

Article

Implementing Sustainability into Virtual Simulation Games in Business Higher Education

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Abstract: The paper aims to determine how sustainability can be implemented into virtual business simulators dedicated to higher education due to the need for raising environmental awareness among students. Climate and natural environmental changes caused by human activities require adjustments in society's mindsets and activities, especially in the business-related sector, which makes the implementation of sustainability in business higher education of crucial importance. Virtual business simulators are innovative tools in business higher education. Their use, as a part of game-based learning, is attracting increasing interest, as this method allows us to understand interactions between business decisions and their results. In this paper, we present our case study of an IT-based business simulator, which includes aspects of sustainability, and the initial experience of a group of test students participating in the business game. The paper discusses the authors' own IT solutions and the possibilities of implementing the concept of sustainability into business-oriented higher education. This paper proposed the manner of implementing sustainability, including pseudocodes, into a virtual business simulator. The results show how challenging it is to implement sustainability into game-based business education, as it increases the complexity of interactions among different aspects of running a business, including the goal of making a company more diversified.

Keywords: sustainability; game-based higher education; sustainable-oriented virtual strategic game; higher business education



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1. Introduction

Human activities, such as massive production and consumption, are often argued to be the reason for environmental challenges highlighted in the concept of sustainability [1]. Anthropogenic changes in the climate and natural environment are believed to be responsible for the majority of these challenges, and addressing them requires a change in societal mindsets and activities.

Educational centers can play a crucial role in raising awareness among future generations by providing them with useful information on sustainability and environmental protection and helping them apply this knowledge in their business decisions after graduation [2,3]. Based on the new global framework of Education for Sustainable Development that was introduced by the 40th UNESCO General Conference, universities are considered to be the main agent for achieving the UNESCO sustainable goals in three ways: by educating socially responsible citizens, by promoting collaborative work among universities and research centers, and by encouraging collaborative and multidisciplinary research activities [4].

As climate changes are directly business-related, the implementation of sustainability into business higher education seems to be crucial for making businesses more environmen-

tal aware [5,6]. Business higher education is based on two principal courses: economics and management. Both of these promote the main goals of maximizing or optimizing company profits by realizing the greatest difference between revenues and costs, while using the limited resources in the most effective manner. To some extent, the environmental concerns can also be discussed within these principal courses, as natural resources are used by businesses. However, the main aim of business higher education is not to preserve limited natural resources, but to raise profitability through the increase in demand for offered products and services and/or through the decrease in costs due to cheaper sources of raw materials and the economy of scale.

Business higher education faces its own challenges related to the methods of teaching, for example, moving from teacher-oriented methods, such as ex cathedra lectures, toward student-oriented methods, such as for example problem-based learning. One of the promising educational methods is the use of virtual simulation games during which students assume the roles of business managers and are asked to make a sequence of managerial decisions in order to understand the obstacles and consequences of running a company.

The purpose of the paper is to propose the implementation of the concept of sustainability into virtual strategic business games dedicated to business higher education. Based on the initial insights from students who tested the game, the possibility of implementing the concept of sustainability into business-oriented higher education is also discussed.

2. Materials and Methods

2.1. Sustainability

Significant evidence shows that human actions lead to much of our planet's dysfunction. The pace at which the land, the air, the climate, and biodiversity are being impacted has increased dramatically over the years. People are responsible not only for the above issues, but for the increase in carbon dioxide levels, deforestation, the elimination of natural resources, and the extinction of specific animals. Therefore, sustainability is becoming an important research area in the search for solutions to the above-mentioned human-caused concerns.

The extensive research and growing knowledge about sustainability in recent years has increased the number of definitions of sustainability [7,8]. The concept of sustainability was first applied in forestry, where it referred to the practice of never harvesting more than what the forest could regrow [9]. Among the main forestry experts who shed light on sustainability during the 17th and 18th centuries were Evelyn and Carlowirtz [8]. Next, economists also began applying the topic of sustainability: Thomas Malthus published his theory of looming mass starvation in 1798, and Harold Hotelling published his theory concerning the optimal rate of exploitation of non-renewable resources in 1931. However, the term became more recognizable after the report from the Club of Rome, which indicated that natural resources are important for the survival of the mankind, and that at the current rate of use, they will be exhausted within a couple of generations; therefore, humanity must act accordingly. Subsequently, sustainability gained more visibility due to the report from the UN World Commission on Environment and Development, also known as the Brundtland Report, where the commission introduced sustainable development as the solution to the problem of limited natural resources and the continuous aspiration for a better life. Based on the commission's definition, sustainable development is development that meets the needs of the present generation, without compromising the ability of future generations to meet their own needs [10].

