A MODEL FOR IMPLEMENTING SIMULATION IN THE TEACHING PROCESSES OF A UNIVERSITY

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Introduction

The COVID-19 pandemic has dramatically changed the perception of ICT tools and their role in implementing and improving educational processes at universities. The position of the university authorities and the academic staff, not to mention the students, has changed. They are noting that nowadays, providing the most modern ICT infrastructure possible to support both educational processes and many others, including administrative ones, is critical for maintaining a prominent position of the university in the market of educational services, both on the domestic and global market. Due to the COVID–19 pandemic, the motivation to use ICT tools during classes has increased even among the staff who have not run the so-called computer exercises. For years, many universities have been trying, with greater or lesser success, to implement didactic innovations using

physical or computer simulations, e.g., simulation games in selected subjects/majors/specialties. However, these were relatively rare cases.

Computer simulations in management education involve using computer-based models to replicate real-world managerial situations, allowing students to interact with dynamic scenarios and make decisions in a controlled environment. These simulations enhance learning by providing hands-on experience, fostering critical thinking skills, and facilitating experimentation with different management strategies. Computer simulations use computer-based models to mimic real-world managerial scenarios, enabling students to engage in interactive decision-making processes within a simulated environment. These simulations are designed to augment learning outcomes by offering experiential learning opportunities and promoting the development of and problem-solving skills among students (Armstrong, Naylor, 2005; Crookall, 2010; Lawley, 2006; Recker, Walker, 2013; Ann, Kim, 2015; Hallinger, Showanasai, 2014). The indicated sources provide insights into the use of computer simulations in management education, offering perspectives on their effectiveness, applications, and contributions to learning outcomes. One of the forms of computer simulations – simulation games – in academic teaching management refers to educational activities that use simulated scenarios or environments to teach students about various aspects of management theory and practice. The games typically involve students taking on the roles of managers or executives within a simulated business or organizational context. In simulation games, students are often tasked with making decisions related to strategic planning, operations management, marketing, finance, human resources, or other management areas. They may be required to analyze data, develop strategies, allocate resources, solve problems, and deal with simulated challenges and opportunities that arise within the game. Using simulation games in academic teaching management aims to provide students with a hands-on, experiential learning experience that helps them develop practical skills, analytical thinking abilities, and an understanding of real-world management issues. By immersing students in dynamic, interactive simulations, educators aim to bridge the gap between theory and practice and prepare students for the complexities of managerial decision-making in professional settings.

It should be noted that along with the widespread increase in the ability to use various IT tools/applications, there is a pressure to update teaching methods and tools to meet the best requirements of the modern world/modern student. At the same time, implementing such changes on a broad scale requires a well-thought-out approach involving various stakeholders and resources.

Similar to other organizations that want to meet the challenges of the market, universities must manage knowledge very skilfully, and this management should be tailored to individual needs and capabilities as well as the strategic goals of a given entity. According to Mierzejewska (2004), the knowledge management strategy should be based on people, technology, and processes. Implementing the knowledge management strategy should integrate knowledge management processes with the strategic goals of the organization and business processes. It requires conducting activities in the social dimension – regarding values and attitudes/good practices cultivated in this area and providing tools (modern technologies) necessary for effectively managing knowledge resources and processes.

Considerations on the role of simulation in improving university teaching can be found in the publication edited by Furmanek, Piecuch (2010) and Mierzejewska (2004), which emphasizes the importance of information and communication technologies in the context of educational changes and matching schools and ways of practicing science to the current needs and possibilities of the material environment in which they function. The changes discussed by the authors should concern not only the content of education but, above all, the IT infrastructure in the learning and teaching processes. They emphasize computer simulations as a tool to support the educational process. Also interesting is the proposal of Toczyńska (2016), who tried to present a general model of the education process management system as a complex, open cybernetic system, specifying the stages of dynamic simulation of this system. The author does not propose a model of the simulation implementation process, but the use of a computer simulation tool to model factors and cause-and-effect relationships of system elements; iterative simulation experimentation on models that include feedback to improve system representation, relational models, and system input parameters (Musioł-Urbańczyk, 2020). In another publication regarding project management at a public university, several projects were described in detail, aimed at increasing the quality of education in the field of process management, e.g., projects related to the launch of, e.g. Process Management Laboratory or Logistics Process Automation Laboratory (Raczyńska, 2010).

