when there were only two or three participants. Larger meetings also worked but required a chair to manage the flow of conversation and decide who speaks when. In physical settings, it's easier to have a more relaxed approach since people can follow multiple conversations and focus on one sound source at a time. This is not the case in virtual settings, which creates problems for certain games, particularly those involving multiple conversations simultaneously.

For example, during a Villego simulation, there are typically 5-10 conversations happening at once within a group. Even if we could virtually simulate the physical aspect of Villego's brick-building, the communication challenges would make a virtual version of the game unworkable.

8.6 Pacification

I rarely, if ever, see students become completely passive when participating in physical games, meaning they sit and do nothing. However, I did notice this in the digital version for various reasons. One reason

is that sitting in front of a computer and clicking is inherently more passive than physically moving around in a 3D space, even if it's just to move a piece on a game board.

Another issue is related to intra-group communication. In some cases, there were groups where 2-3 very active members dominated, consuming all the available communication bandwidth. Other group members would then just sit back, not even trying to break into the conversation.

The game's user interface can also cause passivity. In the APLSO group, I noticed participants resigning themselves to a passive role after struggling to comprehend the user interface.

Lastly, the allure of alternative content is also a factor. If students don't get hooked into participating or feel unable to engage actively, it's very easy for them to browse various online media while nominally attending the game.

9 GOING FORWARD

As mentioned before, I completely revamped the assignment and assessment scheme in TBA4157 Project-Based Production a few years ago. At the time of writing this paper, I am finishing up on the third implementation, and I have been reflecting on how to improve it further.

The course currently has three major pedagogical components: traditional lectures, group assignments that use various lean tools and methods on realistic cases, and games and simulations (like those discussed in this paper) with accompanying reflection notes.

Overall, I am satisfied with both the group exercises and the games. While some adjustments and improvements are necessary, they generally work as intended and are well-received by the students. However, the lectures are a different story. Going forward, I plan to phase them out gradually. Traditional lectures seem to have outlived their usefulness, and I have observed a steep decline in student attendance over the past decade, as have my colleagues. Around one-third of students would skip class a decade ago, but now, having one-third show up is considered a good day. Discussions with students reveal various reasons, most linked to a more utilitarian approach where they attend only if necessary to complete assignments and pass exams.

This utilitarianism seems to have multiple causes. While some students appear to care only about earning a degree rather than genuinely learning, most seem compelled to prioritize differently. Student loans and stipends do not stretch as far as they used to, so more students have part-time jobs. Moreover, the increased focus on active learning has led to more assignments and projects throughout the semester, prompting many students to skip lectures to work on these tasks.

Another reason I have lost faith in traditional lectures is the changing nature of student brains. Generation Z students have brain structures that differ from previous generations due to constant exposure to intricate visual stimuli (Cervi, 2021). Their visual cortex is more developed, making them more responsive to visual learning. However, they also have shorter attention spans, making them more prone to boredom. This means they get bored quickly, and long lectures are unsuitable. Although the lectures can be enhanced with active elements like quizzes, I think it's better to do away with them entirely.

My approach will be two-fold. First, I plan to break down each lecture into small pieces, creating bite-sized videos. Second, I intend to introduce more games and incorporate previously lectured content into the game sessions.

This will be a partially flipped classroom approach. The theoretical side will still be taught in the classroom but will be integrated with games. Students will have videos covering the same content available as a backup. For the practical side, involving tools and methods, the main learning approach will be through practice—using the tools and methods in group assignments, with videos available on-demand to explain these.

10 CONCLUSION

In this paper, I've shared my experiences using games and simulations to enhance learning in the course TBA4157 Project-Based Production, taught to third-year students in the integrated master's program in civil engineering at the Norwegian University of Science and Technology.

Over the years, I've found great success in using games and simulations, particularly in helping students grasp the fundamental theoretical principles and concepts covered in the course. Moreover, these tools have proven outstanding in ensuring long-term knowledge retention.

While digitalization is a hot topic today, my experience running games online during COVID clearly showed that physical and in-person games are far superior. Perhaps, in the future, we will be able to bridge this gap, but the technology is not yet there.

Looking ahead, I plan to phase out traditional lectures and introduce more games and simulations. I believe these are far superior teaching tools compared to traditional lectures.

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