Perspectives on Computer Gaming in Higher Education

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Educating About Complexity and Sustainability Through Serious Games

Introduction

Sustainable development is becoming a pressing matter these days. It can be defined as *"development that meets the needs and aspirations of the present without compromising the ability of future generations to meet their own needs"* (World Business Council for Sustainable Development). It is usually viewed as a challenge for society as a whole. We have to remember that business entities are also an important part of the economic system, and therefore, they are a key element of transition towards a sustainable future.

Our paper aims to present the problem of sustainable development education in light of the complexity of the issue and potential usage of serious games in the learning process.

We postulate that dilemmas connected with sustainable development arise from the complexity and interactions, both current and historical, between stakeholders and other people or institutions involved in the process and environment. Such coupled issues create challenges in the education process that can be addressed through simulations and serious games.

Our paper is organized in the following way: the second part is focused on sustainability and corporate social responsibility, the grounding of theories and empirical research in the field. The third part refers to the literature review of the learning process and system complexity, while the fourth part presents examples of serious games as suitable tools for education purposes on complex issues. The fifth part summarizes and concludes.

Sustainable development – theoretical background and empirical evidence on importance for the business

For companies, sustainability and corporate social responsibility can play an important role in foreseeing environmental conflicts and distributional conflicts, and can be defined as taking actions which reduce the extent of externalized costs or avoid distributional conflicts (Heal, 2005).

According to Porter and Kramer (2006), there are four arguments that companies use to make the concept eligible:

1. Sustainability (economic, social and environmental performance). According to this, companies should operate in ways that secure long-term economic performance by avoiding short term behaviour that is socially detrimental or environmentally wasteful.
2. Moral obligation is understood as the duty of companies to be good citizens; for example, by operating within the law, such as honestly filing financial statements.
3. License to operate is the most pragmatic approach of the four mentioned. Companies identify and choose only those social issues that matter for their stakeholders and make decisions about them.
4. The reputation argument is used by companies to justify CSR activities as those which will improve company's image, strengthen its brand and enliven morale.

Referring back to the major goal of a company's existence, shareholder wealth maximization theory stands in opposition to stakeholders' wealth maximization. Initially, Friedman (1970) stated that the only goal of a company is to maximize shareholder's wealth. This theorem was followed by many, including Aupperle et al. (1985), who presented the opinion that firms implementing CSR policies and activities can get distracted by adopting additional goals, which can then lead to a negative impact on their profitability. Shleifer (2004) also argued that acting towards stakeholders' satisfaction is considered counterproductive from a purely financial standpoint.

While proponents of the stakeholder wealth maximization theory (Freeman, 1984; Donaldson, Preston, 1995) present the standpoint that ethical behaviour and profit are not mutually exclusive. Although money spent on ethical issues is not paid to shareholders over the short term, it might enable the firm to be more profitable in the future. Ethical behaviour can lead to reputational advantages, such as attraction of sensitive consumers (Guenster et al., 2010) and investing in the moral area can be seen as an opportunity to protect the firm against future risks (Godfrey, Hatch, 2007).

Following the theoretical discussions, much empirical research has been conducted in order to test whether imposing additional (CSR) goals on firms distracts them and reduces profitability, or if it has the contrary effect and improves financial performance. To date, more than 100 studies have examined whether corporate social responsibility (CSR) metrics predict or impact financial performance, with a variety of results. There are several studies that attempt to compare

previous findings, among which are Margolis and Walsh (2003) and Margolis et al. (2007). These studies show that a clear conclusion about relationship between CSR and financial performance has not been reached. Elsayed and Paton's (2005) study lists potential sources of biases and problems in the previous studies that might cause inconclusive results. Additionally, problems lie in specifics of the business, i.e. type of industry the company comes from. The research of Daszyńska et al. (2016) show that companies from every sector react differently to CSR performance in terms of value effect; what is more, some sectors are totally immune to any CSR activities, like, for example, the telecom industry.

It can be concluded that acting responsibly towards sustainable development is beneficial not only to the environment and society, but also to companies that implement such strategies and perform in that field. This brings us to the postulate that employees and future employees (students) should get a thorough education on sustainability and its potentially beneficial impact on the contextual environment, as well as on the company itself.

Due to the fact that sustainability is related to many interactions and feedback between various stakeholders, resources and the environment, it can be identified as a system with extended complexity. Complexity and couplings within the system make it hard to understand, even by experts in the area. An inability to grasp the system as a whole leads to "*local optimizations*" and "*green washing*"[1], situations where undertaken actions cannot solve problems on a larger scale.