These observations and analysis formed the basis for posing the following research questions:

1. What phases/stages should be performed in adapting simulation in the teaching processes of universities?
2. Which resources of the university and the environment and when should be included so that implementing a new IT solution runs smoothly?

The article aims to introduce a model for implementing simulation in higher education teaching that will contain the answers to the research questions. The authors review personal, institutional, and technological factors influencing didactic staff readiness and willingness to use computer technology/new tools in teaching and learning processes. There was a research gap of publications that would suggest to interested universities how to carry out such a change step by step, involving the proper entities at the right time, to minimize possible barriers and achieve the highest possible level of acceptance and involvement of staff in specific activities and, as a result, effectively make changes in learning processes.

The presented solution delineates two research areas: designing and implementing simulations in teaching processes at the university, with the emphasis being placed primarily on this second area, treating design as one of the stages in the proposed model. The authors implement them through a literature review, observational research methods, source criticism, and logical analysis.

Literature review

Simulations used in teaching processes can be divided into several categories:

- computer simulations – software that imitates real-world processes or systems; they can be simple, like calculators, or complex, like strategy games,
- physical simulations – these simulations use physical models to imitate real-world objects or systems (e.g., flight simulators or patient simulators in medicine) and
- simulation games that combine education and entertainment can teach various skills, such as problem-solving, decision-making, and teamwork.

Simulations can be used to teach various subjects in such areas as medicine, engineering, and business and bring many educational benefits, such as increased engagement, improved learning, skill development, and accessibility. However, simulation implementation in education also has certain limitations, including cost, complexity (to use them, one must have a certain level of knowledge), and technical limitations (it may require access to specialized equipment and software).

This review explores the application of simulations in university teaching, highlighting its potential and limitations.

Existing literature:

- Fields of use: Simulations are employed across various disciplines, encompassing economics, business (Mierzejewska, 2004), and beyond, as discussed by Morgan (2013). However, these publications primarily address the tools rather than specific implementation strategies.
- Proposals for utilization: Additional authors, like Hyltander (2003), Kuciapski (2013), and Antoniuk et al. (2021), offer valuable proposals for incorporating simulations, often through computer simulations and strategic games (Dobrowolska, Kalinowski, 2014).

Advocates for simulation-based learning:

- Furmanek and Piecuch (2010) propose that computer simulations can be adapted to diverse learning objectives across various fields in schools and universities. He emphasizes their effectiveness in promoting active learning, where students actively engage in the learning process.
- Chernikova et al. (2020). A meta-analysis was conducted reviewing 145 studies, confirming the effectiveness of simulations in facilitating complex skill acquisition across different higher education domains. They highlight the value of diverse support types in enhancing the learning experience.
- Zenios (2020): Investigates integrating technology-enhanced learning within simulation frameworks to optimize learning outcomes.

Potential drawbacks:

- Raczyńska (2010): Warns of potential misuse by students and teachers. Overreliance on simulations may discourage real-world experimentation and problem-solving, possibly due to resource availability and experience limitations. Additionally, students may develop an uncritical trust towards simulated results, leading to the reinforcement of inaccurate understandings or misinterpretations.
- Limited applicability: Simulation outcomes are specific to the modeled conditions and can be distorted by factors like data compression and transmission errors. This necessitates careful consideration during project design and implementation.

While numerous publications address various aspects of simulation use in higher education, both domestically (Wawrzeńczyk-Kulik, 2013; Ragin-Skorecka, Kudelska, 2012) and internationally (Zulfiqar et al., 2019; Chernikova et al., 2020; Zenios, 2020), a gap exists. This gap pertains to the lack of literature outlining a systematic approach for implementing computer simulations within universities. Such an approach would encompass detailed guidance on activities and tasks across various stages of implementation, ensuring proper management of resources (human, material, and organizational; time and space).

Simulations offer substantial potential for enhancing the learning experience. However, their practical and responsible use necessitates acknowledging their benefits and limitations. This review emphasizes the need for further research on developing a comprehensive framework for implementing computer simulations in university settings, ensuring optimal utilization of this valuable learning tool.

