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Bringing Policy Decisions to the People—Education for Sustainable Development through a Digital Simulation Game

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Received: 24 September 2020; Accepted: 16 October 2020; Published: 21 October 2020

Abstract: After repeated warnings by the European Commission regarding high nitrate concentrations in German waters, in 2017, Germany implemented a new fertilizer application ordinance (FO) with stricter nitrate value limits. The new regulations have severely affected agricultural regions in Germany and could lead to a high number of job losses if farmers must conform to the new regulations and do not implement new production methods. Therefore, a simulation game was developed to educate farmers and residents about the new FO and to facilitate adaptation to the new environmentally friendly legislation. The aims of the newly developed simulation game are to educate residents and farmers in affected regions about the new FO and to develop new ideas on how to comply with the new regulations. The aims of the present study are, first, to research participants' evaluation of the simulation game and, second, to assess the effect of the simulation game on subjective knowledge, internal efficacy, and attitude towards the new FO. This pre- and post-comparison design study was based on pre-test and post-test with participants in two games (N = 90). The results were analyzed using descriptive statistics, multiple regression analyses, qualitative content analysis, and mean value comparisons. The simulation game had a positive effect on participants' subjective knowledge (Cohen's d 0.65) and internal efficacy (Cohen's d 0.36), but it did not have an effect on their attitudes toward the new FO, and it was shown to slightly lower their interest in agriculture politics (Cohen's d −0.33). The participants reported that the game made them more aware of both the difficulty and necessity of finding compromises in the field of agriculture politics. Overall, the simulation was rated very positively and was perceived as interesting and informative by the participants.

Keywords: blended learning; digital game-based learning; education for sustainable development; decision making; civic education

1. Introduction

In this article, we present a newly developed digital simulation game (hereafter referred to as the game or the simulation) in the field of agriculture and education for sustainable development, as well as the participants' assessment of the game and its effects on participants' (subjective) knowledge, attitudes, and self-efficacy. The research follows discussions about simulation games in agriculture training and education [1,2] as well as the use of games for education on sustainable development [3].

The simulation game included some elements of face-to-face interaction and was developed to facilitate the new German fertilizer application ordinance (hereafter referred to as fertilizer ordinance or FO). The game was played, in 2018, in two regions of the federal state of Lower Saxony in Germany. These regions were both severely impacted by the reform of the FO, in as much as both areas which are dominated by agriculture were not in compliance with the new laws and nitrate standards. Therefore, farmers in these regions faced painful adaptation measures. The simulation game was played with people who were affected by these issues and included farmers and residents, as well as students from the agriculture faculty at the University of Goettingen, along with a small group of experts from the state administration.

In total, the simulation spanned roughly three days. The participants faced problems concerning the new FO and the roles of farmers, public servants, residents, and entrepreneurs, whose common aim was to determine how to handle the new regulation in the field of farming and the administrative and business spheres surrounding it.

The game was accompanied by a written pre- and post-survey to assess the participants' views of the game and possible changes in their attitudes and knowledge. The overall assessment of the game was very positive over all subgroups. Being female and having a higher level of education had an especially significant positive influence on general contentment with the game. The participants gained subjective knowledge about the new FO, and their internal efficacy increased. This effect was valid for all major participation groups (farmers, students, residents). The game did not seem to have an impact on attitudes toward the new FO or empathy. Subsequent to the simulation, the participants displayed a small decrease in their interest in agriculture politics.

In this article, first we present the background of the new FO, followed by a theoretical approach to (digital) game-based learning from which we draw the research aims and questions. The research design, as well as the development and functionality of the simulation game, are explained in detail, and then, the results are presented and discussed. The article ends with some closing remarks, study limitations, and an outlook with suggestions for further research.

2. The New Fertilizer Ordinance

Since 1991, the European Union has protected watercourses from pollution via agriculture production through the EU Nitrates Directive (Directive 91/676/ECC). This directive compels all member states to monitor the nitrate concentration in their waters. Germany followed the EU Nitrates Directive leading up to the implementation of the FO. Additionally, the German Environmental Agency (UBA) informs the European Environmental Agency (EUA) about the condition of German groundwater every year. In 2010, the UBA reported that 14% of the groundwater monitoring stations detected nitrate concentrations over 50 mg/L, which was the threshold of the German drinking-water directive (TrinkwV, 2001). Hence, this water was not safe to be used as drinking water without further measures being undertaken [4]. In spite of warnings from the European Commission in 2014, Germany did not implement further steps to protect the water against contamination. Consequently, the Commission sued Germany at the European Court of Justice (ECJ) in 2016. After a long period of negotiations, the Federal Government implemented a new fertilizer law, a new fertilizer ordinance, and new balance demands with stricter nitrate value limits to protect the groundwater from contamination.

These new regulations severely affect the federal state of Lower Saxony because it is home to a great deal of industrial livestock production in the western part of Germany, as well as having a high density of biogas plants and many farming areas in the middle of the state. Overall, more than 80,000 tons of nitrogen must be eliminated or brought to other regions [5].

