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Mobility in Metropolitan and Peripheral Regions – an Educational Simulation Game

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1 ABSTRACT

Metropolitan regions worldwide face the same problems: air pollution, congestion, urban sprawl. Decades of interventions by policy makers and planners did not change this fact. The methods of System Dynamics reveal that one of the main causes is a lack of understanding of the complex interactions between urban, peri-urban and peripheral regions. Therefore, it is essential to improve systems thinking skills of policy makers, planners and the public. Educational games promote the development of cognitive, spatial and motor skills and can be used to teach facts (e.g. knowledge, retrieval, memorization, retention of knowledge), principles (e.g. cause-and-effect relationships) and complex problem solving. Hence, educational games and simulations are powerful tools to improve systems thinking skills – even for very young age groups.

The objective of the nationally funded project Systemcheck (2019-2020) was to make use of the abovementioned capabilities. An interactive, digital teaching and learning game based on simulations of social and ecological effects of mobility and transport in metropolitan and peripheral regions was developed and tested in classrooms. The game specifically addresses topics of the Austrian 6th grade syllabus for the subject geography and economics. The game, on the one hand, enables students to learn and practise geography subject matters and on the other hand to develop systemic thinking skills. The basic framework of the multi-level game is the vita of a person from primary school through to adulthood. Players have to solve different tasks related to mobility and the characteristics of urban and peripheral regions to collect points and reach the next level. The game is a mixture of quizzes, identification of the player with a role and simulations. Based on teachers' suggestions, the game was subdivided into two parts to allow the game to be played in portions of one or two teaching units. In accordance with the Citizen Science approach two phases of in-class workshops with feedback from students and teachers were conducted.

The first part starts with the player in the role of a schoolchild living in a small village. The village has a primary school and a small shop. A supermarket and a cinema are located in the district town, about ten kilometres away. The player has to answer (quiz) questions regarding topics like periphery, basic needs, accessibility, urban sprawl, etc. to reach the next level. In following levels, the player commutes to secondary school, moves to the capital to study, starts working and moves back to the countryside when founding a family. At this level, the player engages in local politics to stop the greenfield development of a shopping centre. In the final level of part one the player runs for mayor's office. Feedback on a prototype was obtained from teachers and students of three secondary schools. A total of 91 pupils in four classes tested the prototype in classrooms. The overall feedback was very positive. On a scale from 1 = very bad to 5 = very good the average overall rating was 4.2. The majority saw the game as not too difficult, exciting and useful for learning. About two thirds wanted to play the game again.

In the second part the political career of the player continues. Decisions on municipal level have to be made. Cooperation and compromises with neighbouring municipalities, the federal state and the national government are necessary to achieve environmental and social goals. Simple simulation models are used to mimic real world effects of the player's decisions. Simulation models were programmed using the free, web-based software InsightMaker. The player has to use the simulation models to solve tasks like meeting CO2 reduction goals while keeping the municipal budget balanced. A beta version of the second part was tested in March 2020. Due to the pandemic testing in classrooms was replaced by web-based feedback. Collected feedback shows evidence that the simulation model based part was rather difficult for the target group and not user friendly enough. This can be partly explained by the missing possibility of physical presence and briefing in classrooms. In consequence, teaching material for future classroom application was developed. Nevertheless, the overall rating was still positive and the concept was successful. The game is publicly available for free, in both English and German language: https://ive.boku.ac.at/systemcheck/welcome

Keywords: metropolitan and peripheral regions, system dynamics, educational simulation game, children, mobility

2 BACKGROUND AND MOTIVATION

2.1 Systems thinking and System dynamics

Systems thinking should be a key skill for students as they deal with the complex interrelationships between human actions and natural processes. In Austria as well as in many other European countries, the school education system is characterized by separate subjects. Thus, children mainly learn sectoral expertise. After school, however, children are released into a "real" world that is not characterized by its individual parts, but by complex problems and interrelationships. In order to be able to understand the "real" world, to find one's way and also sustainable solutions for problems and challenges, the ability to think in terms of systems, which is still intuitively given at kindergarten age, must be developed. For this it is essential to be able not only to identify individual elements of a system, but to be able to view a system as a whole (Schnürzler, 2017).

