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Article

SimCity in Infrastructure Management Education

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Abstract: Simulation games offer a safe space to experiment with system models and provide learning experiences about interdependencies and thus, are considered to foster the development of a deeper understanding of systems. This article describes the use of SimCity in the university course Infrastructure Management, which has been in continuous operation since 2002. Methodologically, a total of four events were observed. Students' motivation, the didactic scenario and the perceived learning outcomes were examined with the help of a focus group discussion and questionnaires. The didactic scenario shows characteristics not described in this combination in the literature to date: (1) the moderated open, simultaneous and competitive play in groups, (2) the used regional planning scenario and (3) the long, regular period of application of more than 15 years. The results show that SimCity 4 can still serve as a platform for exciting learning scenarios more than 15 years after its initial release. It could also be shown that the didactic scenario motivates the students and that SimCity also generates gaming fun. Furthermore, it could be argued that a regional scenario can be implemented by simple means and is perceived as motivating by the students. Furthermore, this study indicates that even a technically complex and fast-moving medium such as a computer game can be used in a didactic scenario over a longer period with limited effort. Nevertheless, the challenge of game aging should be actively addressed. Furthermore, the study revealed that game-based learning still faces challenges with being recognized by students as a serious learning activity.

Keywords: SimCity; city builder game; case study; game aging; instructional design

1. Introduction

Computer games are classified as new media and were identified early on as learning tools [1–3]. From the point of view of instructional design, digital games are also appropriate learning tools if they are used in a didactically meaningful way [4]. To this end, serious games must be designed to foster motivation and learning by also keeping the cognitive load of the player low (e.g., [5]). Simulation games are particularly appropriate as experimental environments for handling complex systems—a capability that most people find difficult [6]. In particular, simulation games for managing systems depict such experimental environments [7,8]. Pasin and Giroux [9] confirmed that the complex interdependencies of systems can be taught by simulation games more effectively than with traditional learning methods.

When choosing simulation games for didactic scenarios (the term *didactic scenario* in this article refers to the arrangement of teaching/learning activities, media and methods to achieve defined learning objectives in line with framework conditions such as time frames. Accordingly, Figure 1 shows the time structure of the SimCity didactic scenario described in this article), it has to be decided whether to use a commercial entertainment game or a dedicated serious game [10]. Both alternatives show advantages and disadvantages [11]. Commercial entertainment games are readily accessible and offer great gaming fun. One of the disadvantages is the frequent suboptimal orientation towards the learning goals (e.g., [12]). Most of the simulation models implemented in commercial entertainment games do not correspond to real systems taught. As a remedy, for example, Charsky and Mims [13] suggested that students work out the differences between game and reality after the gaming session as part of the didactic scenario. Rather, commercial entertainment games are optimized for entertainment purposes or they reflect the attitude of the developers [12,14,15]. Rufat and Minassian stated that simulation games can be used to learn the implemented models, but that the player does not necessarily connect the implemented models to the reality [16]. Together, these disadvantages lead to only a minority of the didactic scenarios being covered by commercial entertainment games at present. However, the majority of the didactic scenarios is being served by dedicated serious games [17]. Dedicated serious games, on the other hand, are better tuned to reach the learning goals intended. However, dedicated serious games usually show deficits with regard to gaming fun. Additionally, dedicated serious games often have to be created with a lot of effort, which is necessary in order to achieve the balance between fun, pedagogy and validity (i.e., being close to reality), as postulated by [18].

SimCity, initially released in 1989 [19], is probably one of the best-known and most commercially successful simulation games and has established the genre of city builder games. Its use as a planning tool has been discussed from the first release on [20]. The use of SimCity for planning can also be expanded to specific planning disciplines such as water infrastructure [12,21]. It is similarly referred to as a game thematically linked to urban planning [22,23]. The character as a Geographical Information System has been equally emphasized [24] and is also a conceptual basis of the didactic scenario presented here [25]. Since then, SimCity has also been used in various didactic scenarios, as described in [26] and proposed in [27]. Kafai and Burke [28] have highlighted SimCity as a learning tool that allows instructional learning. Lobo [24] has acknowledged a certain meaningfulness to SimCity's use in didactic scenarios. At the same time, he has confirmed that the gap between the simulation models used by SimCity and real cities is getting smaller and smaller. Nevertheless, he has been rather critical in his overall conclusion about the possibilities of using SimCity as an educational tool: planning and gaming are mutually exclusive from his point of view. For example, he claimed that restrictions result from the fact that the simulation models are operated as a closed black box, i.e., on the one hand, the effective interconnections are not directly visible, and on the other hand, the interconnections cannot be changed by the lecturer. In his argumentation, he refers to Friedman [29], who has already stated that the essence of a game is the demystification of the underlying models. The same thought also occurs in [30] when the need to solve puzzles emerges as a fundamental motivation for play.