System complexity and educating on sustainability

Systemic changes require a deep understanding of system's dynamic complexity. This type of complexity emerges not from the number of elements involved, but from interactions between them. Such problems require in-depth analysis of the dynamics of the system – feedback between its components and delays in its reaction to stimuli (Senge, 1998). This poses a challenge to the traditional education model. The problem of detail complexity can easily be addressed by lectures. Bullet points or schemes are great when it comes to disassembling the problem into small parts that are easy to grasp by the learners. This makes them the perfect method of presenting knowledge in an abstract and condensed way. Unfortunately, the lectures are not as effective when it comes to demonstrating the dynamics of the problem.

Even presenting historical data and documented interventions into the system may not be adequate. Dynamic systems, such as companies or organizations nested within their environment, tend to be chaotic. The complexity of interactions and feedback result in an inbuilt sensitivity to initial conditions (Fullilove et al., 1997). Even if the opening situations are similar, the small differences at the beginning can lead to divergent states of the system. Further complexity

1 It's greenwashing when a company or organization spends more time and money claiming to be "green" through advertising and marketing than actually implementing business practices that minimize environmental impact (definition from: http://greenwashingindex.com/about-greenwashing/).

is added through 'soft' elements of the problem, meaning human interactions within a given context. Optimizing the 'hard' component of the system can be challenging and requires much effort. When human behaviour is added to the equation, it may seem to be close to impossible. Unfortunately, people do not act as rational optimizers (Lane, 1992). Clashes of worldview, attitudes and motives may cause problems that cannot be easily solved (Senge, 1998).

The problem of mapping such interactions can be addressed by using specialized representations of the problem; for example, causal loop diagrams (Senge, 2002). Regrettably, they are still abstract, and, in a way, 'static'. This means that even most accurate diagrams tend to be hard to grasp due to the limited ability of the human mind to process data. Understanding how the system operates require 'seeing it in motion' and analysing how it reacts to changes in parameters.

This experience and observation are present as important elements of Experiential Learning Theory (ELT). According to its principles, learning should be treated as a process that enables students to refine their knowledge of the subject. To be complete, it requires four fundamental components. One of them is Concrete Experience which allows student to experience reality related to the subject. The next step is Reflective Observation, where the participant studies the results of his or her actions made in previous stage. Such contemplation is required for Abstract Conceptualization, which is the process of transforming conclusions into theories about the problem. These concepts have to be tested through Active Experimentation, which leads once again to Concrete Experience. These four components create the cycle that enables the student to experience the issue, create his or her own ideas and theories about the problem and test them in practice. All its elements have to be present for the learning process to be most effective (Kolb, Kolb, 2005).

According to ELT, including experience and experimentation into the process of education about sustainability can improve students' knowledge about the

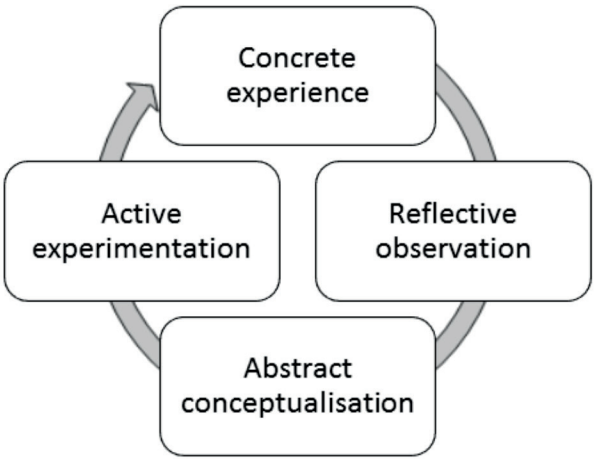

Fig. 1. Key components of Experiential Learning Theory (Kolb, Kolb, 2005)

subject. Unfortunately, such observations and testing ideas in real life would require enormous amounts of money and time. That makes them impossible or close to impossible to conduct. The solution to this problem may lie in computer-aided simulation. Maps of the problem, such as the aforementioned causal loop diagrams, can be translated into a set of rules mimicking the real-life behaviour of the system. It can be used as a model that can be subject to students' interventions (Senge, 2002).