System Dynamics is a method for improving learning in complex systems (Sterman, 2000). It can be used to understand, amongst others, dynamic linkages, identify the causes of policy resistance, and formulate more effective policies. Cause-effect diagrams (causal loop diagrams) as a qualitative method and stock flow modelling as a quantitative method can be used as System Dynamics tools (Arndt, 2016). Cause-effect diagrams can be developed, for example, to qualitatively describe and analyse dynamic systems, such as a core city and its surrounding areas, in a simple way. Stock-flow models can be used to simulate the effects of political decisions or technological changes and thus also to investigate them quantitatively.

There are many topics such as climate change, energy, population development, urbanisation, urban sprawl and resource use which benefit from a systems-based approach. In this context, the holistic analysis of mobility in metropolitan areas and peripheries and its effects is a particularly exciting field of application, since a direct link to students' own experiences and observable processes in their direct environment can be established.

2.2 The problem of urban sprawl and congestion

The term urban sprawl or suburban sprawl refers to "low-density automobile-oriented settlement patterns with little comprehensive public planning" (Bruegmann, 2015). In contrast to a compact settlement development, the phenomenon of "urban sprawl" is associated with numerous negative effects. This refers to negative ecological effects, transport related effects as well as social and health effects (Siedentop, 2005).

Lower property prices and the promise of a calm and green living environment in mono functional suburban regions cause people to move out of the city although most of the jobs and higher educational facilities stay located there, resulting in longer commuting distances. If the public transport supply is low, this promotes car dependent life styles and with increasing car mileage also congestion (and related negative effects such as increased travel time, cost, and pollution).

Overall, the interaction between a core city and its peripheral regions, or respectively transport (accessibility) and space, are very complex issues. In more detail, the causes and effects of population distribution (e.g., migration, traffic impacts, environmental effects) are very difficult to understand and to assess. In addition to this, also the effects of transportation and land use planning measures to limit sprawl and environmental impacts are hard to predict and it usually takes a long time until changes come into effect. Furthermore, dealing with the issue of urban sprawl requires the consideration of many different relevant actors. This clearly shows that, as a result, it is difficult to adequately convey this topic to children and young adolescents in order to foster their understanding of these general processes as well as of their own choices with regard to transport and place of residence.

In the past, scientists made use of the methods of systems thinking and System Dynamics to analyse, visualise and communicate complex interrelations between the transport and the land use system. Causal loop diagrams have been used to qualitatively analyse phenomena like congestion, urban sprawl and the concentration of shopping centres in the periphery of functional urban regions (Pfaffenbichler, 2001a, 2001b, 2011). System Dynamics-based simulation models have been developed for quantitative prediction of the effects of transportation and land use planning policies (Pfaffenbichler et al. 2010, Shepherd, 2014). While for non-experts these models are too complex and not user-friendly enough, simplified versions could be part of educational games and support the understanding of complex system behaviour.

On this basis, the aim of the new teaching and learning tool is to arouse the learners' interest in systems thinking through a playful approach to the topics of mobility and transport, conurbation and periphery, environment, resources and politics. By using the final product, the learners should acquire competences in the field of systems thinking and at the same time learn about central topics of the subject geography and economics about life in urban areas, the interactions between urban areas and their periphery and how people shape their living space.

3 THE SYSTEMCHECK EDUCATIONAL GAME

Educational games promote the development of cognitive, spatial and motor skills and can be used to teach facts (e.g. knowledge, retrieval, memorization, retention of knowledge), principles (e.g. cause-and-effect relationships) and complex problem solving (Felicia, 2009; Boyle et al., 2016).

Systemcheck was developed in 2019-2020 as an interactive, digital teaching and learning game based on simulations of social and ecological effects of mobility and transport in metropolitan and peripheral regions. It was developed and tested in classrooms in close cooperation with two secondary schools in the city of Vienna. For the evaluation, other schools were involved as well. The game specifically addresses topics of the Austrian 6th grade syllabus for the subject geography and economics. The main objective of the game was, on the one hand, to enable students to learn and practise geography subject matters and on the other hand to develop systemic thinking skills. The game should (i) build on children's everyday life experiences, (ii) cover different topics across school subjects and (iii) be motivating and fun as well.