Today, SimCity is recognized as one of the commercial entertainment games suitable for didactic scenarios [31,32]. In particular, two literature-known didactic scenarios for the use of SimCity in higher education are characterized by their long service duration and didactic maturity. Gaber [33] has reported a thirteen-year use in an urban planning course. One of the three main learning goal pursued by the didactic scenario is that cities are multidimensional systems in which each planning decision affects multiple aspects. Secondly, the students' problem-solving skills are to be trained, and thirdly, students are to develop an understanding of the creative craft of planning. Woessner [34] has also been using SimCity as a didactic tool in a governance course for 11 years to capture students' interest in a playful way, a purpose for which games are used extensively [35]. Woessner has identified five principles that should be observed for the successful use of a simulation game in didactic scenarios. First, a suitable computer game must be identified, which is characterized by its closeness to reality. For the cooperative play of several students, easily comprehensible rules are to be developed, which allow the use of single-player games in groups. Thirdly, diverging goals initiate conflicts between the players, whose resolution triggers reflection and thus, learning. Small incentives spur on the competitiveness of students. Fifthly, it is important to transfer the contents of the game to reality. For the transfer, additional learning activities, such as writing short elaborations, are suggested.

Further case studies describing didactic scenarios based on SimCity are known from several disciplines. Urban studies is one of the more frequent disciplines applying SimCity, as the examples in [36–39] demonstrate. The related discipline of urban geography is covered as well [40,41]. Examples from the engineering sciences of Betz [42] and McCue and James [43] fit thematically to the presented study. Ecology is the theme of the study by Nilsson and Jakobsson [44]. However, SimCity is not only used to convey discipline-specific knowledge, but also skills in general, as studies on meta-skills, such as problem solving, show [45–47]. Further, there are examples of how SimCity is used for reflection. For example, Lacasa et al. report on a study on the development of new didactic settings [48].

The study presented here has its specific characteristics, on the one hand, in the long period of experience—the didactic scenario presented has been carried out in this way since 2002. The didactic scenario has been implemented initially using SimCity 3000, and was later transferred to SimCity 4, which is the current platform. On the other hand, the didactic scenario shows some specific characteristics which are not yet described in this combination in the case studies previously mentioned. Among the special features are the open, synchronous, moderated and competition-oriented games, the structured, time-limited lecture structure with common assessment sessions, and the representation of a regional scenario with a subsequent excursion.

The rest of the article is structured as follows: in Section 2, the didactic scenario is described, and Section 3 presents the research goals and methodology. Section 4 describes the results, which are then discussed in Section 5. The article closes with the conclusions.

2. Didactical Scenario

2.1. Background

The course *Infrastructure Management* is part of the Master's programme in Environmental Engineering at Bauhaus-Universität Weimar. The course primarily imparts knowledge about technical infrastructure systems from an overarching perspective. The overarching perspective is also taken up by city builder games. First experiences using city builder games in educational contexts could be made with the simulation game Mobility [49], whose simulation models focusing on traffic infrastructure have been developed at the Bauhaus-Universität Weimar [50–52]. While Mobility is mainly limited to traffic infrastructure, SimCity offers a more holistic approach. In earlier research [53], first SimCity 3000 and later SimCity 4 were found to be appropriate to illustrate the challenges of regional infrastructure development. SimCity 4 experienced relevant improvements compared to SimCity 3000: the visualization was enhanced by 3D representations, the configuration options were extended, and—very relevant from the perspective of the course *Infrastructure Management*—the waste and energy-related models were refined.

The regional SimCity scenario used in this case study was inspired by the professional experience of the first author as a project manager of infrastructure development at the municipality of Nohra and the adjacent industrial area UNO near the city of Weimar. SimCity presenting the regional scenario of Nohra was used initially in the winter semester of 2002. What is remarkable about this scenario is, on the one hand, the availability of an actual development site after the German reunification with a short distance of only 7 km to Bauhaus-Universität Weimar, which is intended to lead to a high level of awareness among the students, and on the other hand, the knowledge of the real demographic, economic, and infrastructural development of the development site allows comparisons of the simulation results with the real dynamic development of the site.

2.2. Implementation of the Nohra Simulation Scenario in SimCity

To create a game scenario in SimCity, a kind of urban land-use planning was first carried out by defining residential, industrial and commercial areas. Based on this planning, the model elements offered, such as roads, water and energy supply infrastructure and special buildings (optional: sewage treatment plant, schools, fire brigade, police, etc.) were then placed in such a way that the model elements simulated the desired target model as realistically as possible. The model elements themselves cannot be added or changed in SimCity, only the composition of the existing elements enables customized game scenarios. However, customized game scenarios can be passed on as saved score files.

As mentioned above, the quantitative similarity of the simulated sub-processes in SimCity with real-world processes is very limited [12]. The limitations affect both the geometric similarity of the modelled infrastructure elements and the socio-economic similarity (area-specific demographic and employment development, specific investment expenditures, operating costs, tax revenues, user charges, etc.). In contrast, the clarity and user-friendliness of SimCity's graphical user interface is very high.

2.3. Structure of the Course and Embedding of the SimCity Didactic Scenario

The course *Infrastructure Management* is carried out each winter semester as block events with three lectures (each lasting 90 min) per block. SimCity is used on one of these days in a classic briefing–gaming–debriefing setting.