Model of the process of implementing simulations in the didactic processes of a university

Along with the dynamic development of information technologies and skills related to their use, there is a growing interest in disseminating didactic tools based on modern technologies, such as various types of simulations. Tools of this type, although still not the cheapest, are no longer perceived as reserved and appropriate for education only in selected fields, such as medicine, aviation, or military, and are gaining in importance also in other areas of science and didactics.

Nevertheless, simulations in didactic processes in higher education are still a novelty. Therefore, according to the authors, it is worth considering how to facilitate and improve the simulation implementation process in the didactic processes of higher education institutions.

One of the proposals may be a methodical approach to the process of designing and implementing simulations for the needs of a university in the form of a model of such a process, along with an indication and characteristics of actions that should be taken to ensure the highest possible efficiency and minimize the risk of implementation failure.

The proposed approach/model is based on the literature analysis and, above all, the experiences, and observations of the authors as teaching staff of the UEW (Wroclaw University of Economics and Business). The model of designing and implementing simulations in the didactic processes was developed based on teachers' experience related to creating and commencing operations by the Business Process Simulation Centre. A critical analysis related to the functioning of the new center was carried out. It was noticed that certain activities did not take place optimally, so the potential of the laboratory was not used to the highest possible extent. Specific actions aimed at educating and involving staff were undertaken too late and with too little support from those managing the teaching area and the administration.

A necessary condition for the smooth implementation of all assumed tasks and processes is having sufficient financial/material and human resources. Any shortages and related delays may disrupt the smoothness of the entire process.

It is worthwhile for such IT projects to be included in the overall didactics management system and involve various parties from the initial phase to optimize the use of the invested resources. It should be remembered that, apart from the teaching staff, the technical and administrative staff, adequately motivated, prepared, and involved at various stages of didactic projects, becomes an essential link in building a modern educational offer, reflecting the university's knowledge management system. The better and more efficient the knowledge acquisition system is, the better the educational offer of a given university.

Below, the author's model of a systematic approach to implementing computer simulations in the university education processes will be presented (Figure 1 and Table 1).

When analyzing the model:

- the first step that should be done is analysis and diagnosis of the university in terms of legitimacy and potential resources necessary to introduce a simulation to the university's teaching system (activity no. 1, 2, 3, 4, 5),
- the next step should be the involvement of participants in the implementation of specific works/tasks and organizing the necessary resources (activity no. 6, 7, 8, 9),
- after diagnosing/organizing resources and engaging participants, you can start implementation of a new didactic tool in the didactic processes in the university (activity no. 10),
- after implementing the simulation, the simulation system's quality and reliability and feedback from teachers and students should be monitored and evaluated after each cycle (e.g., year/semester) (activity no. 11, 12).

Each stage is equally important and must be included in implementing a new teaching tool.

The resources diagnosed in the first stage and those organized in the second stage were divided into human and material ones. Among human resources the following were highlighted:

- Implementation Team (IT),
- Teaching Staff (TS),
- Administrative Staff (AS),
- Support/Technical Staff (STS),
- Students (S),
- External Personnel (EP).

Material resources, on the other hand, include:

- Financial Resources (FR),
- Building and Facilities (B&F),
- IT Infrastructure (hardware and software) (ITI).

Table 1 presents a detailed version of the model, considering the resources necessary to carry out the distinguished activities.

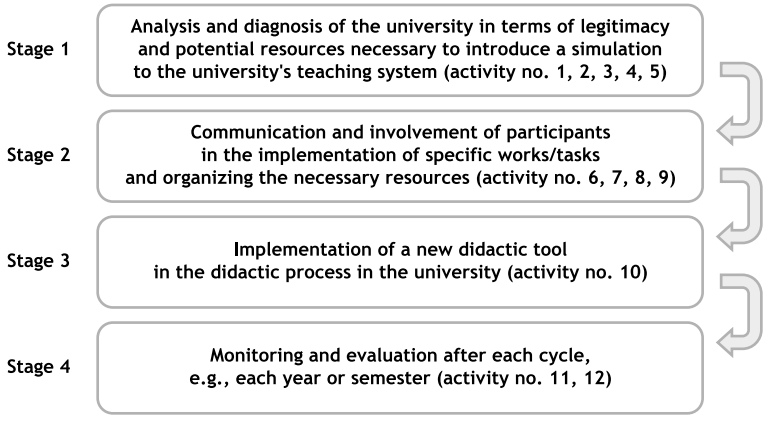

Figure 1. The model of the process of implementing simulations for the university needs
Source: own elaboration