The basic framework of the multi-level game is the vita of a person, starting in primary school and going through to adulthood. Players of the game have to solve different tasks related to the mobility of people of different age cohorts living in urban and peripheral regions. Points are collected in each level if tasks are solved correctly. The game is a mixture of quizzes, identification of the player with a role and simulations. Based on teachers' suggestions, the game was subdivided into two parts to allow it to be played in portions of one or two teaching units. The first part covers the time span from childhood to early adulthood ending with the player becoming mayor of a medium sized town. This part consists of different types of quizzes. The second part deals with the political career of the player and is made up by simulations. The game is publicly available for free in both English and German language via the following link: https://ive.boku.ac.at/systemcheck/welcome

3.1 First part of the game

At the very beginning, the player has to decide whether to choose a female or male character for the game. Then the game starts with the player in the role of a schoolchild living in a small village. The village has a primary school and a small shop. A supermarket and a cinema are located in the district town, about ten kilometres away. The player has to answer (quiz) questions regarding topics like periphery, basic needs, accessibility, urban sprawl, etc. to reach the next level. In following levels, the player commutes to secondary school, moves to the capital to study, starts working and finally moves back to the countryside when founding a family. At this level, the player engages in local politics to stop the greenfield development of a shopping centre. In the final level of part one the player runs for mayor's office.

Figure 1 shows a screenshot of the introduction into the level "Work in the Big City". Each level is introduced with a colourful cartoon symbolising the life stage and living environment of the player and some explanatory text. The introduction is followed by a series of quiz questions. Figure 2 shows a screenshot of such a question. Selecting the correct answer at the first attempt is granted with four points. If the answer is not correct players have the option to modify their choice. Finding the correct answer with the second attempt is granted two points. If the answer is still incorrect, the correct answer is displayed together with a text that provides an explanation, why certain answers are correct and others are not. The answers then are randomly mixed and the player has to find the correct answers again, in order to encourage that the explanation is read and to promote learning. No points are awarded for correct answers once the solution has been displayed. This evaluation scheme should avoid a trial and error strategy by the children. In addition, multiple answers are possible and given answers are randomly mixed.

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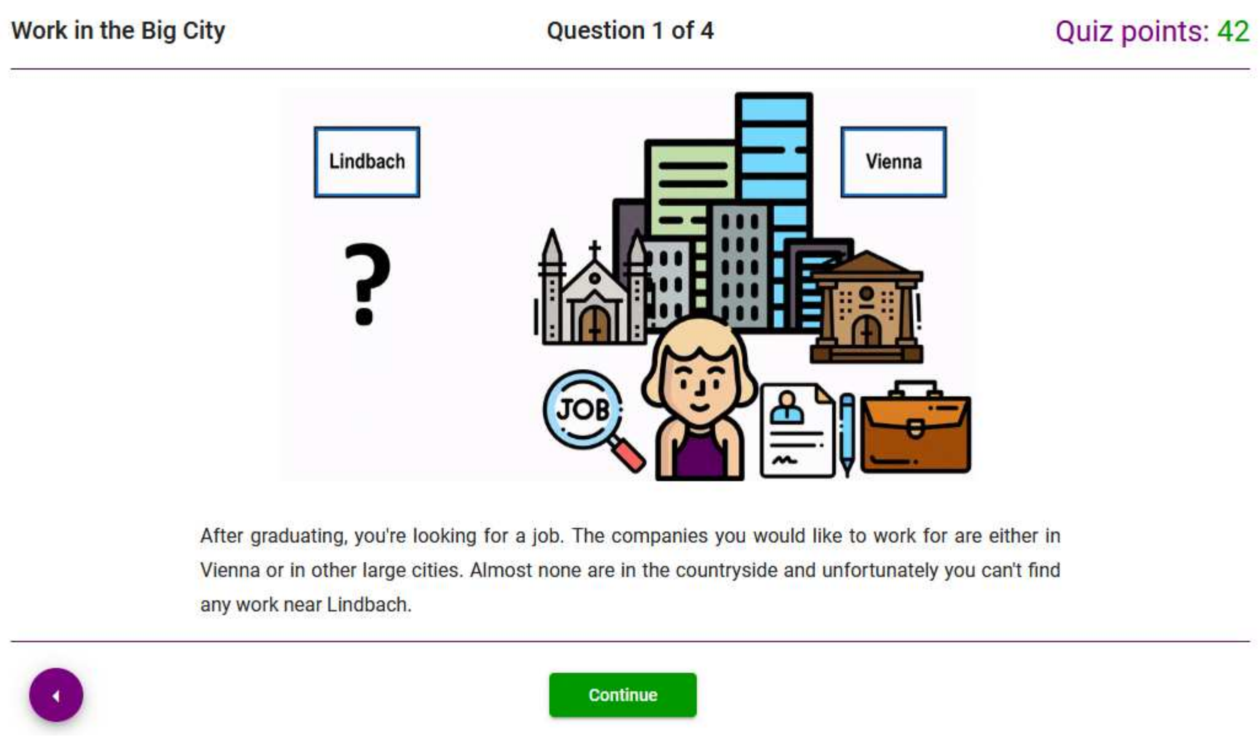