Figure 1 shows the temporal structure of the block. First, a 90-min introduction is provided to the regional scenario of Nohra, its real temporal development and especially to the aspect of the technical infrastructures as systems. The briefing is followed by the gaming phase. For the gaming phase, the students are divided into groups. Each group has its own computer connected to a video projector. Since all the groups are accommodated in the same room, the video projectors enable an open play. The group sizes vary—depending on the participation—from 2 to 7 persons. The gaming phase itself is divided into three separate gaming sessions, each about 30 min: the first gaming session is used to create familiarity with the game software (without evaluation of the results, training session). The task of the second gaming session is to develop the scenario as successfully as possible for a given initial urban land-use planning; in the third gaming session, the urban land-use planning can be independently specified by the students. During the gaming sessions, the moderator gives hints. Together with the previous briefing session and plenum-defined assessment criteria that defined key figures and their according weights, these hints serve as a basis for the gaming decisions. After gaming session 2 and gaming session 3, the game scores were assessed with the help of a cost-utility analysis implemented in a spreadsheet tool. The cost-utility analysis is based on the previously defined key figures. In a moderated assessment session following each gaming session, the key figures required for the assessment of gaming results are determined. The key figures are either transferred from the game (e.g., the number of citizens) or manually retrieved from the game interface by a point value decided by the moderator (e.g., for the quality of the water and energy supply, the transport system, and the environmental pollution) for each group. Thereafter, the ranking of the groups is determined. At the end, a debriefing takes place in which the essential game experiences are discussed and connected to the subject of the lecture.

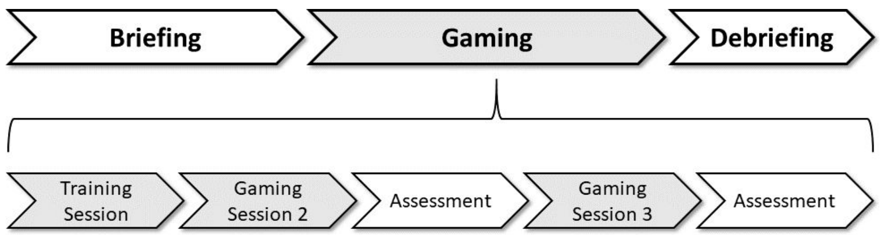

Figure 1. Timeline of the SimCity didactic scenario (total duration: 270 min (three 90-min lectures)).

3. Research Goals and Methodology

The characteristic feature of this didactic scenario of SimCity is its long experience of more than 15 years. On the one hand, this could indicate a successful didactic design; on the other hand, this can also be seen as a case study of the educational media computer game, which generally is subject to rapid technological change. One aim of the study was therefore to identify success factors of the use of digital games in university teaching. In addition, the acceptance and subjective perception of students when using a digital game, which is recognizably outdated, was analyzed. It was examined whether digital games, despite their age, still led to acceptance, gaming fun and motivation to learn. A main research goal was the question of whether the didactic scenario can still be continued, or whether the didactic scenario should be discontinued and replaced by other learning activities. After the second event, the continuation of the event could be recommended on the basis of the collected data. In summary, altogether, four events were observed by two experts (see Table 1). The first event was observed to get in-depth impressions of the didactic scenario. Based on these impressions, the study of the second event was designed to include a guideline-based interview with the lecturer, a focus group discussion lasting approximately 30 min, and a questionnaire surveying various aspects and standardized measures (approximately 90 items). Event 3 and Event 4 then served to increase the number of participants, i.e., the statistical significance of the results. For these events, the questionnaire was extended to obtain comparative values to parallel studies regarding the *Expectancy-Value Model* and to classify different learning materials or activities according to perceived importance.

Table 1. Overview of measurements.

Event	Expert Observation	Focus Group	Lecturer Interview	Questionnaire (Approx. 90 Items)	Augmented Questionnaire	n
1 (2015/16)	X					19
2 (2016/17)	X	X	X	X		7
3 (2017/18)	X			X	X	16
4 (2018/19)	X			X	X	10

Previous studies on the use of SimCity in didactic scenarios have focused on the extent to which SimCity was able to support subject-specific learning objectives (e.g., [21,38]), how didactic scenarios were to be structured in order to contribute to learning (e.g., [34]), and which learning outcomes SimCity led to in cognitive (e.g., [37,39]) or affective terms (e.g., [39]). In addition to findings in literature, the study described here provides quantitative values for acceptance, gaming fun and motivation of the students Thus, the question is to be answered whether a didactic scenario with the digital game SimCity is also understood as a playful learning activity.

For the design of the questionnaire, standardized survey instruments, such as QCCCM and GEQ, were used when possible. For the self-developed part, Likert scales were chosen to avoid yes/no decisions but also to track tendencies. The items were developed during a joint brainstorming session of the two experts involved. For example, the components and characteristics of the didactic scenario were extracted in preferably small parts for the question about the highlights of the event (Figure 6). For the general assessments of the didactic scenario, thought was given to how the students would evaluate the scenario. Care was always taken to ensure that the students also had the opportunity to express criticism or to agree to items expressing criticism. For example, the critical items include items 9 (“The game has aged”) and 10 (“Such games are a waste of time”) from Figure 7 or the items 5 (“Mental effort was high”) and 9 (“No new insights”) from Figure 9. Attention was paid to a direct and clear language. With comment fields, the possibility was provided to capture aspects not considered in item design.

4. Results

4.1. Demographics

The increasing age of SimCity has led to it becoming less known, for example, in event 4, none of the students had previously played SimCity in their spare time. In total, 30% of the participants had previously played SimCity in their spare time, another 30% had already heard about it, and nobody had previously played SimCity in didactic scenarios.