The situation in Lower Saxony is likely to intensify since the ECJ ruled, in June 2018, that the new fertilizer laws do not fulfil the EU standards. Germany is required to impose stricter laws in order to avoid penalty payments of up to 861,000 € per day [6].

The new FO is a very controversial topic. While residents in the affected regions support the increased protection of their groundwater and environment, Lower Saxony's farmers criticize the

administrative burden and higher costs. It is also predicted that around one third of livestock producers in the northwest of Lower Saxony may have to close their businesses as a result of the stricter FO. This will have a devastating effect on the economy of the whole region [7].

Structural changes to production and farming systems with lower nutrient surplus will depend largely on good communication, knowledge, and an understanding between all parties involved in the process. New and efficient adaptational actions in the field of sustainable agriculture production, commercialization, and consumption of agricultural products have to be found in order to comply with the stricter regulations. Therefore, the idea to facilitate the new FO with a simulation game about the nutrient surplus was developed.

3. The Simulation Game: A Possible Solution to Ease the Implementation of the New Fertilizer Ordinance

Given the problematic and intense situation in areas of Lower Saxony that are dominated by agriculture, why should a simulation game help to bring the relevant actors together, educate them about the new FO, help them to better understand each other's situation, and give a spark for new ideas and innovative solutions?

In the simulation and gaming literature, there is profound research on how policy games can help to develop strategies in a new and complex environment and to foster communication between affected groups [8]. Many elements of the five Cs, i.e., complexity, communication, creativity, consensus, and commitment to action of policy gaming [9] (p. 541) are present in the simulation game, which should provide an environment to create, test, and analyze strategies to cope with the new fertilizer ordinance. Focusing on complexity and communication, the game should bring participants into a fruitful discussion, help them to understand different points of view, and additionally, educate them about the complex new regulations. The connection between elements of the game and the five Cs is further elaborated upon in the detailed description of the game, as well as in the discussion section of this article.

In civic education, simulation games are a recognized teaching approach by which the participants to experiment with a problem and new ideas in a safe environment by reducing reality to a more simplified model [10,11]. This also applies to digital simulation games as implemented in this study. Digital simulation games should inspire intrinsic motivation, support strategic thinking, and help participants to reach solutions in areas with complex problems by giving the opportunity to experiment with different courses of action [12] (p. 6). Digital simulation games give the players the opportunity to test their ideas in "a constant cycle of hypothesis formulating, testing, and revision" [13] (p. 5). The games should also enhance other competences such as negotiation skills, teamwork, and empathy because participants must cooperate to achieve their goals [14]. An important point about the simulation game is that it is not completely digitalized and has some elements of traditional face-to-face interaction. For example, participants can meet and have face-to-face negotiations upon request. Furthermore, there is an analog debriefing at the end of the game. Therefore, the game includes many elements of blended learning [15] and generates the potential to combine both digital and face-to-face simulation game advantages [16].

Overall, simulation games can be a useful didactic method and approach to promote process-oriented action and a positive learner experience [17]. Several positive expectations are linked with simulation games [18–20]. Most importantly, they foster an understanding of the difficulties of (political) compromises and connect the problem to participants' everyday lives. Knowledge about the simulation's topic is transferred through an experience-based method, and hence leads to a more sustainable learning effect [21]. There are many positive results expected that adherents ascribe to simulation games, but there is a lack of empirical evidence to support them. There are only a few quantitative studies about simulation games in civic education [17,22–24], or education for sustainable development [3,25], and even fewer about digital simulation games [26]. A recent study about digital simulation games in civic education showed that they fostered knowledge and internal efficacy [27] and a similar result was found for blended-learning simulations [28]. Digital and blended

learning simulation games have both very small effect or no effect on participants' attitudes, however, regarding their learning effects, participants, in general, assessed blended learning simulation games more positively, which has been shown by a study using the simulation game assessment model by Oberle, Ivens and Leunig [17,28].

Another advantage of digital, and partly of blended learning, simulation games is a higher level of anonymity of the participants. Studies have shown that this took the pressure out of the situation and made it easier for participants to advocate for new ideas, as well as minimized the prejudices against other players [29,30]. This is especially important for a conflict-based topic, as that featured in this article, and it can lead to higher motivation and engagement [31].

Agriculture education through simulation games is rarely performed and lacks sufficient research, but there are notable exceptions outside of Europe. Dionnet, Kuper, Hammani and Garin [1] facilitated the modernization of large-scale irrigation schemes of smallholder farmers in Morocco with simulation and gaming tools during a time of political and environmental transition. They reported that simulation games helped farmers face current changes, work together to improve their farming systems, and better manage their irrigation systems [1]. Another good example of simulation games in agriculture education is the recent experimental study by Pruksakorn, Kiratiprayoon, Uttaranakorn, Sukreeyapongse, and Dumrongrojwatthana [2], which evaluated simulation games as tools for educating Vietnamese farmers in soil analysis and appropriate fertilizer use. It was discovered that, after taking part in the simulation game, the farmers had a better understanding of appropriate fertilization approaches, and they even taught their knowledge to other farmers in their respective villages.