There are differences between sustainability and sustainable development, even though these two concepts are often intertwined throughout history and the literature. The question that many ask is how development can be a part of sustainability. Previous studies, such as that of [11], referred to it as the necessary growth of developing countries, but the United Nations has connected development with growth, and it has also included developed countries. This having been said, many researchers argue that the meaning of development comes from Western capitalist movements that do not pay attention to

sustainability [12]. Other authors also mention that it is problematic to group development with sustainability when there have been so many ecosocial abuses throughout the history of development [13].

Sustainability is a multidimensional concept connected with the complexity of human and ecological systems, requiring the bridging of not only specialized experts, but more stakeholders on a local or global scale [14]. Sustainability as a multi-dimensional concept, is commonly separated into three main pillars: economic, social, and environmental, which represent the balance of the desirable goals between these three categories. The idea of the three dimensions of sustainability was introduced based on the triple bottom line concept developed by Elkington [15]. The idea behind this concept was to organize corporate social responsibility, such that profit, care for the environment, and the well-being of the people should all be taken under consideration. However, the pillars are addressed differently by public policies: the government is not supposed to have the goal of profit, so the profit-economic pillar is defined as the money made by the country—the GDP—thus, it can be called an economic dimension. As far as the social dimension is concerned, it refers to everything related to the well-being of humans, such as health, equity, and inclusion [16]. The environment is related to the protection of nature and sustaining and using resources with as little damage to the environment as possible. In order to achieve the sustainable goals, all of these pillars should receive equal weight. In addition, the main three pillars of sustainability can also be found in sustainable development. Economic development, as mentioned by [17], seeks to satisfy consumer demand without compromising the quality of life; social development refers to the protection of human life from pollution coming from businesses, and environmental development is about protecting the environment, for instance, by demanding that businesses keep their carbon emissions low. Even though these three pillars help us define the concept of sustainability, setting goals and strategies to help with the planning and support of changes [18], they limit the concept of sustainability to a strict structure. On the other hand, even though the three pillars may limit the concept of sustainability, there is research that considers some additional pillars, for instance, technology and innovation [19]. Sustainable pillars can be defined or assessed as conceptual foundations, and there is research justifying why and how more pillars are important to the concept of sustainability.

The environmental pillar should be as important as the other pillars for many reasons. The human population, its expected growth until 2050 [20], and urbanization is estimated to increase the pressure on natural resources, the level of air pollution, the lack of clean water and energy, and food insecurity. In addition, natural resources are also eliminated due to the constant need for development. One of the key aspects of the environmental pillar is the maintenance of natural resources, which are crucial for the survival of the human species [21]. Even though it is considered that the first steps are already being made, as the problem of natural resources has been identified, more action should be taken by different agencies in order to reach the expected outcomes [22].

Climate change is another aspect of the environmental pillar which must be considered. There is a growing consensus regarding climate change, but the general public is not always aware of natural or human causal factors [23]. Scientists generally agree that the climate change is caused, if not entirely, at least predominantly, by human activity. It has even been called anthropogenic climate changes [24–26].

2.2. Virtual Simulation Business Games as Teaching Tools in Business Higher Education

The crucial problem is how to make people in general and businesspeople in particular more aware of environmental issues in the wider context of the sustainability pillars. Business higher education seems to be the area of special importance for raising the awareness of sustainability, but the most important questions concern what should be taught (the content of courses on sustainability and the implementation of the aspects of sustainability into other business courses) and how sustainability should be taught (the most effective methods of education).

Courses on sustainability might be easier to implement into business universities' curricula, but the awareness of sustainable pillars should also be included in standard courses to make the education more coherent. Two basic courses in business higher education, microeconomics and management, teach students the main mode of business thought, which aims at the maximization or optimization of company profits by realizing the greatest difference between revenues and costs (e.g., textbooks of [27–29]). To some extent, the environmental concerns might be discussed within these basic courses, as they discuss how to utilize limited resources, including natural resources, in the most effective manner. Resource scarcity is one of the fundamental issues in business education, but the educational discussion with business students focuses on the increase in demand for offered products and services and/or the decrease in costs, thanks to cheaper sources of raw materials and the economy of scale, rather than on limited natural resources.