Table 1. The model of the process of implementing simulations for the university needs – extended version

Stage	Activity	Implementation Team (IT)	Teaching Staff (TS)	Administrative Staff (AS)	Support/Technical Staff (STS)	Students (S)	External Personnel (EP)	Financial Resources (FR)	Building and Facilities (B&F)	IT Infrastructure (ITI)
1	Establishment of a team for the implementation of simulation	✓								
	Conducting a study on the legitimacy of introducing simulation as a tool supporting university teaching	✓				✓				
	Defining the goals/expectations regarding the introduction of simulation as a teaching method	✓								
	Review of the staff in terms of motivation and skills related to conducting classes based on computer simulations		✓	✓	✓					
	Review of the university's infrastructure in terms of conducting classes with the use of computer simulations	✓			✓			✓		✓
2	Determining topics/types of simulations and creating a list of subjects/courses in which simulations with a predetermined topic can be used	✓	✓							
	Designing/modelling and creating a simulation (using inside or/ and outside resources). Fulfilment of the order/purchase	✓	✓				✓			
	Analysis of the collected information	✓								
	Introducing changes and taking necessary actions related to preparing the university to use the simulation	✓	✓	✓	✓		✓*	✓	✓	✓
3	Implementation of classes with the use of simulation		✓		✓	✓			✓	✓
4	Inspection after each semester/academic year, conducting research (among students and academic staff) and evaluation	✓	✓			✓				
	Analyzing the collected data and taking the necessary corrective actions	✓								

(*) – in some cases

Source: own elaboration

In the proposed model of the process of implementing simulations for the needs of the university, the following key activities were distinguished:

1. Establishment of a team for the implementation of simulation at the university X. Such a team would be responsible for planning, organization, coordination, monitoring, and evaluation of activities related to simulation implementation as a didactic method of the university. The team should include the university's teaching, technical, and administrative staff.
2. Conducting a study on the legitimacy of introducing simulation as a tool supporting university teaching (among students and academic staff).
3. Defining the goals/expectations regarding the introduction of simulation as a teaching method (e.g., strengthening the didactic potential of the university; development of employees in applied teaching methods; making classes in selected 20% of classes more attractive; thanks to this, attracting more candidates for studies, etc.).
4. Review the staff in terms of motivation and skills related to conducting classes based on computer simulations (both research and teaching staff and technical staff who would/could support the teachers when introducing simulations as a tool in the didactic process).

Surveying to collect information such as: the number of employees interested in conducting classes with the use of simulation, experience with simulations, the perceived potential of simulations about specific classes conducted by the employee, training and technical support needs for conducting classes using simulation (working in a modern laboratory/simulation center), the ability and willingness to independently develop a simulation model (e.g., for later software by a specialist external company), etc.

5. Review of the university's infrastructure in terms of conducting classes with the use of computer simulations.

Conducting a review of the available infrastructure necessary to conduct classes with the use of simulation, comparing the existing state with the expected/estimated demand for equipment/labs in the case of introducing classes using simulation on a specific scale throughout the university, determining the need for specific tools/equipment, rooms, room reservation system, and others.

6. Determining topics/types of simulations (carefully looking at which topics are suitable for simulations) and creating a list of subjects/courses in which simulations with a predetermined topic can be used.

Organizing meetings (a series of meetings) with employees interested in conducting classes with the use of simulation to discuss the details of the simulation design:

- determining who and what type of simulations is needed (name of the subject, form of classes, declared number of hours to be conducted in the form of simulation, type of simulation (game, with the use of VR)),
- determining who will be responsible for preparing the simulation model/input of information necessary to provide specialists (e.g., an external company specializing in creating simulations) – the interested party, an employee in cooperation with other university employees, an external company or whether it will be the purchase of a ready-made simulation available on the market,
- determining deadlines for task implementation – the decision on purchase and/or preparation of simulation models internally or on request in an external company.

