Lessons Learned 3, 1 (2023)
Submitted: 01.12.2022
Accepted: 23.12.2022
DOI: https://doi.org/10.25369/ll.v3i1.70
ISSN: 2749-1293 (print); 2749-1307 (online).

Gamification of Science

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Abstract

Digital development and the greater spread of social media with, among other things, special academic channels are leading to a change in students' expectations of teaching. At the same time, the requirements for graduates are changing towards interdisciplinary knowledge. The goal of the learning project to be implemented is to combine the previous individual formats with the application of a type of business game in order to strengthen interaction as well as attendance participation in this way. This makes it possible to link theoretical knowledge directly with practical components and thus to illuminate energy technology issues from different points of view. Elements of gamification are used to create a motivating learning situation for the students, which promotes a high level of interaction. The first implementation takes place in the context of the lecture "Analysis of complex energy systems", in which a building model is to be created and the heating system is to be designed.

Die digitale Entwicklung und die stärkere Verbreitung von sozialen Medien mit u. a. speziellen wissenschaftlichen Kanälen führt zu einem Wandel der Erwartungshaltung der Studierenden an das Thema Lehre. Gleichzeitig wandeln sich die Anforderungen an die Absolventen hin zu einem fachübergreifenden Wissen. Ziel des umzusetzenden Lernprojektes ist es, die bisherigen Einzelformate mit der Anwendung einer Art Planspiels zu kombinieren, um auf diese Weise die Interaktion sowie die Präsenzteilnahme zu stärken. Dies ermöglicht, die theoretischen Erkenntnisse direkt mit praktischen Komponenten zu koppeln und somit energietechnische Fragstellungen aus verschiedenen Standpunkten zu beleuchten. Durch Elemente der Gamification wird hierbei für die Studierenden eine motivierende Lernsituation hergestellt, welche eine hohe Interaktion fördert. Die erste Umsetzung erfolgt im Rahmen der Vorlesung „Analyseverfahren von komplexen Energiesystemen“, indem ein Gebäudemodell erstellt und die Heizungsanlage ausgelegt werden soll.

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This article was originally submitted in German.

1. Background and idea

Up to now, topic-specific knowledge has been imparted via the familiar formats of lecture, seminar and practical courses. Depending on the subject area, these are coordinated with each other - in each case related to a focus - with a defined interaction between students and teachers.
Through the aspect of gamification, this previous stationary process is to be broken up and the students are to be directly involved in the transfer of knowledge in the form of a business game, enabling participation in courses hybrid, in presence and online. Especially in the field of energy technology with the question of a future CO_2 -neutral and resilient supply, holistic and partly controversial points of view and approaches must be considered with the theoretical foundations and new developments and combined in teaching. The question raised by this example cannot be answered from a technical point of view alone, but must be seen in a holistic context, since there is considerable tension between climate protection, reliable energy supply, acceptance of technology and economic issues.

2. Aim of the teaching project

The goal is to develop a gamified learning environment for the development of "Cellular Energy Systems", which links the aspects of electrical engineering and thermal power engineering. For this purpose, it is planned to embed the game to be developed in realistic, authentic scenarios and to integrate these - moderated by qualified (tele-)tutors from the environment of the TUD - into various courses or teaching modules. Here it is necessary to test didactics, understanding and handling of a game for methodical knowledge transfer (principle: train the trainer). In the course "Analysis methods of complex energy systems", elements of gamification are integrated into the existing concept within the framework of the seminar. The aim here is to create a motivating and challenging competitive situation between the students in connection with the processing of a holistic task over several seminars. For this purpose, ecological as well as economic evaluation indicators and rules of the game (e.g. compliance with the comfort level in the buildings) are used in order to make the different solutions of the students comparable. The task is directly related to a part of the lecture, in which several technically relevant questions are to be answered. Fig. 1 shows an example of the graphical user interface of the previous RVK simulator game, which was developed in the context of a research project on the "Regional Virtual Power Plant (RVK)" [1]. It thus represents the preliminary stage of a cellular energy system. In this game, the user can control the respective purple cells. Each cell represents a building with thermal buffer storage and a combined heat and power plant. Several of these cells can be virtually connected to form a larger cell. Finally, all purple cells are bundled in a central station, which is exemplarily shown as a power plant in the picture. The goal of the game is to achieve the highest possible revenue with the virtual power plant over the course of a day. Among other things, the electricity price, electricity consumption and thermal consumption in the building are taken into account (diagram in the picture). By "switching on and off" the respective purple cells, the user can influence the course of the game and thus the revenue.