Business higher education must address the paradox reflecting the dilemma between productivity and sustainability. To behave in a more sustainable manner, companies should produce less and encourage consumers to consume less. However, such behavior is opposite to the major goals of businesses: to be productive, aiming at maximizing the production size regarding limited resources, and profitable, aiming to ensure that the sales revenues exceed the costs of production as much as possible. Reaching business goals often requires raising the level of production to gain scale effects. Two theories attempt to describe the impact of sustainability on the financial performance of a company: value-creating and value-destroying [30]. The value-creation approach is based on the theory that companies that adopt environmental strategies have lower performance risks, while the value-destruction approach theorizes that companies adopting sustainable strategies, such as reducing their production levels, tend to lose focus on their profitability. Past research has examined the relationship between sustainability and financial performance. Singal [31] examined the link between sustainability and economic development in the hospitality industry and found that going green does not downgrade financial performance, but pays off in future periods, as customers support green initiatives. In addition, Martínez-Ferrero and Frías-Aceituno [32] tested an unbalanced sample of 1960 multinational non-financial listed companies and come up with the finding that environmental practices have a positive effect on the financial performance of corporations. Past systematic review research examined 132 publications in regards to CSR and financial performance and found a connection between sustainability and corporate financial performance; however, the size of the firm, the type of economy, and the type of industry play an important role in this relationship [33]. When facing the productivity-sustainability dilemma, companies should consider other sustainable ways that will increase their financial performance, based on the above-mentioned literature, while maintaining the ability to lower their production levels without sacrificing profits. Moreover, deciding between sustainability or profitability, businesses should examine more factors that will allow them to find the balance between being a profitable, but environmentally friendly, company. Another dilemma of combining business and sustainability is related to positive versus normative economics as a science. Business education refers to positive economics, which analyzes and teaches how the economy operates in its all aspects. When applying sustainability, we move toward positive economics as a science that explains how the economy should operate to fulfil sustainability goals.

Another aspect of implementing the aspects of sustainability into business higher education is the problem of teaching-learning methods. This issue is part of bigger discussion related to the shift from teacher-oriented methods, such as ex cathedra lectures, toward student-oriented methods, such as for example problem-based learning; in other words, developing a more flexible teaching-learning model [34]. Problem observed today, including the lack of student motivation and engagement in learning [35,36], pushes educators to look for the most effective education methods.

The game-based teaching-learning method is a promising educational approach aimed at boosting learners' motivation, engagement, and satisfaction [35,37–39]. Game-based, or

gamification learning, adopts the educational content to the story and rules of a game [40], leading students to explore relevant aspects of games in the learning context [41,42]. The education process progresses mostly by playing games to learn the content of the education course [43].

Although the idea of implementing games into education is not totally new—it was originally rooted in the teachings of the ancient philosophers, Plato and Aristotle [44]—game-based education is still a relatively young idea in the context of higher education. The implementation of this method requires the clarification of important aspects, such as different game-based teaching and learning strategies, the variety of used technologies, digital or non-digital games, the use of particular game elements or mechanisms, etc. [45], as well as primary and secondary characteristics, such as learning support, learner control, assessment, immersion, interaction, or narrative [46]. The implementation of games into the education process can take diversified forms, starting with a relatively short game played during one class to a semester-long role play game [46].

There are different types of games used in education; among these, virtual simulation games are one of the promising methods for use in business higher education. Such games are classified as serious games, meaning digital games used for purposes other than entertainment [47], having explicit educational purposes [41]. Simulation games are an imitation of the real world, with an alternative reality and a controlled environment [41]. In virtual simulation games, students are put into the roles of business managers and are asked to make sequences of managerial decisions to understand the obstacles and consequences of running a company, as well as the interdependencies among the different areas of business [48]. Business simulation games allow students to gain personal experience related to managing a business, especially to understand relationships and market tendencies, or competitive dynamics [49].

There are several specific features of business simulation games [48]. Business simulations let learners experience different managerial roles and the areas of running a business in quasi-real situations [48,50]. Students use the trial-and-error method as they develop the ability to analyze the results of decisions, to make alternative choices, and to modify a business strategy [51]. Thanks to simulations, learners get real-time feedback on the results of their decisions, aiding them in self-assessment and supporting a better understanding of the areas in need of improvement [48]. The next feature is related to the risk of decision making, as simulations are risk-free spaces, and students can train their decision-making skills without the risk of actual failure [52].

Being aware of the discussion on the effectiveness of game-based education [35,44,53–55], we do not aim at verifying the pros and cons of such a method, but our aim is to propose the implementation of the concept of sustainability into virtual simulation business games based on the game created and implemented by the authors.

The potential to implement sustainability into business higher education through virtual simulation games is related to the following aspects. Simulations are believed to facilitate cross- and interdisciplinary learning, as students of different disciplines can collaborate to solve interdisciplinary problems [56], such as sustainability. Since games are also an education method which emotionally engages students [37], including aspects of sustainability in the business simulation should help students develop environmental awareness.

There are examples of how simulation games involving role-playing deal with climate issues, allowing learners to increase their knowledge concerning gas emission reduction and climate change actions [57], or to understand a new regulation regarding fertilizer ordinances [58]. Contrary to [59], we did not intent to implement the dilemma between biological conservation and economic development into the game; instead, our aim was to propose the algorithms for the implementation of sustainability aspects into the regular business-oriented simulation.