Fig. 1: Screenshot of the level "Work in the Big City" of part 1 of the educational game Systemcheck

Fig. 2: Screenshot of the 1st quiz question of the level "Work in the BigCity" of part 1 of the educational game Systemcheck

3.2 Second part of the game

In the second part the political career of the player continues. Decisions on municipal level have to be made. Cooperation and compromises with neighbouring municipalities, the federal state and the national government are necessary to achieve environmental and social goals. Simple simulation models are used to mimic real world effects of the player's decisions. Simulation models were programmed using the free, web-based software InsightMaker (www.insightmaker.com). The player has to use the simulation models to solve tasks like meeting CO2 reduction goals while keeping the municipal budget balanced. The models are white box models, so the players could take a look at the parameters and equations behind them, even though without further instruction by teachers this is unlikely the case. Players can experiment with the models as often as they like before submitting an answer. A playful trial and error strategy is encouraged in this part of the game.

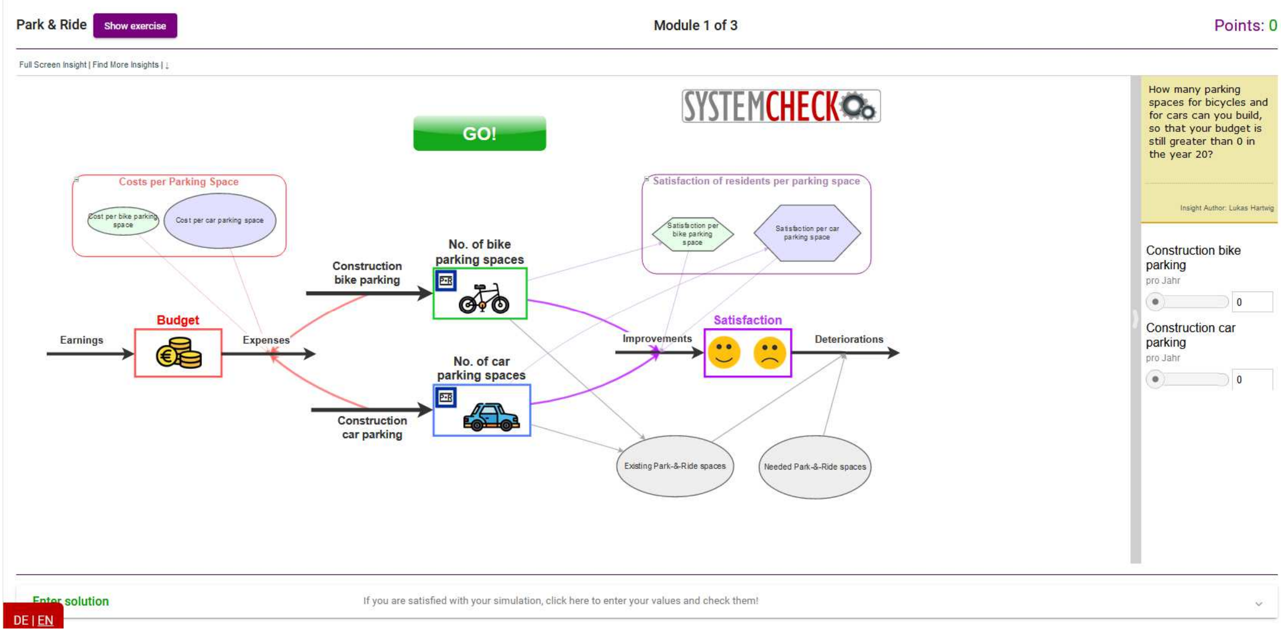

Fig. 3: Screenshot Insightmaker simulation "Park & Ride" of part 2 of the educational game Systemcheck

4 TESTING THE GAME

In accordance with the Citizen Science approach, several feedback loops were conducted to involve students as well as teachers in the development of the game.

In a first phase, feedback on a prototype of the first quiz-based part of the game was obtained in 2019 from teachers and students of the two project partner schools and a third secondary school. The feedback was collected in open feedback rounds in class (teachers, students), observations (of students while playing the game), and with the help of written questionnaires (students). A total of 91 pupils in four classes tested the prototype in classrooms. Ideas for improvements were collected and implemented as far as possible. For example, definitions are given as mouse-over text for important core terms of the game. In addition, explanations are given as feedback in case that incorrect quiz answers were given by the students to promote the learning effect. The beta version of the complete game including the second simulation-based part was tested in March 2020. Due to the pandemic, further testing in classrooms had to be replaced by feedback via a web-based questionnaire. In total 128 persons tested the quiz-based part only and 101 people tested both parts of the game.