Researchers have promoted the potential of simulation games in other fields of education for sustainable development, mainly for education regarding climate change and climate change communication [3,32]. Jasper Meya and Klaus Eisenack [3] found that through playing the climate change game KEEP COOL, participants gained greater confidence in climate politics, and experienced an increased sense of personal responsibility.

Despite these interesting studies, there is still a pronounced quantitative research deficit in (digital) simulation games regarding their effects on the field of agriculture politics and education for sustainable development.

4. Aims and Research Questions

The intention of this study is to analyze participants' assessment of the game and the effect of the simulation on participants' attitudes toward the new FO in Germany, their (subjective) knowledge, and their internal efficacy. The study aims to contribute to the systematic assessment of the didactic value of simulation games. It intends to investigate the usefulness of a simulation game as a tool to facilitate policy decisions; to highlight the importance of compromises surrounding a controversial topic; to bring opposing parties back to the table; and finally, to motivate them to work together to solve their problems. The study also assesses the participants' assessment/opinion on the quality and helpfulness of the simulation itself. The following questions and hypotheses have been derived from the research aims:

Question 1. How do the participants themselves rate the simulation game, its effects, and the simulation supervising team?

Question 2. Do the participants assess the game differently regarding their personal backgrounds (age, sex, level of education)?

Question 3. Does the simulation game help the participants to understand how difficult the problem is and how important compromises in this field of agriculture politics are?

The closed and open formatted questions, which were integrated into the post-test, were analyzed and illustrated through descriptive statistics and qualitative content analysis to answer these questions. Classification of the messages that the participants sent through the simulation team was used as

another indicator. Due to the classification, one could observe whether the participants were more open to negotiations, compromise, and positive interaction, or were leaning more toward pressuring other actors, declining compromises, and having negative interactions. A qualitative analysis of the messages will be addressed in another article. The impact of background variables such as age, sex, and education on the game's assessment was tested via multiple regression analyses.

Question 4. (How) does participation in the simulation game affect participants' (subjective) knowledge about the new fertilizer ordinance, attitude towards the fertilizer ordinance, interest in agriculture politics, and their internal efficacy regarding the application of the new ordinance? And are the effects similar within all participation groups (farmers, residents, students)?

Given the existing literature on digital and blended learning simulation games, two hypotheses regarding the effects of the simulation game are established:

Hypothesis 1. *Taking part in the simulation game will have a positive effect on participants' subjective knowledge about the FO and their internal efficacy.*

Hypothesis 2. *Taking part in the simulation game will have no effect on participants' attitudes towards the FO.*

The fourth question and the hypotheses were answered through mean value comparison between the pre- and post-test results, using Cohen's d value as indicators for the effect size of changes [33] and through a paired t-test.

5. Study Design

5.1. Sample and Data Collection

Overall, 107 people participated in two simulation games. The participants were recruited via regional key multipliers in the regions, such as the Lower Saxony Chamber of Agriculture and students from the University of Goettingen. Everybody freely participated in the simulation game and in the surveys without any compensation. Among the 107 participants, 10 participants did not want to take part in the surveys, 4 participants had too many missing answers, and 3 participants could not be connected with their pre- and post-surveys. Therefore, the sample consisted of 90 participants (30% female, average age 31.88 years, SD = 12.44) and the sample was a convenience sample without random selection. The participants were mostly regional farmers (31.1%), residents (28.9%), agriculture students at the university of Göttingen (32.2%) and experts from the agriculture administration and water administration (7.8%). All of the participants signed a letter of consent granting permission for anonymized usage of their survey answers for scientific research. The letter was written in accordance with the European General Data Protection Regulation and approved by the data protection officer of the University of Göttingen.

The pre-test was conducted directly before the simulation and the post-test directly afterward. The games were played in Cloppenburg, the most prominent livestock-farming region of lower Saxony, and in Rotenburg, a strong farming region with a high density of biogas plants. These two regions were selected because they are both agriculture-based regions, which do not comply with the new FO of Germany due to over-fertilization and excessive livestock.

5.2. Survey Instruments

A pre- and post-comparison design with pre- and post-surveys was employed in this study. The written questionnaire consisted mainly of closed questions, accompanied by semi-open and open questions. The closed questions on participants' attitudes, subjective knowledge, and their assessment of the simulation game in general consisted of four-point Likert scales (for aiding interpretation in the article, and scores were reversed in a coherent manner, i.e., 1, disagree entirely, to 4, agree entirely). In order to assess the changes related to the dispositions regarding the FO

and the subjective knowledge, new scales were created based on established scales validated in other studies [17,34–36]. The attitudes toward the new FO were measured in a construct with seven (four-point) Likert scale items (adapted from) [35,36], the internal efficacy with seven items (adapted from) [17,37,38], and the subjective knowledge with six items (based on) [37,39,40]. All three constructs showed acceptable reliability values, with a Cronbach's alpha of over 0.70, as depicted in Table 1. Interest in agriculture politics was measured through a single (four-point) Likert scale item (adapted from) [36]. Furthermore, the pre-test collected data on participants' sociodemographic backgrounds, including variables of gender, age, education, and employment/occupation.