3. Results—Implementing Sustainability Aspects into Business Simulator

Implementing sustainability into virtual simulation games dedicated to business higher education is a multidisciplinary problem, as it combines sustainability, management, education, and IT software programming. In our paper, we focus on 2 issues: specific IT solutions, which we implemented into the software (Section 3.1), and initial insights from students testing our simulator (Section 3.2). By doing so, we combine the programming and educational aspects in our simulator.

3.1. Assumptions and Pseudocodes

We have been using virtual business simulation games in teaching business students since 2014, in the form of the original virtual business simulator, BizArena. We use the expression “virtual simulation games” in computing as synonymous with the following three aspects of our solution:

- Our simulation is based on an IT solution based on software designed by a project team. Our simulation does not exist physically, but the software creates it;
- Our simulation is an online simulation;
- Within our simulation, we created a fictional market as close to a real market as possible, albeit a fictional one.

The first version of BizArena was developed as the part of the Strategic Management Virtual Games project, No. 2011-1-PL1-LEO05-19884, funded with support from the European Commission under the Lifelong Learning Program. This simulator was designed to manage a manufacturing company. The second version of BizArena was developed as part of the Virtual Game Method in Higher Education project, No. 2014-1-PL01-KA203-003548, funded with support from the European Commission under the ERASMUS + Program. This simulator was designed to manage a service company. The third version of BizArena was developed as part of the Central European Network for Sustainable and Innovative Economy project, No. PPI/APM/2019/1/00047/U/00001, funded with support from the Polish National Agency for Academic Exchange, and it is available at: <https://bizarena.ue.poznan.pl/cenetsie/> (access: 1 July 2022). This simulator was designed to manage a manufacturing company, in compliance with the principles of sustainable development.

In BizArena, a single game is played by several players who are grouped into teams. The purpose of the game is to establish and run a company which develops products (through R&D activities), then manufactures them and ships to retail offices operating in various local markets, where it finally tries to sell them to customers. Companies comprised of different players compete against each other for a scarce demand generated by customer groups. Each customer group has its own unique profile. Players must try to adjust the characteristics of their offer to the profiles of the customer groups. The more accurate the adjustment, the greater the possible sales. Greater sales do not necessarily mean higher profit; players must balance income with the expenses necessary to run a company, including human resource expenses (salaries, benefits, training sessions), research and development expenses, and premises expenses.

BizArena is a turn-based game—in each turn, players make managerial decisions in the following areas: marketing and sales, research and development, operations (manufacturing, inventorying, and shipment), and human resources. Turns are closed by the teacher. The teacher has access to several breakdowns presenting detailed data on the players’ decisions within all managerial areas. Before closing each turn, the teacher is able to adjust various parameters influencing game business conditions within the next turn. The comprehensive description of the BizArena simulator can be found in [60,61].

BizArena allows for the achievement of two main didactic goals. The first is to make students aware that the effects of operational activities require time to emerge; e.g., fulfilling the higher demand for products at a specific local market cannot be obtained immediately because, it is first necessary to increase production capacity by purchasing and setting up an additional manufacturing line; then, it is necessary to hire additional workers, manufacture

more products, and ship those products to local sales offices. Only then will it be possible to meet that higher demand. Therefore, managing a company requires the detailed planning of operational activities sufficiently in advance.

The other didactic goal of the BizArena simulator is to make students aware of the fact that managing a business requires the coordination of the decisions of various managerial areas. During university education, specific areas of business management are taught within independent courses; as a consequence, students often get the impression that these are completely independent areas, and that decisions in specific areas do not influence each other, and can therefore, be made in isolation, without requiring coordination.

The initial version of the BizArena simulator was developed based on traditional microeconomic assumptions—the company's primary goal is to maximize profit without taking into account the sustainable development principle:

- The production aspect has the form of the Cobb—Douglas function: the manufacturing cost depends on the human labor cost and the capital cost.
- Labor effectiveness depends on the number of employees, remuneration, and additional benefits and training; however, the labor supply (number of employees available to be hired) is unlimited.
- The number of components necessary to complete the final product is unlimited, and the component price is fixed.

Virtual business simulators must introduce some type of simplification in relation to the business reality due to the fact that they are used during university classes—players, being students, must be able to make managerial decisions within a limited time frame resulting from the duration of classes or the time between sequential classes.

In summary, the initial version of the BizArena simulator is a business-oriented virtual game dedicated to higher education, with the logic of managerial decisions being assumed by students-players, as presented in Figure 1.