Early examples of such learning aids, based on simple non-computer models, were already introduced in the 1950s when th Rand Corporation created the *Monopologs* game that concentrated on inventory management (Renshaw, Heuston, 1957). A study conducted by Faria that analysed usage of serious games in AACSB schools (The Association to Advance Collegiate Schools of Business) has proven that they are getting more popular over time, especially in Business Policy, Marketing, and Management courses (Faria, 1998). Serious games enable participants to make decisions in safe, simulated environment and experience their results (Barreteau et al., 2001). As opposed to the real world, the resources used are virtual, and time can be compressed, but the outcomes imitate real responses of the system. Therefore, they can be used as models of reality for the Concrete Experience and Active Experimentation elements of the ELT (Daré, Barreteau, 2003). In general, they enable people to test their ideas and learn from their mistakes without endangering real companies and organizations.

As mentioned before, such experience is a key factor when it comes to learning about dynamic complexity. Computer simulations have been present in this area from early the 1990s, when they were introduced as a part of systems thinking workshops (Senge, 2002). As they are established methods of showing people problems and opportunities connected with dynamic complexity, they should be the first choice when it comes to educating people about broadly-defined sustainability. As challenges associated with implementing sustainable business solutions are the result of multiple interactions and feedback present in such coupled systems (Fiksel, 2006), the participants should have the opportunity to face them.

Computer simulations can be responsible for dealing with 'hard' components of the modelled system. Nowadays, hardware is able to calculate numerous parameters and variables almost instantly and present them to participants in a user-friendly, graphical form. On the other hand, introducing the 'soft' elements is the result of actual interactions between students. Their aim is to act as they would think they should behave in real-life simulation, dealing with different access to information, various responsibilities and interconnections between the roles. This type of multi-player computer-aided simulation can create the most accurate representation of the coupled system that can be introduced in classroom or during the workshop. It engages students in social learning that emphasizes need to deal with differences in opinions and divergent views of the problem. An inability to create an effective discussion process that leads to transparent decisions may create a situation when the outcomes of the system are suboptimal and unsatisfying for the stakeholders (Pahl-Wostl et al., 2007).

All of these elements are present in workshops that use serious games. Even though the situation is simulated, people tend to act out their roles. This gives them the opportunity to experience the behaviour of both 'hard' and 'soft' components of the system in a workshop environment. They are able to test their ideas and get immediate feedback about their results instead of waiting for weeks, and even years, as in real life. This can be later used for reflection that can lead to better understanding and redefinition of the problems encountered. Therefore, it is a great way to introduce experience-driven learning in the area of sustainability to academia.

Serious games – educating for sustainability

There are many different serious games that can be recommended for higher education and business training. Choosing the right one for the university curriculum requires considering both the alignment of the activity with the topic of the course and the time required to conduct it. Therefore, we would like to present some examples provided with descriptions that specify in which context the specific game can be most useful.

One of the examples of a serious game that simulates a real-life business situation with different responsibilities and various access to information is the Green & Great game. It aims at getting participants involved in managing a consulting business and allowing them to make successful business decisions not only in the scope of profitability, but also in sustainability matters.

In the Green & Great game, participants play the roles of managers of a large consultancy company. The major goal of the activity is to ensure the growth and economic position of the organization. There are a couple of stages of the game connected with the advancement of the contextual environment in the scope of a low-carbon economy, CSR, and sustainable development. Playing the game allows participants to acknowledge that the environmental and social reputation of the company can be a crucial factor in creating a business advantage over competitors. It also puts emphasis on the idea that running a successful business requires creating and implementing a long-term company-wide strategy, rather than focusing on occasional, one-shot actions that do not have a lasting effect. The game addresses this problem by using a complex reputation system based on The Sustainability Compass created by the AtKinson Group. Players have to plan and perform their actions carefully, balancing between the long-term vision of the company and current operational and economic performance. Additionally, the competitive environment is created by participants themselves, as their groups represent different companies on the market that have the same target to bid for the same set of projects and then to implement it. Participants run external business projects as well as internal project that engage their employees. Human resources management and proper training and remuneration policy are some of the challenges of the game. Missing out on high-impact projects can create a serious handicap in achieving goals set by the player. It has consequences for the following business opportunities and limits the ability to generate profits.