Table 1. Measurement models (intervention group, pre-/post-test) and item examples.

Category	Number of Items	Cronbachs α	ITEM EXAMPLE
General attitude toward the new fertilizer ordinance	5	0.78/0.85	"I think the new fertilizer ordinance is a good thing."
Internal efficacy	7	0.73/0.70	"When the new fertilizer ordinance is discussed, I usually can participate in the discussion."
Subjective knowledge	6	0.80/0.71	"Generally speaking, I'm in the know about the new fertilizer ordinance."
Relevance for everyday life	9	0.90/0.88	"In my everyday life I often encounter the new fertilizer ordinance."
Assessment simulation leading team	6	0.73	"The answers of the simulation leading team were helpful."
Assessment of simulation (3-factorial): I = in general, II = learning effect, III = motivation	I = 10 II = 7 III = 5	I = 0.82 II = 0.87 III = 0.88	I = "Altogether, how satisfied were you with the simulation game?" II = "Through the simulation game … I have an overall better understanding how the new fertilizing ordinance works." III = "The simulation game … motivated me to further deal with the fertilizing ordinance."

In the post-test, participants' assessments of the simulation game, its effects, and its simulation supervisor team were queried through four constructs with good reliability values, as shown in Table 1. The simulation supervisor team assessment, with six Likert scale items, was newly constructed for this study, whereas the general assessment of the simulation game and its effects was adapted from the study by Oberle, Ivens and Leunig [17]. The post-test also contained open questions about what the participants liked, disliked, and would change about the simulation game.

Lastly, the communication during the game was monitored and classified by the simulation supervising team in categories reaching from give information or positive interaction to exercising pressure or negative interaction. A further analysis of the messages will be done in another article but, here, we used them as an indicator for the interaction between the participants and the atmosphere during the game, as well as an indicator for negotiations and openness for compromises of the participants.

6. Conception and Implementation of the Nutrient Surplus Simulation Game

The game follows the method of Reimann [41] and Vagt [42] and is additionally supported with a digital communication engine for the game. The explanation of the game is structured in two parts as follows: (1) the conception of the game, which includes the explanation of the digital engine flexsimgame and (2) the implementation of the game in Lower Saxony.

6.1. Conception

During the conceptualization of the simulation, the game was tested twice, in 2016 and early 2018, with students from the University of Göttingen (n = 85). Through the pre-testing, it became clear that the different roles in the simulation needed a certain amount of specialized knowledge, as well as qualified advisors, whom the participants could contact for their expertise during the game. Therefore,

a leadership team of 16 experts from agriculture and social science as well as farmers, civil servants from the agriculture and water protection administrations, politicians, and IT experts was assembled to integrate a strong knowledge base into the game to help build understanding of the complexity of the situation [9]. A minimum of 10 of these experts supervised every simulation conducted. For the preparation of the game, participants received e-mails containing videos of four specialized lectures to enhance their knowledge about the topic and to close the gap in specialized knowledge needed to successfully play the game.

For digital gameplay, a website and engine flexsimgame has been developed, and it is an open access product that can be used for other simulation games as well. The interactive website of flexsimgame works similarly to an e-mail program. Every role profile has its own password-protected access from which it can send messages to the other players. Although the website, technically, also allows for direct exchange between the individual groups, in the simulation game for nutrient surplus, however, all messages first appear automatically only to the game management team. There, the messages are classified into predetermined categories (e.g., information search, information sharing, positive interaction, negative interaction, negotiation, pressure, nonsense, or public relations), and then forwarded to the addressees. The messages are automatically numbered in the order in which they are received and can only be sent by the game management team while maintaining that order. This guarantees that messages previously sent by the senders reach the receivers sooner. All messages are permanently saved and can be searched by keywords or senders and addressees via a search function. Therefore, quantitative evaluations of the classifications and the number of messages sent by the individual groups can be created immediately after the game and used for discussion in the debriefing.

The simulation also has group chat rooms for players with the same role profile and combined chat rooms for the residents from the rural areas to simulate a community. The advantage of the engine is that the simulation team can simulate every party not represented in the game (e.g., the European Commission or the Federal Cartel Office), and they also have an overview of the strategy and communication of every player. In this way, the supervising team can intervene through a simulation team role, should participants pursue unrealistic strategies or even criminal activities such as building a cartel for agricultural products. Lastly, the engine has other optional features such as a video chat to integrate players who cannot be present. This feature was not used due to insufficient internet connection in rural areas, or virtual stores for trade.