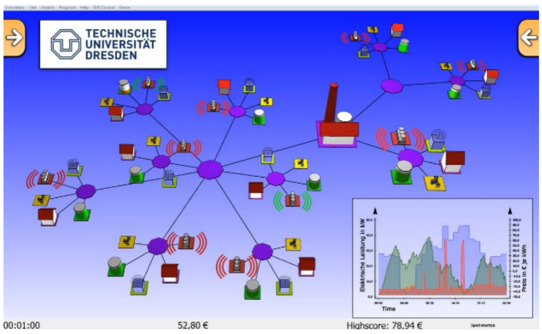

Fig. 1: Illustration of the predecessor game "RVK Simulator" [1, 2].

3. Practical implementation

The first implementation is carried out on the example of the holistic consideration and design of a heating system in a residential building (as the smallest energetic cell) in the context of the lecture "Analysis methods of complex energy systems". The idea is presented below.
For the consideration of a cellular energy system it is necessary at the beginning to consider

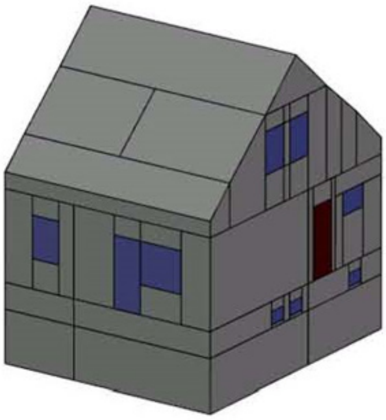

Fig. 2: Representation of the building model

the different levels of detail separately. This means that in the first step a single building is considered as the smallest unit of a cellular system.
This includes the building cubature as well as the installed generation system (heating and air conditioning), which is adapted to the respective building.
In the second step, several buildings are then combined to form a district. It is also possible for several buildings to be supplied with energy together as a district solution. In a third step, several quarters are then combined to form a holistic energy system.
Thus, the holistic goal would be a resilient energy supply of all energetic cells among each other. This means that the energy supply is characterized by a high degree of resilience in that many different small controllable generation and consumption plants take over the energy supply as a network and the individual energy cells thus secure each other with the exchange of energy. Since this task is very extensive and complex in its entirety, subtasks have been developed from it. These subtasks are revised during the semester according to the playful approach, so that the theoretical basics can be applied directly to a practical example. In this context, playful means that points are awarded for subtasks and that the students can determine the respective evaluation focus before starting the subtask. This can be, for example, low operating costs, high efficiency or a high regenerative share of the building's energy supply. In this way, a different focus (within specified limits) can be placed in each seminar.

As described, the first implementation of the concept is carried out on the smallest unit of a cellular energy system, a residential building. For this purpose, the building and system simulation tool TRNSYS-TUD [3] developed at the professorship is used.

The following tasks must be completed by the students:

- Creation of a building model (see Fig. 2)
- Carrying out a heat demand calculation
- Creation of a model of the heating system (heat distribution and transfer, see Fig. 3).
- Creation of different heat generator models
- Scenario investigation by means of building and system simulation

The building model, which has the same boundary conditions for all participants, is based on predefined construction plans, wall structures and user behavior. With the heating system, in turn, the variable implementation begins through different options for heat generation and transfer, such as:

- Underfloor heating or radiator
- Air-source heat pump, ground-source heat pump or gas boiler
- Solar thermal
- Buffer storage volume
- Type of domestic hot water production
- Type of regulation

With these variations, students can test up to five scenarios using an annual simulation.
The task can be supplemented with additional components of economic efficiency, the use of renewable energies or specific questions from other teaching areas. Essentially, the area of electrical energy supply should be mentioned here, which has a decisive influence in the context of a holistic energy supply using sector coupling. Questions in this context are therefore, for example, whether the building within a cellular energy system will represent a pure consumer or a producer in terms of energy in the future. In this way, the task will be constantly expanded.