4.2. Obersvations

One noteworthy observation made was the open playing style: at any time, all participants could observe the activities of the other groups and learn from them. For example, the phenomenon that "scouts" were actively sent out to "observe" the other groups became apparent. However, scouting was one of the activities stimulated by hints from the moderator. The moderator also demanded that the groups came up with creative names, such as the group *TFB—The Future is Bright*). This requirement seemed not only to increase group identification, but also seemed to contribute to a playful atmosphere. It was also observed that the moderator's excellent knowledge of the game software was very helpful to enable the students to carry out targeted actions to develop the scenario in the relatively short time of 30 min. The moderator's continuous roaming through the groups with hints and activating comments provided a playful and relaxed but nevertheless focused atmosphere. In each gaming session, partially detailed goals, such as addressing supply shortfalls, also helped to quickly generate a sense of achievement and thus to encourage students' engagements. An ideal group size was set by the focus group discussion, as well as by the observation with 3–4 persons. Such a size allows, on the one hand, intensive reflection; on the other hand, all group members must be involved.

4.3. Motivation

An integral part of using games in didactic scenarios is to increase students' motivation to engage in learning activities. The motivation was examined in three variants described below, each with a standardized measurement.

4.3.1. General Motivation

To assess the students' motivation, it is important to know the students' expectations and values about the courses. If, in extreme cases, the students are only interested in the credits, but not in the subject-related content of the course, it is difficult to convey subject-related content even with motivational games. With the help of the *Expectancy-Value Model* [54,55], students' expectations and values can be measured. It could be ascertained that the students—ideally—are primarily interested in the contents of the course. Thus, the *Expectancy-Value Model* measures how much interest students have in subject-related content ("Interest"), to what extent subject-related content is regarded as useful ("Usefulness") and how important subject-related content is ("Importance"). Figure 2 shows the results and compares them to two previous studies, both of which indicate students being mainly interested in subject-related contents. The values measured in this study are in the same range and present students interested in the subject-related content. This finding is supported by the reasons for participating in the course visualized in Figure 3: interest in the subject-related content is the dominant reason for participation with 54% of the respondents mentioning it.

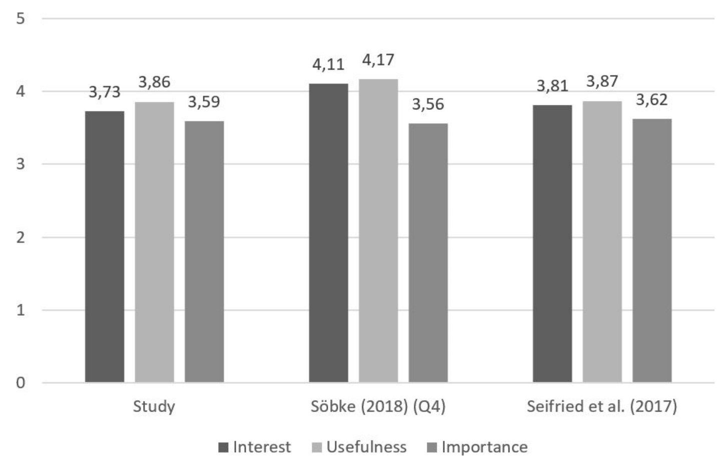

Figure 2. Values according to the *Expectancy-Value-Model* [54] (References: [56,57] (N = 27)).

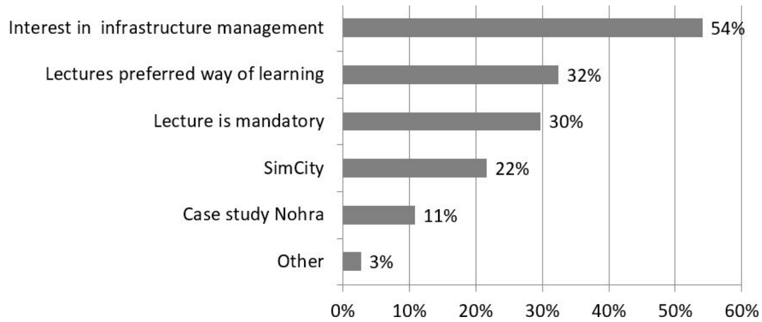

Figure 3. Reasons to participate in the lecture (multiple selections allowed, n = 33).

4.3.2. Game Experience

It can be assumed that intrinsic motivation is very important for the success of game-based learning activities and that intrinsic motivation is present when the game-based learning activity is perceived as a game experience. Therefore, the in-game variant of the Game Experience Questionnaire (GEQ) [58] was used to measure the game experience. Figure 4 shows the results. The high value of the category *Positive Affect* and the low values in the categories *Negative Affect* and *Tension* are typical for a game-like experience. The lower values in the categories *Competence* (i.e., the players do not feel sufficiently prepared to solve the problems of the game) and *Challenge* (i.e., these problems do not seem to be perceived as a big challenge either) could reflect the doubts of the students as to whether the content conveyed with the help of the game has the necessary complexity to be transferred to reality. This doubting effect is not unknown from discourses of teaching and learning research: learning is always associated with an activity "that has to make an effort in order to be successful". This is contrary to the approach of game-based learning, in which the perceived effort of the students is, at least partially, compensated by their intrinsic motivation. In comparison with a study in which quiz apps were used asynchronously [59], i.e., interrupted again and again in contrast to the didactic scenario of this study, the correspondingly higher values for the categories *Flow* and *Sensory and Imaginative Immersion* are noticeable.