The simulation setting was as follows: Every participant received a general initial position, which describes the new FO and the current situation. Additionally, everyone received information on his or her role-specialized starting position, describing, for example, their farm and budget if they were a farmer.

The general and specialized positions were drawn from interviews with experts, as well as affected persons from problematic areas that assessed their individual and the regional situations. As a result of these interviews, 19 different role profiles were designed to ensure every perspective on the FO was included. Each role profile could be assigned to three to five participants. The role profiles incorporated all parties involved or affected by the new FO (e.g., farmers, public administrations, businesses, the press, and resident organizations). Additionally, certain roles were assigned special tools, for example, farmer roles received access to a professional online fertilizer calculator, a tool often used in agriculture businesses to calculate the amount and type of fertilizer a field would need to grow crops. This web module already followed the new FO and helped the participants familiarize themselves with the legal boundaries of fertilizer use (see) [5]. This should enhance the seriousness of the simulation and help the participants to have trial and error strategies and safely test new, creative ways of dealing with the regulations [9].

6.2. Implementation

The simulation game was played twice, once in May of 2018 in the county Rotenburg-Wümme, and for the second time in November 2018 in the county Cloppenburg. The game included 107 participants overall. In order to reach as many people as possible from different target groups and motivate them to participate in the simulation game, contact was established with multipliers in both regions. Information events were held on site and, in cooperation with regional stakeholders, press talks were conducted, and press information was sent out. In addition, the multipliers, which included the regional farmers' association, the county of Rotenburg, and an environmental center, sent flyers and invitations to their members via their own distribution channels.

The simulation lasted approximately three days. It started on the first day in the afternoon with an introduction of the supervising team and the participants, as well as an introduction to the game itself, its rules, general starting situation, and the digital engine. Afterwards, personal roles and starting positions were drawn at random. Everybody was provided with an additional short lecture about the topic of fertilizer and the new FO to make sure that they had a shared knowledge base.

The participants were assigned different rooms depending on their role profiles. Only participants with the same role profile sat together in the same room. There was one exception to this rule, i.e., all livestock-keeping farmers were in one room and all crop farmers were in another to simulate the regional producers. The press was seated in the same room with the simulation supervising team to overhear press-relevant information. Participants communicated using the flexsimgame engine. The simulation supervising team monitored the entire online communication. The participants were not able to contact other players directly online without the supervising team reading and accepting the messages first to prevent unrealistic or false play, or even cheating. For example, in one of the trial runs, the participants created a cartel for organically produced meat, which led to a situation where all livestock-keeping farmers and food stores were very successful, but the situation was also unrealistic and illegal. Face-to-face communication and negotiations, as part of the blended learning experience, were possible, but the participants had to inform the simulation supervising team and write a protocol of the negotiations.

The game concluded with an analog debriefing, during which the players reflected upon their strategies, decision making, and the overall situation of the simulation. The supervising team explained their actions during the game and, if they had occurred, possible interventions by the simulation team. The simulation ended with a reality check and a comparison with the solutions, ideas, and decisions during the simulation and their possible uses in a real-life situation.

7. Results

7.1. General Evaluation of the Simulation Game

Overall, the participants' evaluation of the simulation was positive; 86.2% of them were satisfied with the simulation game and 27.6% were even very satisfied. Furthermore, nearly 50% would strongly recommend the simulation game. Overall, 92% would recommend it and 85.1% would take part in a game like this again. The participants' assessment of the simulation supervisors was very positive, as well as the general satisfaction with the simulation game, whereas the perceived learning effect and motivational effect only leaned toward a positive mean value.

As can be seen in Figure 1, participants were asked to associate the simulation game they took part in with a selection of adjectives. It is apparent that the simulation was perceived as interesting, varied, informative, and exciting. It had a suitable duration and an adequate complexity.