The overall feedback was very positive. On a five-point-scale from 1 = very bad to 5 = very good the average overall rating was 4.2. The majority saw the game as not too difficult, exciting and useful for learning. About two thirds wanted to play the game again. The possibility to get into a character and go through the different stages of life was highlighted by the students in the workshops as an interesting feature. Nevertheless, there is a significant difference in the overall rating of people who played only the first part and people who played both parts (Figure 4). About 86% of the people playing only the first part rated the game as good or very good. In the group playing both parts this share is reduced to about 63%. This gives first evidence that the second, simulation-based part might be too difficult or not user-friendly enough. A detailed analysis of the collected feedback supports this finding. Figure 5 shows the feedback on the question about the difficulty of the game of the sample playing both parts of the game. While 27% of respondents say that the difficulty of the first part is appropriate, only 21% think the same for the second part. The percentage of those who think the game is easy drops from 35% to 6%. On the other hand, the share of those who think the game is difficult increases from 11% to 45%. The share of those who think the game is very difficult even increases from 3% to 25%. Hence, we have to conclude that the simulation part was rather difficult, especially for the target group, and not user-friendly enough. The low rating might partly be explained by the missing possibility of physical presence and briefing in classrooms. Nevertheless, there is a strong need for improvement of the simulation-based model part. But, the overall rating was still positive and the proof of concept was therefore successful.

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Due to limited resources, further revision of the simulation-based part or the development of a simulation tutorial was not possible within the project. As a temporary fix, extensive teaching material was developed that can be used for briefing before and de-briefing after the game is played. Teaching experience with other learning games in an university context highlights the importance of collective reflection in a de-briefing session for the players' learning effect.