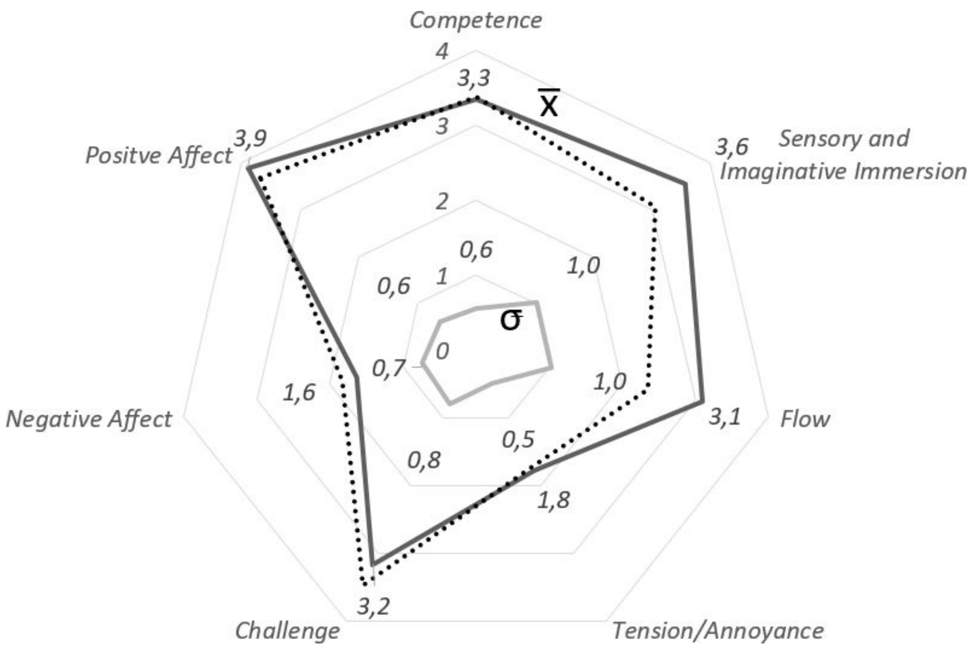

Figure 4. GEQ: Mean value and standard deviation (n = 33) and mean value of a reference study (dotted line, [59]).

4.3.3. Current Motivation in Learning Situations

A further aspect of motivation is that of current motivation in learning situations, which can be measured with the help of QCM (FAM) [60]. To keep the acceptable size of the questionnaire, only the items of the categories *Challenge* and *Interest* were included in the current study. As Figure 5 shows, comparatively high values could be measured here as well.

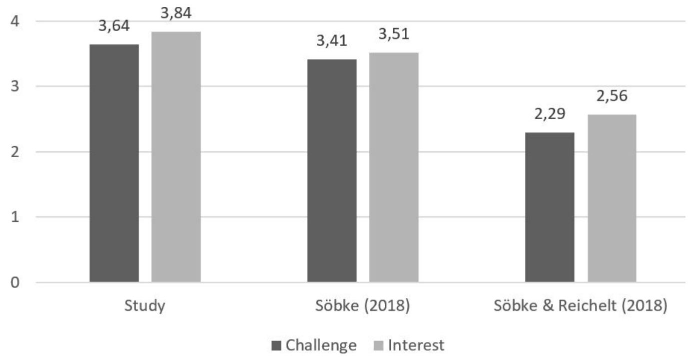

Figure 5. QCM [60]: Categories Challenge and Interest compared to previous studies ([56,61]) (5-point Likert scale, n = 33).

4.3.4. Correlations

To connect the partial measures of motivation, the correlation coefficients were calculated. Table 2 shows that in particular the partial measure for *Sensory and Imaginative Immersion* of the GEQ shows a medium correlation with all other measures of the QCM and the *Expectancy Value Model*, suggesting that immersion is an indicator of motivation. It is also noticeable that the partial measures of QCM and Expectancy Value Model correlate with each other within the measure.

Table 2. Correlation coefficients between motivational measures (>0.5 and <0.8: grey; >0.8: dark grey).

		Competence	Sensory and Imaginative Immersion	Flow	Tension/Annoyance	Challenge	Negative Affect	Positve Affect	IntrinsicValues	Usefulness	Importance	Challenge	Interest
GEQ	**Competence**	1.00											
	Sensory and Imaginative Imm.	0.29	1.00										
	Flow	0.30	0.65	1.00									
	Tension/Annoyance	−0.39	0.10	0.07	1.00								
	Challenge	0.22	0.70	0.63	0.31	1.00							
	Negative Affect	−0.33	−0.22	−0.19	0.51	0.03	1.00						
	Positve Affect	0.60	0.24	0.24	−0.63	0.06	−0.54	1.00					
Eccles	**IntrinsicValues**	−0.04	0.64	0.25	−0.16	0.30	−0.09	0.21	1.00				
	Usefulness	−0.06	0.52	0.38	−0.09	0.35	−0.25	0.03	0.67	1.00			
	Importance	0.06	0.64	0.33	0.10	0.33	0.02	-0.01	0.64	0.61	1.00		
QCM	**Challenge**	0.52	0.65	0.52	−0.09	0.62	−0.05	0.36	0.43	0.23	0.49	1.00	
	Interest	0.39	0.51	0.27	−0.09	0.27	−0.11	0.29	0.20	0.20	0.49	0.54	1.00

4.4. Didactic Scenario

The design of the didactic scenario considerably influences the effectiveness of the game. Therefore, it is of interest to know the strengths and weaknesses of the didactic scenario evaluated in this study. For this purpose, the students identified the highlights of the didactic scenario by assigning a value to different characteristics of the didactic scenario on a Likert scale. The game itself was given the highest rating, followed by the practical relevance and interactivity of the didactic scenario and the cooperation of the students (see Figure 6). The gaming sessions 2 and 3 with free play were also rated better than the training gaming session 1.