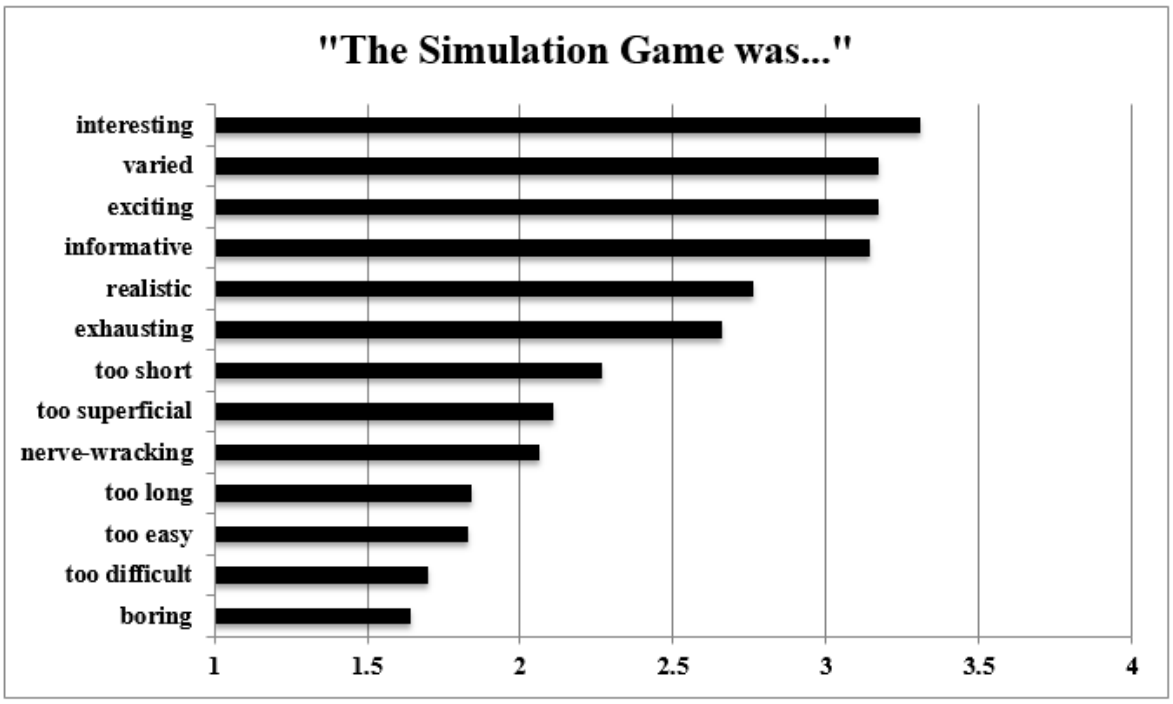

Figure 1. Adjectives attributed to the simulation game by the participants (mean value, four-point scale from 1 = don't agree to 4 = fully agree).

To give the participants a chance to assess the simulation game outside the closed Likert scale assessment questions, they could fill out open questions about what they liked, disliked, and would change for the better.

One can see in Table 2 that over one-third of the survey participants favored the exchange with others in the game. This statement supports that of Geurts, Duke, and Vermeulens [9] that policy games can facilitate effective communication across diverse groups such as the ones in this simulation game. Participants also seemed to appreciate the good atmosphere during the simulation game and the role identification.

Table 2. Coded results of open question in mentions and percentage. Multiple categorizations for one answer were possible.

What Did You Like about the Simulation Game?		
Category	**Mentions**	**Percent**
Exchange with others	31	34.07%
Dive into the role	22	24.18%
Atmosphere/food	15	16.49%
Acquisition of knowledge	12	13.32%
Realism	9	9.90%
Solutions	2	2.20%
Overall	91	100%

Compared with the features that participants liked about the simulation games, there were far fewer aspects that they did not like. As is shown in Table 3, there approximately 30 percent fewer mentions of dislikes, and there was also not one particular aspect that most participants directly focused on.

Table 3. Coded results of open question in mentions and percentage. Multiple categorizations for one answer were possible.

What Did You Not Like about the Simulation Game?		
Category	**Mentions**	**Percent**
Insufficient information	11	17.74%
Delay of game management	10	16.13%
Role conflicts/ Missing roles	9	14.52%
Too few participants	5	8.06%
Too much Information	5	8.06%
Intervention of game management	4	6.45%
Mandatory Participation	3	4.84%
Other	15	24.19%
Overall	62	100%

Insufficient information and role conflicts have often been named for other simulation games as well and could be a result of the heterogeneous participants. What some participants consider to be not enough information is too much information for other participants, which another 8% of participants complained about. The delay of game management came from a situation during the second game, when some members of the simulation management team were tied into a discussion with some participants.

There are several small aspects that single participants did not like about the game, such as the duration, etc. However, it was quite a positive result for the game that there was no single aspect that was disliked by the majority of the participants.

Our investigation of suggestions for improvement found similar results. Again, there were fewer suggestions for improvement than there were for aspects that participants liked about the game (See Table 4). In addition, there was no clear point that participants want to have improved; more extensive role description and more information were the most frequently mentioned suggestions. From the participants' point of view, there was still room for improvement regarding the communication as it took too much time for the simulation management team to read and forward all of the messages in the game. All in all, the analysis of the open questions mirrors the participants' positive assessment based on closed questions of the evaluation. Therefore, the second research question about the participants' assessment of the game can be answered with an overall positive assessment despite some small areas of improvement.

7.2. Influences on the Participants' Assessment of the Simulation Game

To answer the third question, we checked the influence of background variables on the assessment of the game to see if sex, age, agricultural interest, and level of education made a difference in how participants reviewed the simulation. Therefore, a multiple regression analysis with background variables on the three factors of participants' evaluation of the simulation was applied. The results are shown in Table 5. Despite the fact that there was a huge age difference between the participants (19–68 years), there was no significant influence of age on the assessment of the game. Interest in agricultural political topics also showed no influence. Participants with higher education seemed to be more satisfied with the simulation and perceived a higher learning effect. Lastly, female participants rated the simulation game more favorably than their male counterparts.