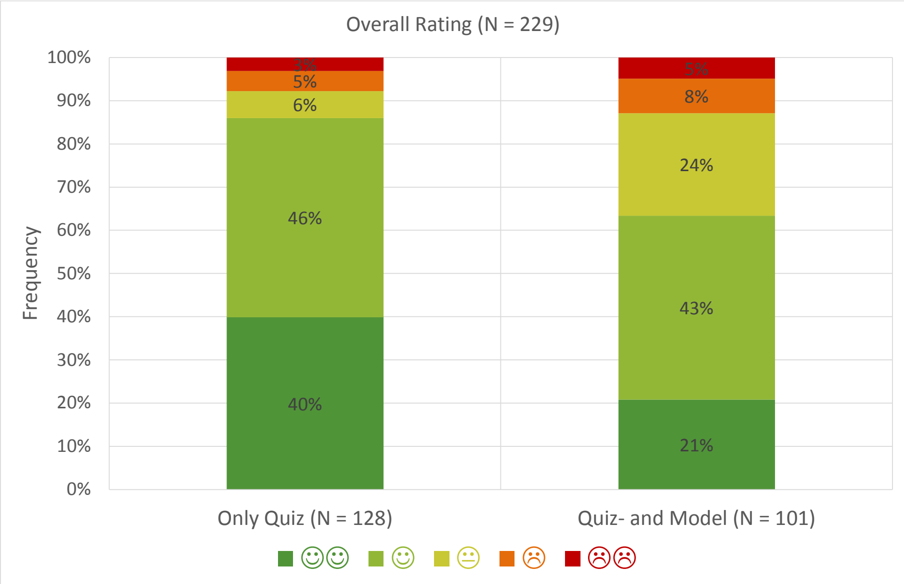

Fig. 4: Overall rating of the educational game Systemcheck

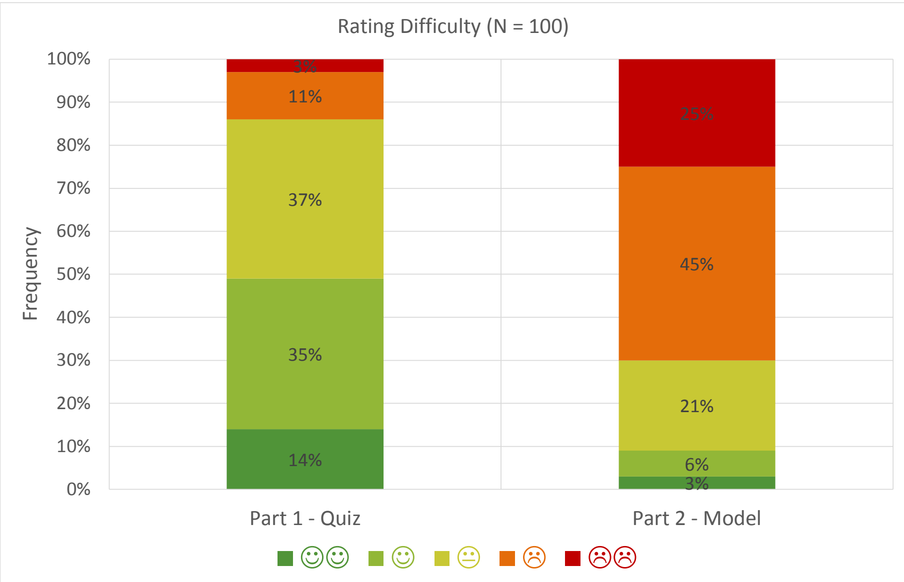

Fig. 5: Rating of the difficulty of the two parts of the educational game Systemcheck

5 CONCLUSION AND OUTLOOK

The multi-step approach of involving teachers and students of different schools to test and develop the digital game proved to be very successful. Due to the pandemic and related measures it was, unfortunately, not possible to conduct more feedback loops and evaluations with the cooperating schools. However, the overall feedback was very positive both from teaching staff and from students. The students thought it was good to get into character and go through the different stages of life. There is, however, strong evidence that the simulation model-based part was too difficult and not user-friendly enough. This can be attributed to several reasons: For example, programming required higher efforts than expected. Hence, resources had to be shifted and were not available for the simulation model design. In addition, the incorporation of InsightMaker into the game could not be realised as seamlessly as intended, so design options were limited. There was also the requirement to keep the game short and concise, so that it each part could be played in one teaching unit. This meant that we decided against tutorials and lengthy introductions. As a result, the simulation games were not as intuitively understandable as planned. More effort on this issue is needed for revised future versions of the game.

There are still many ideas for future adaptations and endless possibilities of extending the digital learning game. Further fields of application are seen in the education of university students; new target groups require further adaptations. Based on the German version of the game, an English version was developed with the help of the prize money (BOKU Sustainability Award 2020 in the category "Education for Sustainable Development") and is also freely available. An evaluation of the effect of improving system thinking among different target groups would be an interesting future challenge. Regardless of the challenge of further adaptations, authors are enthusiastic about the potential of the gaming approach and very keen to continue the work on educational games and are looking for co-operation partners!

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