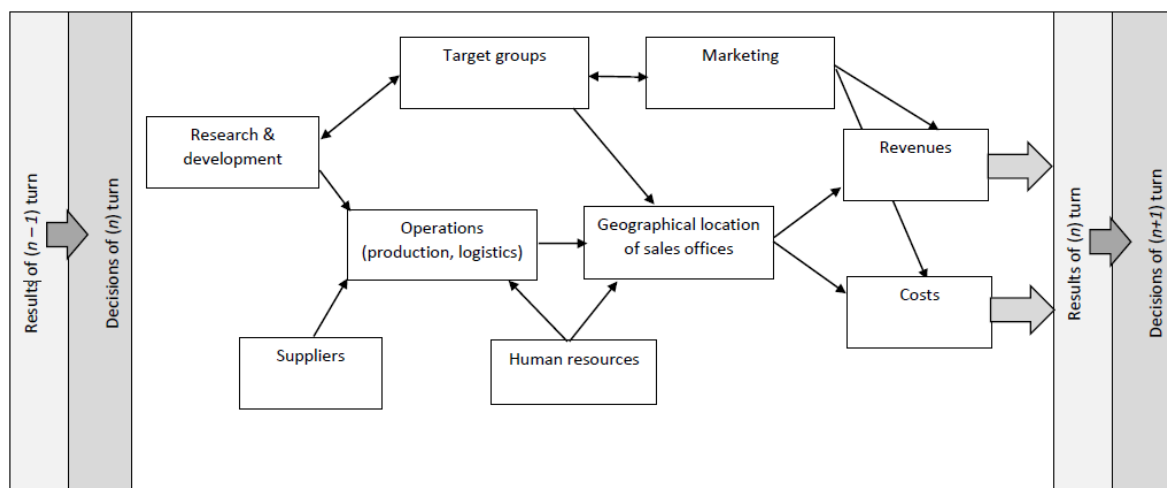


Figure 1. The logic of the business-oriented version of the BizArena business simulator.

To implement the concept of sustainability into the virtual strategic game, the new version of the BizArena simulator was adopted. The initial assumptions were modified to take into account the sustainable development paradigm and thus, to educate students and make them aware of the need to favor that concept in business management. The implementation of sustainability was achieved through several aspects.

First of all, sustainability aspects are introduced in a softer and more strategic manner through a change in the scenario of the game to incorporate a discussion on sustainability into the main narration of the management classes. In the initial version, scenarios were based on environmentally neutral assumptions, but for our study, we developed a scenario using both environmentally sensitive products and target groups. Electric scooter

production is the industry represented in the sustainable-oriented version of the BizArena simulator, enabling the discussion of different issues related to the environmental aspects of transportation. To simplify the process of brand design, the sustainable-oriented version of the BizArena simulator assumes that the products are composed of three components, which refer to the materials, batteries, and the design. Two of these components are connected with some environmental aspects; the eco-friendliness and recyclability of the materials is the first component, and the durability, capacity, and recyclability of the battery is the second component. In the game scenario, some level of sustainability awareness is also implemented into the description of all the assumed target groups; however, two of the four target groups are much more oriented towards ecological sensitivity.

Second, the adoption of the game engine, being the software of the game, was also made based on the following assumptions:

- A progressive environmental tax depending on the manufacturing volume has been introduced.
- The cost of production factors is variable; in particular, the cost of materials and components is variable and depends on the demand volume.

We implemented these assumptions to solve the productivity versus sustainability dilemma. The increase in production over a certain level causes the increase in the processing of raw materials and necessitates the payment of environmental taxes. Through these two aspects, we restrict the students' decisions, to some degree. Students could reach higher productivity, but higher productivity is connected with higher expenses in our simulation game, due to the necessity of maintaining a sustainable perspective.

The environmental tax is progressive, and it is calculated on the basis of manufacturing volume; the unit of the tax amount increases in ranges within the increasing manufacturing volume. The mechanism for determining the environmental tax in the game, based on the scenario of manufacturing electric scooters, is presented in Figure 2. The tax is deducted after each turn, and it reduces the company's income for that turn. The teacher conducting the game receives full information about the amount of tax calculated for all playing teams and can change the range levels and tax rates applicable for the next turn.