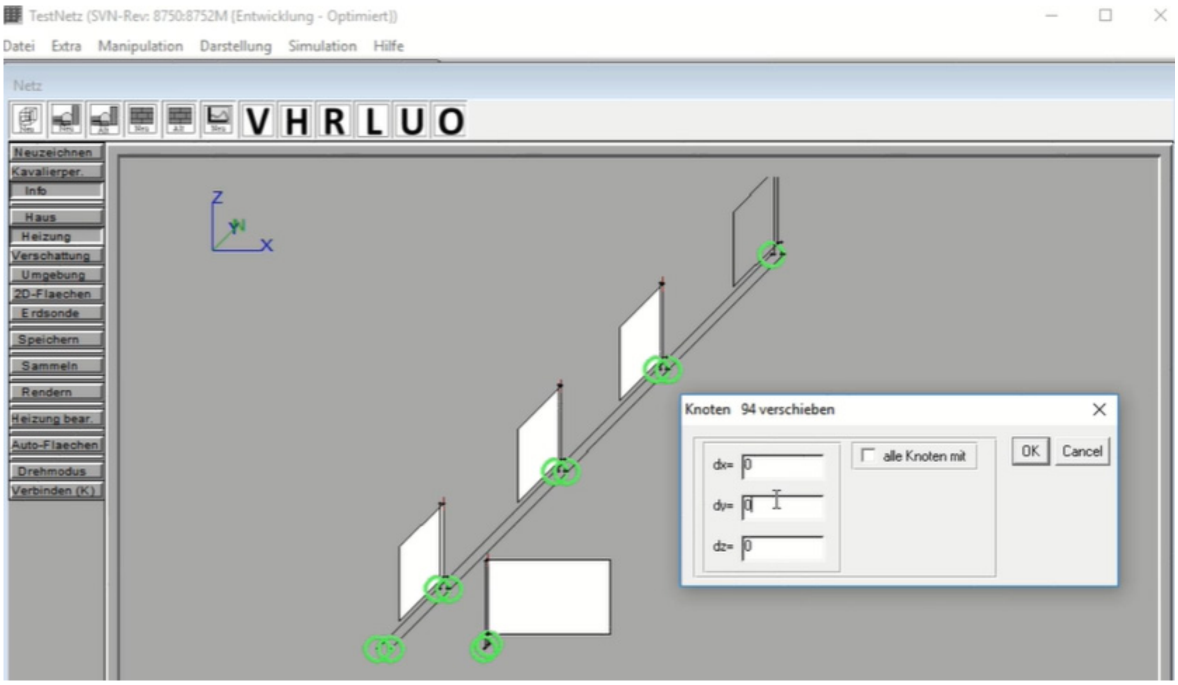

Fig. 3: Interactive editing of subcomponents (simulation model of the heating network) using the example of the placement and dimensioning of radiators.

4. Evaluation within the game/seminar

Within the framework of the seminar in connection with the lecture, the paths on the way to different answer options are given in a structured way (depending on the task focus and teaching module combination). During the processing, support is offered by the lecturers, which means that complete failure is not possible. Rather, the result quantifies how well different goals were achieved. In this way, several winners can also be determined.

The main evaluation of the task presented here is based on two main parameters. These are the annual heat consumption of the building and the maintenance of room temperatures during the time of use. Further evaluation criteria used are the primary energy demand and the economic efficiency with a simplified calculation of the costs for installation and operation of the system.