Table 4. Coded results of open question in mentions and percentage. Multiple categorizations for one answer were possible.

Do You Have Suggestions for Improving the Simulation Game		
Category	**Mentions**	**Percent**
More information	10	15.15%
More extensive role description	10	15.15%
Faster Communication	9	13.64%
More participants	7	10.61%
Clear guidelines	7	10.61%
Better role distribution	4	6.06%
Transfer results into politics	3	4.55%
More time	3	4.55%
Other	13	19.70%
Overall	66	100%

Table 5. Multiple regression models with background variables on the three aspects of participants' evaluation of the simulation game. 1, General contentment; 2, learning effect; 3, motivation effect.

	MOD I			MOD II			MOD III		
Variables	**SG Evaluation 1**	**SG Evaluation 2**	**SG Evaluation 3**	**SG Evaluation 1**	**SG Evaluation 2**	**SG Evaluation 3**	**SG Evaluation 1**	**SG Evaluation 2**	**SG Evaluation 3**
Sex (f)	0.30 **	ns	ns	0.31 **	ns	ns	0.27 *	ns	ns
Age	ns	ns	ns	ns	ns	ns	ns	ns	ns
Agriculture Political interest				ns	ns	ns	ns	ns	ns
Level of education							0.30 ***	0.30 *	ns
R^2	0.09	0.02	0.03	0.10	0.04	0.04	0.18	0.10	0.05

Significance level: *** $p < 0.001$; ** $p < 0.01$; * $p < 0.05$; ns $p > 0.1$. SG evaluation 1 = general contentment; SG evaluation 2 = leaning effect; SG evaluation 3 = motivation effect.

7.3. Importance of Compromises and the Difficulty of the Problem

Over 90% of the participants claimed to better understand the difficulty of finding a solution for complying with the new FO through the game. They also saw the importance of compromises in this area by participating in the simulation (see Figure 2). This was one of the main objectives of the simulation game. Additionally, participants also said they understood the function and problems of the new laws better, as well as the positions of other actors involved in the implementation of the laws.

Another indicator of the importance of negotiation and compromises is the classification of messages through the simulation supervising team. As illustrated in Figure 3, the simulation team classified the overall 1416 sent messages of the participants in eight different categories. Overall, there is a high amount of negotiation (24.89%) and positive interaction (25.21%) messages, which emphasizes the willingness of participants to offer and accept compromises. In addition, the classification also shows that exercising pressure (4.87%) on other players was not a move that was often used, and there was also limited negative interaction (6.43%), such as the declining of offers between the players. These results support the previous findings of the descriptive statistics that the simulation game encourages the participants to compromise, and therefore shows them how important compromises are in a conflicted topic.

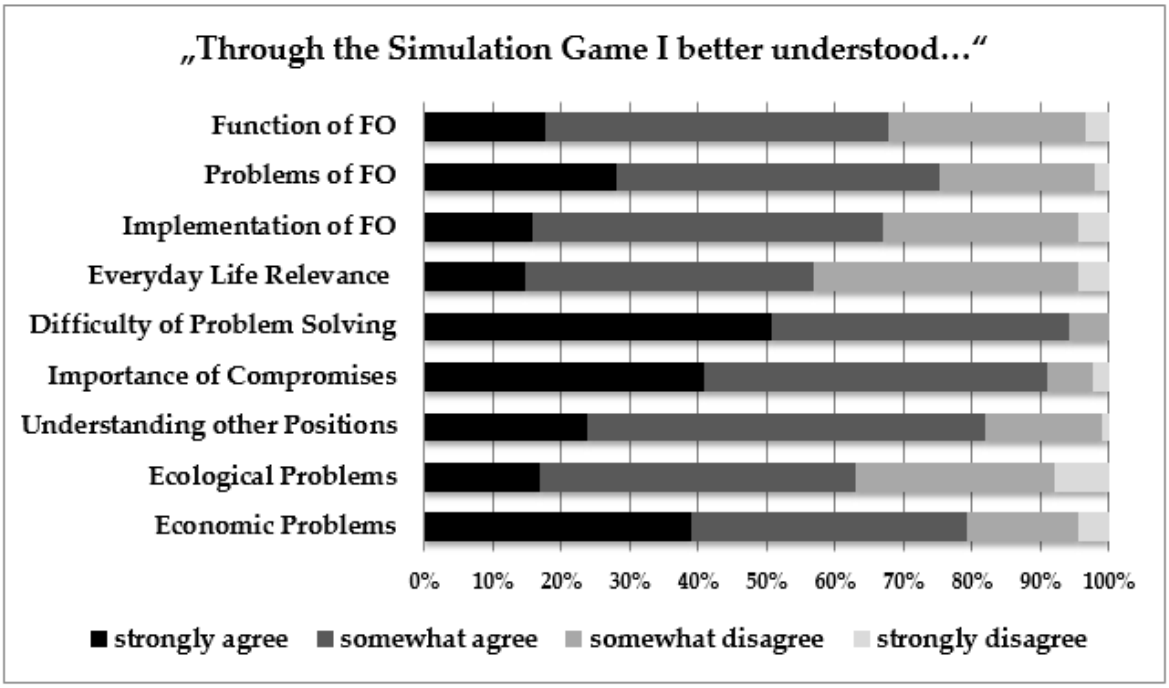

Figure 2. Effects of the simulation game from the participants' perspective (percentages).