Sustainability: Production tax

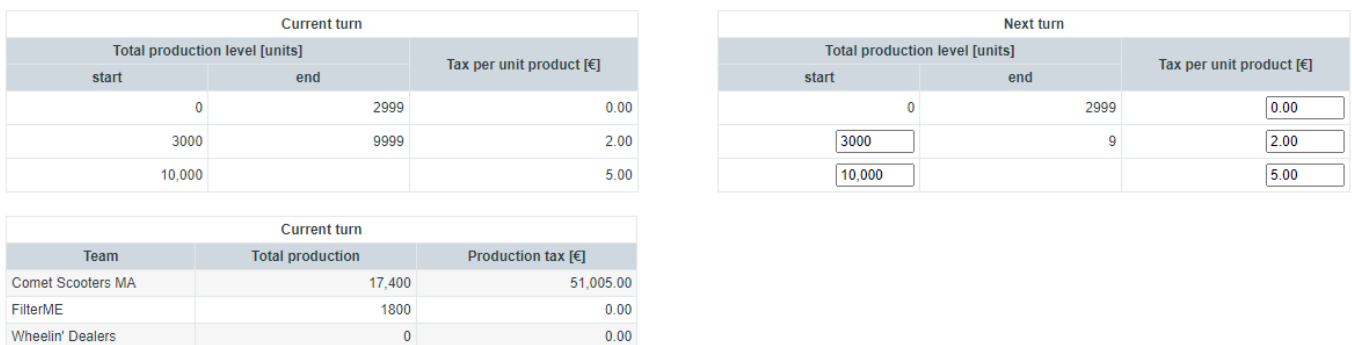


Figure 2. The mechanism for determining the environmental tax in the BizArena business simulator.

The pseudocode depicting the core of the algorithm for calculating the environmental tax is presented in Figure 3.


```

function calculate_production_tax(player) {
    total_production = 0;
    for one_line in player.all_manufacturing_lines {
        total_production += one_line.production;
    }
    component_demand = total_production * COMPONENT_PRODUCT_RATIO;
    production_tax = 0;
    for i = 1 to TAX_RATES.length {
        lower_limit = TAX_RATES[i].lower_limit;
        upper_limit = TAX_RATES[i].upper_limit;
        unit_tax = TAX_RATES[i].unit_tax;
        quantity = component_demand < lower_limit ?
            0 : min(component_demand, upper_limit) - lower_limit;
        production_tax += quantity * unit_tax;
    }
    return production_tax;
}
    
```

Figure 3. The pseudocode of the algorithm for calculating the environmental tax in the BizArena business simulator.

The prices of the components and materials needed to manufacture the final product are variable and depend on the current demand generated by players in a given turn. The component pricing mechanism in the game based on the scenario of manufacturing electric scooters is presented in Figure 4.

Sustainability: Component demand

Team	Production line				Product				Production Quantity	Total component demand		
	Name	Size	MAT	BAT	Name	MAT	BAT	DES		MAT	BAT	DES
Comet Scooters MA	Line Eco Scooters 1	large	9	9	Comet Eco Scooters	8	8	4	5000	40,000	40,000	20,000
	Line Fashion Scooters	large	7	7	Comet Fashion Scooters	6	6	9	9500	57,000	57,000	85,500
	Line Value Scooters	large	4	6	Comet S-Value Scooters	2	4	2	2900	5800	11,600	5800
FilterME	Line 2	small	9	9	SolarX	8	8	6	1800	14,400	14,400	10,800
Wheelin' Dealers	Production Line 1	small	8	8								
								grand total:	19,200	117,200	123,000	122,100

Supplier	MAT prices [€]				BAT prices [€]				DES prices [€]			
	init	max	current turn	next turn	init	max	current turn	next turn	init	max	current turn	next turn
China Motor Parts Inc	2.00	10.00	5.68	<input type="text" value="5.68"/>	4.00	8.00	8.00	<input type="text" value="8.00"/>	5.00	7.00	7.00	<input type="text" value="7.00"/>
Jumac Industries	3.50	10.00	9.94	<input type="text" value="9.94"/>	3.50	8.00	8.00	<input type="text" value="8.00"/>	4.00	6.00	6.00	<input type="text" value="6.00"/>
PaxWater	3.00	12.00	8.52	<input type="text" value="8.52"/>	3.50	8.00	8.00	<input type="text" value="8.00"/>	4.50	5.00	5.00	<input type="text" value="5.00"/>

Refresh data

Figure 4. The component pricing mechanism for the BizArena business simulator.

In this scenario, three components are required to manufacture electric scooters: MAT (materials), BAT (batteries), and DES (design). The components are provided by three suppliers, where each supplier has a different price for each component. The range of price changes is specified by the initial and max values. The final price for the next turn is determined on the basis of the grand total demand generated by all players in the current turn. The component pricing protocol is presented in Figure 5.

```

if total demand for manufacturing components exceeds MAX_DEMAND units
then
  for every increase of demand by DEMAND_INC [%]
  the next turn component's price will be increase by PRICE_INC [%]
    
```

Figure 5. The component pricing protocol for the BizArena business simulator.

The implementation of this protocol in the game based on the scenario of manufacturing electric scooters is presented in Figure 6.