In this way, different solution approaches and concepts can also lead to winning the task with regard to the use of regenerative energies. The weighting of the individual factors can be determined jointly by the students at the beginning (such as a team with the lowest costs, a team with the lowest CO_2 emissions).

The most important aspect here, however, is the discussion and the holistic approach across individual subjects (mechanical/energy engineering as well as electrical engineering away from a given problem. This process takes place over the course of an entire semester or, alternatively, over the course of several seminars on a smaller scale.

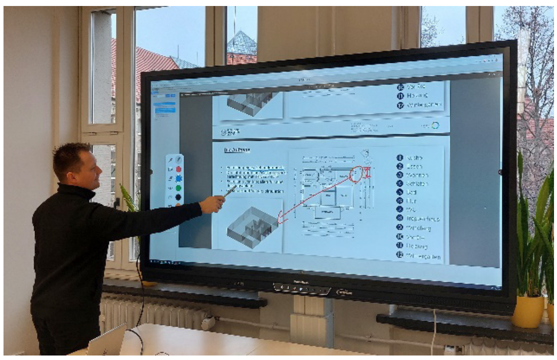

Fig. 4: Practical implementation and live processing during the seminar.

Through this new concept, the previous learning mode of single task processing was made more flexible and broken up. The feedback from the students was very positive, as theoretical considerations were directly linked to real-life applications. It should be noted, however, that only six students participated in the lecture during this first run.

5. Type of implementation

The implementation of the idea was very variable. This means that the test run of the seminar was implemented as a playful competition hybrid. This includes the processing of the task on site in presence (see Fig. 4) as well as by means of online access. The central point is that a platform was created in which the students can interact and use the software for building and system simulation within the campus network. Various tools and items are used for this purpose. These include tools for surveys [4], shared whiteboards and interactive slides/presentations, and a newly procured digital whiteboard [5] that greatly increased interactive collaboration over traditional PowerPoint presentations. In this way, the task as well as different approaches and detailed problems could be discussed interactively with the students.

Another point, which was planned but could not yet be fully implemented, is the use of additional digital possibilities of knowledge transfer (e-learning) to complement the teaching in presence. Within the current time frame, however, it was possible to create a first tutorial in the form of a video for the introduction to the simulation software. This includes a part of the PowerPoint presentation of the lecture as well as an on-screen video of the creation of an example building with explanations.

The continuing online offer for the students will be created by setting up a kind of recording studio in the laboratory of the professorship. For the implementation, a higher-quality webcam and a green screen will be used. The editing of the recording will be done with the software Camtasia [6], with which videos of presentations can be recorded interactively with more effects. For the provision of videos, knowledge content and knowledge tests, resources from the Saxony Education Portal will be used within the framework of Opal.

6. Transferability

The concept of gamification of courses/seminars can be applied to almost all topics of an entire teaching module or only individual lecture series.

Examples could include:

- Ventilation and air conditioning / development of ventilation and air conditioning strategies
- regional virtual power plants / development for supply strategies
- Gas technology / development of strategies for H_2 integration (resilience)

Taking the lecture series "Ventilation and air conditioning" as an example, aspects such as the climatic boundary conditions, the structure and design of components (heat exchangers, fans, etc.) and questions relating to air purity and pollutants (CO_2 concentration, pollutant load) should be mentioned. These technical questions are coupled with practical approaches in that the students work out certain boundary conditions (such as the space conditions or the structural conditions) on site as a technical excursion, e.g. behind the scenes of the lecture hall center.

7. Note

Due to the current situation with very long delivery times, direct practical implementation could not yet be fully started. For the first test, the task of planning and designing a heating system for a residential building was implemented by means of simulation with playful approaches within the framework of a seminar as a basis. This additionally included the creation of a building model based on given construction drawings or piping and installation diagrams (R&I) as well as taking into account different user behavior as well as thermal insulation standards of the building.

The concept is continuously extended to further partial aspects up to the holistic consideration of a cellular energy system. In the next step, several buildings have to supply each other with energy and the economic consideration is included in the task design.

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