Participants get involved in the game very quickly; they have to put forth a lot of effort in order to grasp all the nuances of business operations simulated by the game. Finally, they are rewarded by gaining positive economic result as well as through reputation points in all the required fields under the condition that they understand how important it is to work in all reputational fields and adjust the business to a growingly competitive environment in the field of sustainability, a green and not brown economy. The game aims to change the mindset of the participants and draw their attention to the complexity of business operations and long-term strategy, which includes sustainability of the business performance. Green & Great was introduced to many workshops in academia, as well as business. It was played at the Wrocław University of Economics, Corvinus University from Budapest, Lufthansa trainees, EIT+, as well as during the workshop "Creative and Responsible: Sustainable Business as a Source of Competitive Advantage". The workshop was a part of the European Week of Creativity conference for small and medium enterprises.

Ecopolicy® is a simulation that emphasizes the complexity and interconnections that have to be dealt with when governing the country as a whole. It emulates the various aspects of running the state, such as politics, production, environmental pollution, quality of life, education and population. The game is aimed at showing how actions undertaken in one area can influence the dynamics within the system as a whole (Vester n.d.). Social and environmental aspects implemented in the game are as important as the economics. Therefore, finding balance between these elements is the key to success.

In this game, players assume the role of the leaders of fictional country of Cybernetia. They have to work together to decide about policies and their implementation. Their performance is measured by KPIs. During the game, participants not only learn about how to deal with the complexity in the context of managing the state, but also about group decision making. The 'soft' aspect of the system is emulated by their interactions and it is their goal to make their teamwork effective. They learn how to present complicated information in simple ways and also how to work on common agreement (No Rules Just Words, 2013).

Ecopolicy® was already introduced in multiple workshops and academia. It was presented to various governing bodies, such as local authorities, as a learning tool. Furthermore, it is the key element of the ecopolicyade®, the international student tournament where groups of participants compete with each other to find out which of them is the best government of Cybernetia (Malik, 2011).

Another example of serious game developed for education in the area of sustainability is Energy Transition Game. It puts participants in the roles of various actors taking part in the process of shifting from fossil fuel energy production to renewables. The game presents multiple aspects of such a transition. It emphasizes the fact that implementing systemic change cannot be done by just introducing new technologies to the market. It emphasizes interconnections between actors and stakeholders that are typical of *technological systems*, where they have to function within a given institutional arrangement and technological regime (Geels, 2004). The Energy Transition Game can simulate situations where in-

novation cannot spread through the system because it does not have support from the authorities or society, or because it lacks the necessary scientific advancements. Only if all these elements are aligned can the transition be successful. When some of them are absent, it may result in spectacular failure (Yergin, 2014).

In the game, this problem is emulated through enabling participants to play various roles. They can be energy producers, technology developers, energy distribution company, different NGOs or various departments of the government. Each of them have a different range of responsibilities, possible decisions and goals. Some stakeholders compete with each other for the shares of the market. Therefore, the initial setting of the game is aimed to reflect the real diversity of roles and attitudes that is present in real life. The system, as a whole, is unstable. Introducing no changes can result in damages connected with climate change. On the other hand, introducing small, uncoordinated changes can result in failure. For example, the government can push forward the change for renewables, but without the advanced technologies that enable production and storage of energy, it may result in blackouts and infrastructure failures. On the other hand, energy producers may not be willing to bear the cost of the transition and technology developers may not be able to introduce the necessary innovations on time. Financing the change may be possible by increasing price of the energy, but doing so may cause public unrest that affects the government budget. Those are only few examples of the problems that can arise from the interconnections built into the system. Even more issues can emerge from interactions between the players. They are free to exchange information and create agreements, but different responsibilities and unclear interests may hinder the efficiency of the collaboration (Vansina, Taillieu, 1997).

The Energy Transition Game shows that a successful transition requires stakeholders to come up with procedures of sharing knowledge and data. Furthermore, it emphasizes the need to establish ground rules, participatory decision methods and transparent policies that legitimize the process of change and enables players to align their activities and effort. What is more, the computer model behind it is used to simulate the behaviour of power production and distribution system, which enables students to learn more about real-life infrastructure and technology problems connected with using renewable energy sources. The complexity of the simulation and number of aspects involved make the game attractive not only for students, but also professionals in the field.

A similar problem is addressed in the Lords of the Valley game. It was developed as a Floodplain Management Game in 'NeWater' to show the dynamics behind the transition between different river valley management regimes (Magnuszewski et al., 2010). It presents the difference between a traditional approach and the idea of 'living with the river'. The first one emphasizes building dikes to keep the water within a constrained area. It is connected with creating crop monocultures that require protection from the excess water. In the latter, all activities within the floodplain have to be changed to ones that are resilient to excess water. When there is a flood, it is allowed to flow in a controlled way

through the water distribution system and it is stored in specified areas. This approach increases the resilience of the valley economy and establishes more effective flood mitigation measures on the scale of the whole river (Stefańska et al., 2011).