7. Designing/modelling and creating a simulation within the university, ordering a simulation to be prepared by an external company, or purchasing a simulation and determining the deadline for completing the task – handing over the finished presentation (by an employee or a team from the university); fulfilment of the order/purchase.
8. Analysis of the collected information (points 3–6).
9. Introducing changes and taking necessary actions related to preparing the university to use the simulation:
   - preparation/adjustment of appropriate infrastructure; providing technical support from technical staff for people who will conduct classes using simulations and, e.g., VR systems for the first time (at least in the initial phase of simulation implementation),
   - preparation of appropriate rules, procedures, and regulations related to the use of selected tools/devices/laboratories,
   - planning training for teaching and/or technical staff who want/will be involved in conducting classes using the simulation method,
   - preparation of a system/module in the class planning system that considers conducting classes in laboratories providing access to simulations, considering such additional criteria as the number of hours to be conducted in specially dedicated rooms/laboratories; the number of people/students who may be in the room; support of technical people during the hours when classes are conducted with the use of simulation,
   - publishing information on training,
   - conducting training.
10. Implementation – implementation of classes with the use of simulation.

At this stage, it would be advisable to regularly monitor the implementation of classes and possible problems to react to emerging difficulties as soon as possible.

11. Inspection after each semester/academic year/ Conducting research (among students and academic staff) and evaluation in terms of:
    - enjoying the simulation,
    - assessment of the presentation (appropriateness in the context of the subject syllabus, ease of use, detail, degree of impact on the development of specific competencies, impact on commitment, etc.),
    - degree of simulation use (number of subjects, instructors, hours spent "with the simulation," etc.),
    - problems related to the implementation of classes (e.g., hardware, organizational problems (problems with planning classes using simulations (in computer rooms),
12. Analyse the collected data and take the necessary corrective actions.

After the first "course" and later, it is necessary to study the needs (students and staff) of improving the simulation and/or implementing more modern methods supporting didactic processes. The change made in the didactic processes, like any organizational change, requires consolidation. It involves adapting policies, procedures, regulations, systems, and organizational culture to the new reality and supporting teaching staff to adapt and develop new skills.

Discussion

Considering the literature review and the disadvantages of using computer simulations in education, the problem of responsible IT education is significant. In addition to the unquestionable advantages mentioned by the authors in their previous publications (Binsztok et al., 2022), certain limitations should also be considered in designing and implementing the simulation. The examples mentioned above of even sometimes destructive effects of computer simulations indicate the enormous role of the teacher. They enforce the need for rationality

and responsibility in using computer simulation in the educational process. The selection of appropriate, constantly educating teaching staff is of great importance. No less critical is proper hardware and software, which will undoubtedly contribute to eliminating content distortions.

As shown, the planning and implementation of computer simulation for didactic processes is a complex process combining two areas of university activity: didactic and administrative. The process involves many tasks (points 1–12). To ensure the coherence of the implementation of these tasks, it is necessary to appoint a coordinator for the entire project. It seems that it is crucial that the process coordinator/leader, just like every project manager, has the appropriate competencies (Musioł-Urbańczyk, 2020, p. 46):

- professional (e.g., resource management, organization and communication, change management in the organization, planning and control, time management, project scope management, etc.),
- contextual (e.g., knowledge of university systems and processes, knowledge of standards and legal regulations, strategic management, etc.),
- social (e.g., leadership, teamwork, entrepreneurship, creativity, negotiating skills, focus on self and co-workers' development, interpersonal communication, results orientation, etc.).

Due to the ongoing organizational, economic, legal, demographic, and social changes in Poland, knowledge management at the university, as part of such projects as implementing computer simulation or other advanced IT tools, cannot be limited only to the administrative approach. It requires the development of a conscious concept of managing entities, defining the most important goals and ways to achieve them using inventoried, available resources at a given place and time, and considering the limitations and opportunities, both internal and external.

Universities must keep up with the expectations and challenges of the environment and offer "products/services" that are attractive to the recipient/students/listeners. Indeed, attention to modern teaching tools and educators proficient in their use are necessary conditions for schools to survive in the era of artificial intelligence and universal access to knowledge/information.