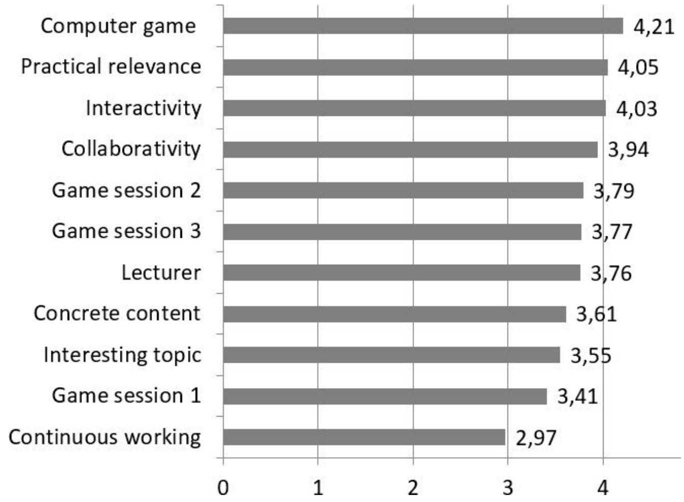

Figure 6. Perceived highlights of the didactic scenario (5-point Likert scale, n = 33).

The survey of general assessments (see Figure 7) showed that competition between the groups was important for excitement and fun. The gaming sessions further supported the objectives of the didactic scenario. Group work was likewise praised (03) or felt that there was no need for improvement (08). The good explanations of the lecturer (04) and the regional scenario were noted positively (05). Interesting are also statements which did not receive approval: games like SimCity are not considered a waste of time (10). Similarly, the aged game is not seen as outdated (09). However, time pressure has prevented the simulation model from being understood in all interdependencies.

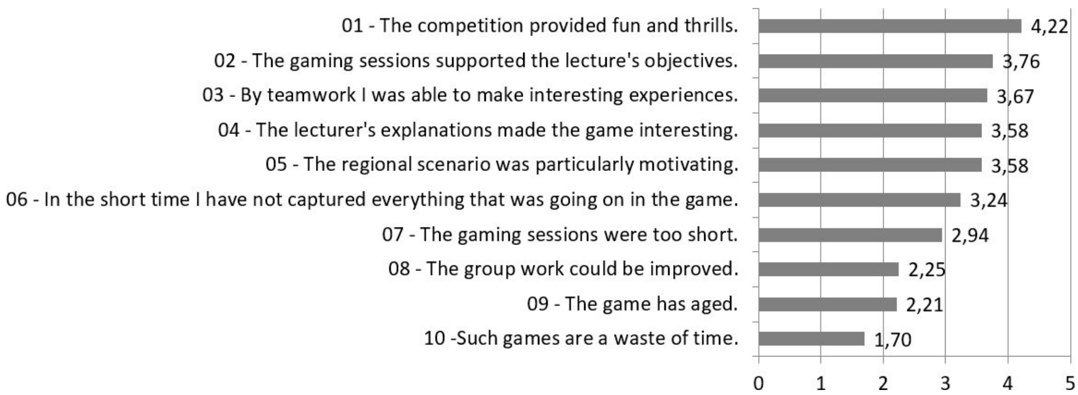

Figure 7. General statements regarding the design of the didactic scenario (5-point Likert scale, n = 33).

The undoubtedly existing time pressure during the time-limited gaming sessions leads to the question of the goals of the gaming sessions. Figure 8 shows that the most important goal is the achievement of the assessment criteria defined in advance. It also becomes clear that competition between the groups has created tension but has not led to unhealthy pressure.

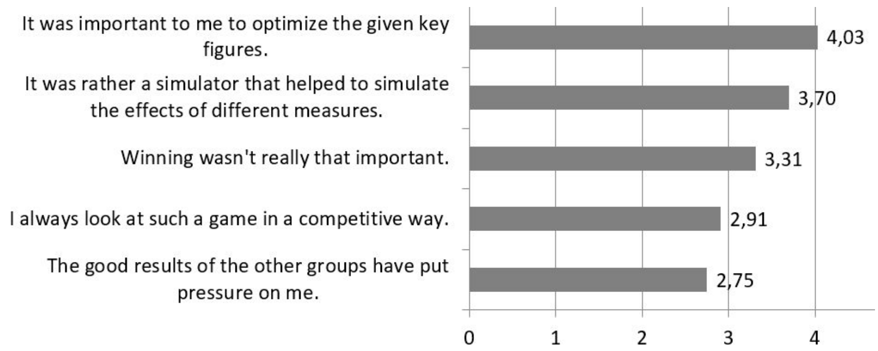

Figure 8. Directions of play (5-point Likert scale, n = 33).

4.5. Learning

In the group discussion, the students referred to the presentation of the complex problems of infrastructure management. The students spoke positively about the different perspectives that are explained by the simulation game SimCity. The students found the handling of the problems to be easier than traditional learning methods but doubted whether this method would lead to a comparable result in the final exam. Also, critically noted were the simplified simulation models, which could not adequately represent the more complex systems in reality. The students rated the variety of learning activities enriched by playing SimCity as motivational.