Demand adjustment protocol

If total demand for manufacturing components exceeds units

then

for every increase of demand by %

the next turn component's prices will increase by %

Recalculate ☰

Figure 6. The component pricing protocol in the game based on the scenario of manufacturing electric scooters.

The pseudocode depicting the core of the algorithm implementing the component pricing protocol is presented in Figure 7.

```

function calculate_component_price(component_total_demand) {
  demand_inc_factor =
    (component_total_demand / MAX_DEMAND - 1) / DEMAND_INC;
  price_inc_factor = demand_inc_factor * PRICE_INC;

  next_round_price = round((1 + price_inc_factor) * INIT_PRICE, 2);
  if (next_round_price > MAX_PRICE) {
    next_round_price = MAX_PRICE;
  }

  return next_round_price;
}
    
```

Figure 7. The pseudocode of the algorithm implementing the component pricing protocol in the BizArena business simulator.

In summary, the implemented aspects of the sustainability-oriented version of BizArena simulator are highlighted (in grey and bold) in Figure 8.

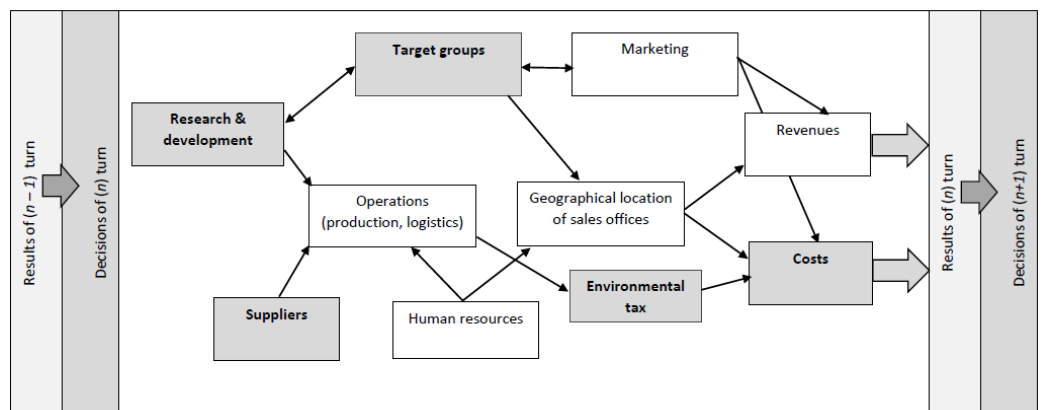


Figure 8. The logic of the sustainability-oriented version of the BizArena business simulator (sustainable aspects highlighted in grey and bold).

3.2. First Insights of the Testing Students

During the spring semester of the academic year 2020/2021, between March and June 2021, a group of students at the Poznan University of Economics and Business, Poland, participated in the management course of based on the sustainability-oriented version of BizArena simulator. They were international students, studying in the third (last) year of bachelor's study in the international business program. The testing group consists of 18 students, including 10 men and 8 women. The students were divided into 5 teams, with 2–4 people in each group; however, the students chose their own teams, based on their preferences and previous experience.

Within the course, as the students proceeded through the simulation game, they were expected to establish and run a virtual company, competing with each other during 10 decision turns. Their initial situations were the same; but with the progress of the game, the situation of each team changed, depending on both the quality of their own decisions and the quality of their competitors' decisions. The general workflow of the students was as follows: after the presentation of the game logic and the scenario description, students determined their business strategy, mostly aimed at the target customer groups and the development plan; then, the students made a set of managerial decisions for each of 10 decision turns; finally, they were expected to make the final presentation of their strategy and its subsequent results. The students also met with a teacher weekly to explain their doubts and to discuss their current progress. The final grades of the students for this course depended partly on their weekly activities, but also on the results of the game for the aspects of revenue, market share, and financial cashflow.

The insights regarding the possibility of implementing aspects of sustainability into business higher education through the use of strategic games come from both qualitative (discussions with the students) and quantitative (game results) sources.

Discussions with the students, both through the whole semester and at the final presentation at the end of the course, revealed that all the students referred to sustainability when they presented their business strategy. The students determined to focus on the most environmentally oriented target groups, to create environmentally friendly product brands, and to restrict the development of their virtual companies with the respect of limited resources. However, when comparing these declarations with the decisions made by the students, some doubts arise. Looking at virtual brands designed by the students, there were two components that referred to environmental and sustainable aspects: materials and batteries. While designing their brands, the students were supposed to assign a value from 1 to 10 to these components, meaning that the higher value is related to the higher level of eco-friendliness; however, the costs of production are also higher. In total, the students created 21 brands, where the average value of the materials' component was 5.6 and that of the battery component was 6.5. Out of 21 brands, in the case of 12 brands, the value of the materials component was higher than 5, and in the case of 13 brands, the value of the battery component was higher than 5. This means that at the declaration level of strategy, the students were very open to considering sustainability. However, when it came down to real decisions, they combined these strategic declarations with the costs of production and attempted to find a compromise. Sustainability was seen in the students' declarations, rather than in their manner of making decisions.