The game presents a stylized version of the systemic problem and possible solutions based on the real-life case of Tisza River in Hungary (Stefańska et al., 2011). Similar ideas were also tested in the Netherlands ('Room for the river' programme) (Wiering, Arts, 2006) and Germany (Huang et al., 2007). The core of the problem is similar to the one depicted in the Energy Transition Game. Systemic change between regimes requires cooperation between various groups and stakeholders.

In this case, farmers tend to specialize in crops cultivation, which enables them to earn the most. On the other hand, this type of production is susceptible to excess water. This means that they are prone to put pressure on building the dikes that protect their fields from floods. Such investments, as well as the ones connected with an alternative management regime, are developed by a water board that is financed from taxes gathered by local authorities. Therefore, these roles are dependent on the economic level. When the weather conditions are stable, none of the roles has an incentive to change the management regime to be more adaptive and bear the transition cost. This creates a situation where participants tend to become entrenched in their initial positions. When the situation becomes uncertain and weather conditions become more extreme (severe floods and draughts that may be attributed to climate change), players are faced with the decision to invest even more in the current management regime or change it. Unfortunately, changes have to be coordinated. One stakeholder cannot proceed with the transition on his or her own – it always results in lower income or property damage (Stefańska et al., 2011). Two remaining roles – NGO and bank – are not initially connected economically with other players, but with their financial resources may play the key role in triggering or hindering the process of transition.

Therefore, the Lords of the Valley game can be used to educate students about implementing systemic changes. Even though it simulates economic and environmental situations in the floodplain, it can be used in other contexts, as the social aspect of transition process is most prevalent. As such, it was presented to various groups of participants that require first-hand knowledge about introducing changes on systemic scale (CRS 2013a, CRS 2013b, CRS 2015).

Finally, many companies have to deal with sustainable use of limited resources. The ability to assess, secure and utilize them among all projects or departments may be key factors to ensure the constant growth of the organization (Mishina et al., 2004). The issue of management of commonly-owned goods is a key problem in the About That Forest game. It puts players in the roles of members within a small community. They, as a group, have the opportunity to take part in the process of managing a common forest. Each person has incentive to cut the most of it to maximize his or her own profit. At the same time, the amount of resources is dynamic. The next round's amount of resources depends on how much was

left after the harvest in the previous round. The more they cut, the fewer new trees appear. Furthermore, the forest mitigates the floods by absorbing rainfall. Its destruction can not only endanger the future income of the community, but can also lead to losses from property damage.

Even though this model may seem to be quite simple, its dynamics can create a complexity that is hard to be addressed in formal way (Pajak, 2015). The community as a whole can benefit from restricting their harvest, as it guarantees sustainable growth and gives all players protection from the floods. On the other hand, each player has incentive to cut the most. This strategy maximizes profitability while benefiting from protection. Therefore, the community as a whole has to come up with management strategies that secure their long-term growth. The game gives participants mechanisms that enable them to vote on laws regarding the use of the resource as well as means to enforce them. Introducing them may improve the chances of achieving the sustainable growth (Ostrom et al., 1994). Still, they have to be selected and accepted by the whole community. Even if rules are legitimized by voting, none of the players can be forced to obey them. He or she can receive sanctions for not cooperating, but only wide collaboration can result in reaching the optimal result for the community.

Therefore, the game uses a simple model to present the problem of reaching common agreement about managing resources. In this case, the social dynamics of change are the most important. The context, due to the simplicity of the simulation, is only relevant as it presents players with the dilemma of choosing their own benefit over the long-term wealth of the community.

As mentioned before, there are other serious games that can easily be introduced into academia or can be adapted to be used in such context. Teachers can find other examples of games aimed at teaching students about sustainability online. There are several websites and blogs that gather information about them. For example, 'Learning For Sustainabilty' (http://learningforsustainability.net/online-games/), 'Games For Change' (http://www.gamesforchange.org/) or 'Games4Sustainaiblity (http://www.games4sustainability.org/), to name the few. Such websites can be treated as hubs when it comes to searching for new educational opportunities.