The questionnaire also included a group of statements on which the degree of agreement had to be stated (see Figure 9). The results partly confirm the findings described above. Playing tends to be perceived as relaxation rather than learning (04), an effect intended with the use of a game. It is stated that the facts of the game were understood (10), that the task is rather easy (09), and that there were various "eye opening" moments leading to learning experiences (03). The students did not agree on the fact that most of the learning content (06) is already known. Nevertheless, only a medium mental effort required for the gaming sessions (05) is assumed. Some new findings (08) are also stated. Remarkable is the high interest in monitoring cause and effect relations (01) and exploration of interdependencies (02).

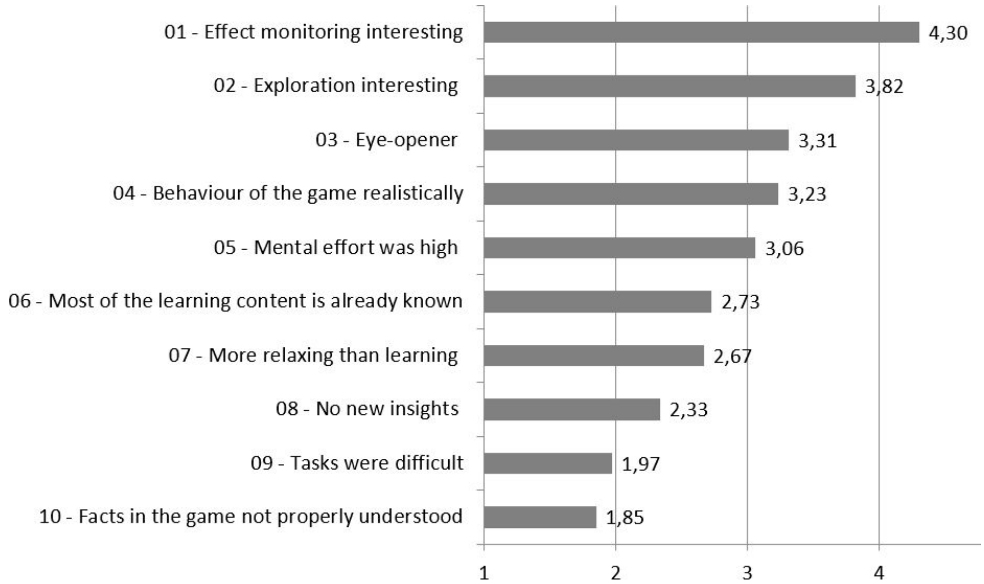

Figure 9. Agreement on learning-related statements (5-point Likert scale, m = 33).

The students conclude that the lecture should be continued in the future, that SimCity is an aid to understanding and that the learning goals would not be as accessible without games (Figure 10).

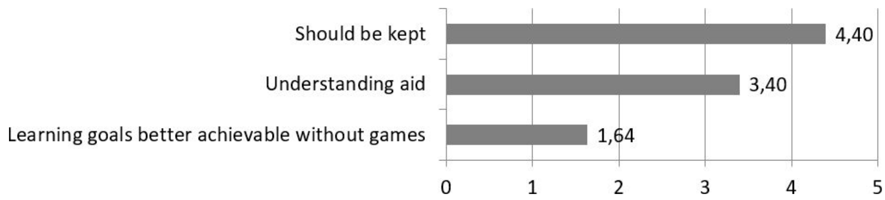

Figure 10. Students' conclusion (5-point Likert scale, n = 33).

The evaluation of the SimCity lecture was also based on a question about the comparison with other learning activities. The SimCity lecture was classified as least relevant to other learning activities, both in terms of final exam and professional practice, as Figure 11 shows.

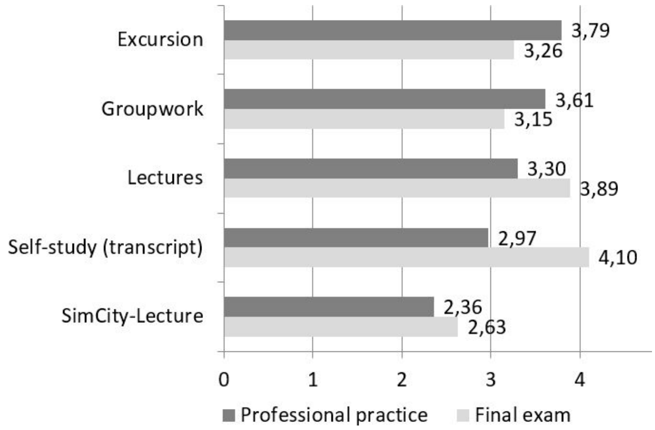

Figure 11. Perceived relevance of learning activities regarding final exam and professional practice (5-point Likert scale, n = 26).