Conclusions

The widespread availability of technology makes it more and more efficient to find new applications, e.g., in educational processes. However, implementation activities must be carefully planned on many levels. Implementing simulation (or other ICT-based, advanced tools) as a didactic method at a university requires appropriate preparation of infrastructure, teaching materials, and training of teaching staff. It is also crucial to define the goals and expectations precisely and assess the effects, which will allow for the improvement and further development of this teaching method. It is worth emphasizing that achieving the expected results with the correct methodology, action template, and model in such complex and vital processes will be easier. Hence, it is essential to study these elements and constantly develop them. After the literature research, it is easy to conclude that applying simulation in the educational processes is still rare, and there are still many aspects to explore, implement, experiment on, and standardize.

Given these challenges, the authors formulated two research questions and proposed a model for implementing simulation in higher education teaching. Regarding the first research question, the graphical model (Figure 1) was created, which distinguishes four primary phases within the model of the simulation implementation process at the university. Table 1 – an extension of the model presented in Figure 1 – is a graphical representation of the answer to the second question about when and what resources should be included in the process.

Although it refers to computer simulations, the proposed and discussed in detail model can become a universal tool supporting the implementation of any ICT tool (requiring more significant financial, material, and human resources) in university teaching processes after some corrections. It may aid/ be a guide to people responsible for improving the teaching area of a university, such as deans of education, administration responsible for organizing teaching, and the teaching staff themselves involved in improving the quality of education at the university. The model indicates activities that are important from the point of view of the effectiveness of the entire process of implementing a new teaching tool within four primary levels:

- analysis and diagnosis of the university in terms of legitimacy and potential resources necessary to introduce a change – introducing a simulation to the university's teaching system,
- communication involvement of participants in the implementation of specific works/tasks and organizing the necessary resources,
- implementation of a new didactic tool in the didactic processes in the university,
- monitoring and evaluation after each cycle (e.g., year/semester).

The intention was to draw attention to the phase of planning and organizing resources necessary for the new tool to be smoothly integrated into the existing teaching system of a given university with the most significant possible understanding/acceptance and involvement of the necessary resources. In the future, the authors would like to expand the model with detailed methods and techniques supporting the analysis and organization of projects, such as Gantt charts/scheduling and resource allocation, evaluation metrics and assessment questionnaires, etc.), so that it can support the already mentioned groups to an even greater extent in undertaking and implementing activities related to the improvement of didactics/education through broader use of advanced IT tools.

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Model wdrażania symulacji w procesy dydaktyczne uczelni wyższej

Streszczenie

Dynamiczne zmiany we współczesnym świecie, szczególnie w kontekście nowoczesnych technologii, wymagają stworzenia modeli, dzięki którym implementacja i zastosowanie wybranych narzędzi w określonych dziedzinach/sferach będzie realizowane sprawnie i efektywnie. Jest to szczególnie ważne w przypadku stosowania ICT w procesach dydaktycznych instytucji edukacyjnych, gdzie istotne jest zaangażowanie oraz rozwijanie umiejętności i kompetencji wielu podmiotów. Podstawowym celem artykułu jest zaproponowanie modelu procesu zarządzania wdrażaniem symulacji jako narzędzia dydaktycznego uczelni wyższej. Wstęp artykułu wskazuje na znaczne przyspieszenie zastosowań ICT w edukacji spowodowane pandemią COVID-19. W początkowej części artykułu dokonano przeglądu literatury na temat zastosowania narzędzi edukacyjnych wykorzystujących symulacje zarówno w aspekcie pozytywnym, jak i niepożądanym. W kolejnej części zestawiono i szczegółowo opisano elementy realizacji symulacji w procesie dydaktycznym. Na końcu omówiono istotne zagadnienia dotyczące procesu wdrożenia symulacji oraz związane z nim potencjalne trudności. Proponowany model, choć odnosi się do symulacji komputerowych, może być traktowany jako uniwersalne narzędzie pomocne w planowaniu przedsięwzięć związanych z wdrażaniem do systemu dydaktycznego uczelni zaawansowanych narzędzi ICT, wymagających szerokiego angażowania czasu, środków i innych zasobów ludzkich i materialnych.

Słowa kluczowe

edukacja, narzędzia ICT, symulacje, implementacja