Summary and conclusions

Introducing serious games similar to those presented in this article into academia can create new learning opportunities for students. They are new way of influencing the attitudes of participants and creating engagement, which is crucial for traversing through the whole cycle of learning as introduced in ELT. This idea is supported through the results of the surveys gathered for the 'Green games' project. It was aimed at introducing serious games in education about sustainable development and ecology at the high school level. In this project, educators, such as librarians and NGO workers, were given the opportunity to use various examples of this type of games in their workshops and were asked to assess their effectiveness. It turned out that 76% of the people who took the part in the

survey were positive that using serious games influenced students' attitudes towards environmental issues (Q1). Furthermore, the survey showed 82% of that educators agree that students become more interested ecology (Q2) and 92% are sure that using them created room to reflect on the results of the game (Q3). 97% of the people that filled out the questionnaire agreed that learning through entertainment is more effective (Q4). Educators were also positive that workshops that used serious games improved students' knowledge in area of climate change (87%, Q5), value of ecosystem services (85%, Q6) and biodiversity (84%, Q7) (Hutniczak, 2016).

The games presented in this article are only few examples of wide range of serious games that can be used in academia to teach students about sustainable development. Their common denominator is the way they approach the issue, addressing the complexity connected with system approach. Furthermore, each of them puts emphasis on the social aspect of transition towards sustainable solutions. It can be the reputation in the society and employees' satisfaction within the company, as in the Green & Great game or the much more complex problem of finding common ground and discussing possible solutions with multiple stakeholders. Regardless of the scope each of them gives students a unique opportunity to become part of the change process, to affect it and see how it unveils.

Such participation (even if it is only within the simulation) and the possibility to reflect on it is a cornerstone of the Experiential Learning Theory. Using this concept enables teachers to find appropriate place for serious games. As they can be used as a part of only two of the four components of the ELT, they are meant not to make lectures obsolete but to support them. Serious games can be used before them or after the traditional presentation of the theoretical knowledge. In the first case, the theory is derived from the experience. In the latter, students are able to test their knowledge about the subject in a simulated environment

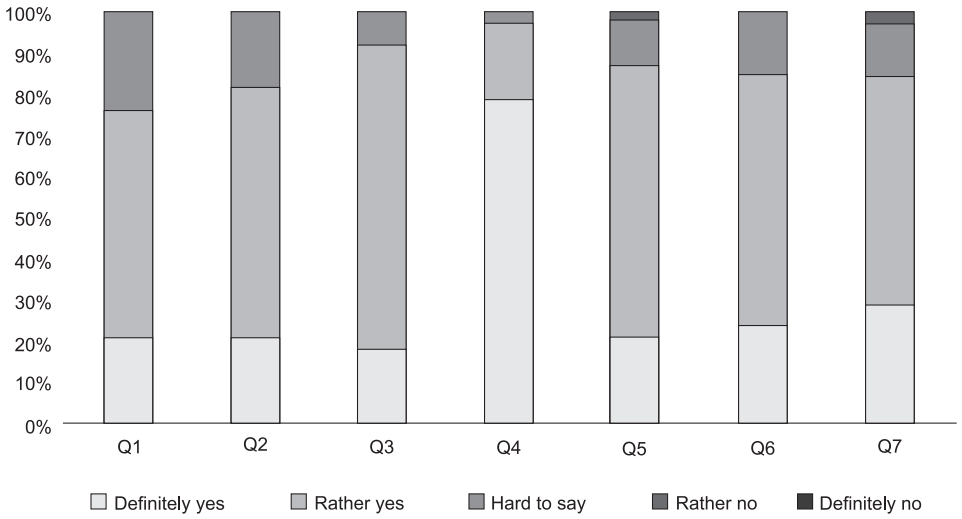

Fig. 2. 'Green Games' project survey results (Hutniczak, 2016)

and to try out ideas they know from the lectures. Still, according to the principles of ELT, the most beneficial way to introduce serious games would be to use them within the Concrete Experience and Active Experimentation parts of the learning cycle. If the course schedule allows it, they can be used multiple times. In this case, participants can learn from their experience, test their ideas for the solutions and repeat this problem in several iterations. This approach would be mostly beneficial for the students, yet may be more demanding from the course schedule point of view.

Furthermore, most of the serious games can be modified by changing parameters, initial conditions or creating asymmetric access to information. This can be used to change the relative power of stakeholders and introduce new dilemmas and conflicts for the transition process. This can create various scenarios for students to deal with. Introducing new variants of the games can further improve user experience when the simulation is replayed multiple times, and it enables participants to create new, creative approaches to presented issues.

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