4.6. Game Aging

One of the main challenges to using a game over a long period of time is a phenomenon we call *Game Aging*: a game ages over time. Game aging manifests itself in different categories [52]. The first category is *Technology*: the software and hardware with which the game software works becomes unavailable after some time. The version of SimCity used in this study, for example, requires Windows XP as the operating system. The last update for Windows XP was released in 2008. A remedy is the use of virtual machines: through the use of virtualization software—in this case study VirtualBox [62] worked well—the life time of the game software can be significantly extended. Another category of game aging is *User Experience*: new games show new game elements, game mechanics or even operating paradigms. The user experience makes the game clearly recognizable as old and can reduce the gaming fun and acceptance, as was noted in the group discussion. *Domain Knowledge* is a further category of *Game Aging*. Aging of domain knowledge occurs when new subject-related options are available in the meantime but cannot be represented in the game. For example, the game Mobility does not support e-mobility that has recently emerged and therefore cannot provide an all-encompassing overview of current traffic systems [52]. Overall, all categories of game aging have occurred, but no relevant influence on the efficiency of the didactic scenario could be found; however, game aging is a phenomenon to be considered.

5. Discussion

SimCity has been used in educational contexts for years. The case study presented shows features differing from the descriptions in the literature: (1) It is characterized by moderated, open, simultaneous and competitive play in groups; (2) it deals with a regional planning scenario and (3) particularly noteworthy is the long, regular period of employment of more than 15 years.

The observation of the gaming sessions revealed a relatively high level of engagement of the students. It could be observed that—despite the age of the game—acceptance of the game and gaming fun were perceived as high among the students. Thus, the didactic scenario could be continued. Regarding the research goal, if the didactic scenario can be considered as a playful learning activity, the observed values substantiate the hypothesis of SimCity being perceived as a playful learning activity. The engagement of the students was supported by the high level of dedication of the lecturer as well as his detailed knowledge of the game software. The didactic scenario is closely structured, which leads to a focused way of working compared to conventional lectures. At the same time, the students have freedom in their game actions and can develop the gaming scenario competitively through individual decisions receiving short-term feedback. Although the game software was recognized as old, there were no restrictions in operation observed. Technical aging of the gaming scenarios was not determined. A motivating effect of the regional scenario can be assumed. Positive effects in this respect can be expected during the subsequent excursion to the model area. In addition, the existing detailed knowledge about the regional scenario was very helpful in the development of the gaming scenario. In this respect, the didactic scenario presented has benefited from the favorable circumstances of background experiences, which might not be possible for any didactic scenario.

Although, in the questionnaire, nobody mentioned the use of the game as a reason to participate in the event and the described use of the game only covers a relatively small part of the course, the final course evaluations regularly refer positively to the use of the game. This is further evidence that simulation games can also be used beneficially in university didactic scenarios.

The study showed that the players were committed and attentive, but did not perceive the relevant issues as surprising, new or difficult. This contradicts the assumption that behind the technical infrastructure in SimCity there is a complex model with many interdependencies. A possible explanation to be validated is that the game character leads to a distorted perception of the difficult tasks. The sustainability of the learning experience must also be clarified. First of all, competition creates time pressure, which could have a negative impact on learning processes. This time pressure—triggered by content-related factors such as interdependencies of all processes and infrastructure elements, as well as continuous system development (e.g., increase and decrease of population and companies), while decision-making processes on meaningful changes in the framework conditions are still taking place—is, however, also one of the desired learning goals in the didactic scenario. Furthermore, the use of such a game certainly holds a prominent position in the curriculum. It is therefore worth investigating whether the SimCity didactic scenario also triggers corresponding deep learning experiences that lead to long-term memorizing of knowledge.

The SimCity didactic scenario presented is followed by an excursion to the development site. Interviews with various stakeholders, such as representatives of the public administration, the companies located and affected by infrastructure and the infrastructure operators, are part of this excursion. Plan/actual comparisons, an assessment of the similarity of the simulation with the real system and a description of the dynamic changes in the development framework conditions, which a priori would have made simulations of "what if" scenarios desirable for decision-makers, should increase the learning effect of the simulation. In further work, the learning outcomes of the excursion supported by the SimCity lecture must be evaluated.

Overall, the picture of the SimCity didactic scenario was quite positive, but it was interrupted at one point when students were asked about their preferences for different learning activities of the course in terms of final exam and professional practice. For the final exam, the transcript of lectures was considered most important. For professional experience, excursions were considered the most useful. In both cases, the SimCity lecture is considered the least important, which may be related to the general terms used for the other learning activities. However, it is likely also a consequence that "playing" is not yet socially recognized as a learning activity.

In addition, further work on the topic of game aging is necessary: With the increasing use of computer games as educational technology, it will become increasingly common to find applications in which one or more of the ageing categories described here (Technology, User Experience and Domain Knowledge) lead to restrictions in use. A systematic consideration of the effects can be used to establish constructive measures to remedy game aging and thus to protect the development costs of a game-based didactic scenario.

6. Conclusions

A main result of this study advancing the findings known from literature is that, even 15 years after the publication of SimCity 4, motivating didactic scenarios can be created based on SimCity. The study proved that even a technically complex and fast-moving medium such as a computer game can be used in a didactic scenario over a longer period with limited effort, although the challenge of game aging must be actively addressed. Further, SimCity is perceived in the didactic scenario described as a motivating and accepted diversification of learning—the learning activity can be considered as playful. This finding, too, has not yet been presented broadly in the literature. In addition, it has been shown that regional scenarios can be implemented by simple means. Such regional scenarios are acknowledged by students. In general, however, game-based learning struggles with social recognition as a reputable learning activity. In summary, further research is necessary to, among other things, arrive at detailed design recommendations (e.g., regarding time pressure), to review the sustainability of learning outcomes and to identify further learning goals, which can be achieved with commercial entertainment games.

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