Looking at the environmental tax and the mechanism of the increase in component prices, only one out of five teams of students realized that sustainable aspects impacted their financial situation and tried to adjust their decisions. The problems regarding component prices and taxes were discussed with this team during weekly meetings. Other students did not discuss these aspects, although they might not have been aware of them, as their scale of virtual production was much lower and less impacted by taxes and increases in components prices. However, looking at the same aspects from the point of view of the game results, in the cases of three out of five teams of students, the prices of components increased twice, on average, because of the increase in the demand for the components.

Two out of five teams paid environmental taxes, but their level was rather low, compared to the revenues, and therefore, might not have been deeply analyzed.

Some of student teams struggled to understand all the interactions among business decisions in the game, and for this reason, sustainability aspects could only be presented to them indirectly, using the scenario with a specific product, components, and target groups of virtual customers.

4. Discussion

The anthropogenic character of changes in the climate and the natural environmental requires a shift in the way society thinks and acts, especially in the business context, requiring the implementation of sustainability into business higher education [5,6]. The challenge of this implementation comes from the fact that business education focuses on profitability, emphasizing the importance of the economy of scale, while sustainability is related to responsible production and consumption, often translating into the reduction in both. The educational challenge is related to the dilemma between productivity and sustainability, highlighted by the value-creating and value-destroying theories [30]. In the paper, we aimed to discuss these issues from the perspective of a virtual business game, dedicated to business students, simulating the running of a company. The use of game-based learning, especially business simulators, is a promising educational method; by pushing students to make a set of managerial decisions and allowing them see their results, this method allows students to understand the complexity of these interactions.

We proposed pseudocodes reflecting aspects of sustainability to be implemented into the game engine; namely, that sustainability is related to environmental taxes, depending on the volume of production and the mechanism of an increase in the prices of raw materials, depending on the demand growth. Our conceptual model can be used as a guideline for the developers of educational games, suggesting ways to design and implement such a simulator. We also introduced sustainability into the game scenario, mostly in the description of product lines and target groups. We tested these solutions with the initial group of test students who participated in the simulation.

After analyzing and observing the students' behavior while engaged in the virtual game, we came up with the following conclusions. First of all, we found it a challenging task to find the best way of integrating the business logic and sustainability logic together in one virtual game. Both logics consist of many different aspects that are not easy to combine in a single virtual game. By implementing sustainable logic into business logic, we made the simulation far more complex, which, on the one hand, reflects a real-life dilemma, but, on the other hand, makes it more difficult for students to understand.

The challenges faced by the students in integrating business and sustainability logic into the decisions made during the business simulation game confirm the multi-dimensional and complex nature of sustainability [14]. Our observations are also in line with the belief that simulations facilitate the cross- and interdisciplinary learning of students [56].

Our observations also confirm the benefits of some features of business simulation games, such as experiencing managerial roles in quasi-real situations [48,50], making and modifying a business strategy using a trial-and-error method [51,52], and receiving real-time feedback on the results [48].

Second, the students' difficulties with understanding the virtual game could be explained by the fact that most of their previous courses had been focused on the separate aspects of management and business, for instance, economics, marketing, and management. In the case of the virtual game, several business aspects were implemented together, so students experienced difficulties applying their theoretical knowledge in making business decisions. As sustainability is a broader concept, it is difficult to add it to the virtual game by adopting some aspects of sustainability in business decisions. Thus, the main challenge that we noticed is the integration of all aspects of business and sustainability in one virtual game. In order to do so, it would not only require additional programming work, but also

a high level of understanding of both concepts among students in order for them to be able to apply their knowledge in their business decisions in the virtual game.

One possible solution would be to combine the virtual game with discussions or case studies on sustainability-related business aspects, which could provide students with a better background in the field, and then allow them to use this knowledge in a practical way through the virtual game.

We also face some limitations in our paper. As we aimed to combine the discussion on programming and the educational aspects of our simulator, we limited the students' outcomes regarding their first insights. Further research requires deeper qualitative and quantitative analyses of students' outcomes in understanding the aspects of sustainability in businesses with the use of simulators. Special attention should be given to the comparison of understanding sustainable aspects of management with the use of a business simulation game and other educational approaches. Another drawback of our research is related to the fact that it was restricted to a one-university perspective. To overcome this limitation, further research should include the feedback and outcomes of students from different universities.

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