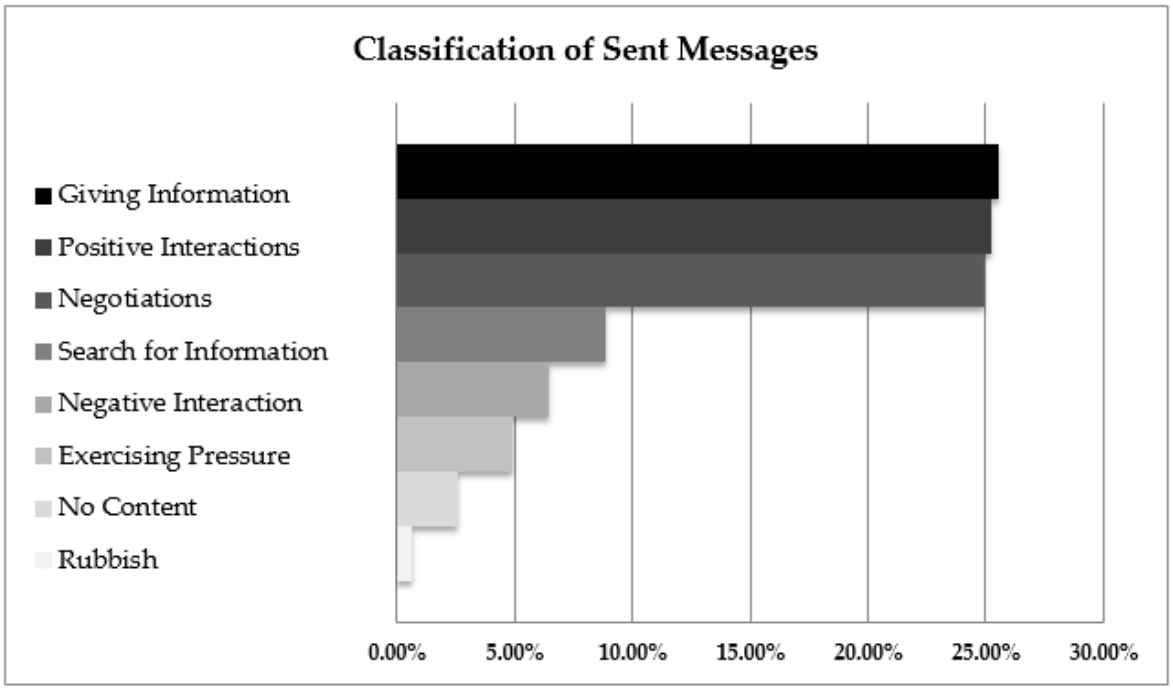

Figure 3. Classification of participants' messages by the simulation supervising team (percentages).

7.4. Effects of the Simulation Game

The mean value comparison (see Table 6) shows that there is a significant positive effect on participants' subjective knowledge and internal efficacy about the new FO. The strength of the effect on internal efficacy is rather small (Cohen's d = 0.36), however, for subjective knowledge, there is a robust medium effect (Cohen's d = 0.65). This supports the first hypothesis of the fourth question. There are no significant effects on the attitude towards the new FO or everyday life relevant to the new laws, which supports the assumption of the second hypothesis that the simulation game has no

persuasive effect on the participants. The everyday relevance of the new laws increases, but it is only significant at a 90% confidence interval, and the Cohen's d effect size is also under 0.20. This could be due to the fact that the relevance for the participants of the region is already very clear and the simulation does not bring the topic closer to them. However, there is a small but significant decrease in interest in agriculture politics, which differs from our prior expectations regarding the effect on interest in agriculture politics. The small decrease in interest in agriculture politics could be a saturation effect, as the interest was already very high before with a mean value of 3.48.

Table 6. Mean value (M) and standard deviations (SD) in the pre- and post-test comparison; effect size of changes (Cohen's d) and significance (T-Test) for constructs captured before and after the simulation game.

Measurement Models		Pretest		Posttest		Cohen's d	T-Test
		M	SD	M	SD		
General attitude towards the new fertilizer ordinance		2.57	0.50	2.60	0.52	0.06	0.706 ns
Internal efficacy		2.90	0.46	3.05	0.38	0.36	4.063 ***
Subjective knowledge		2.98	0.58	3.31	0.42	0.65	6.729 ***
Relevance for everyday life		3.17	0.63	3.27	0.55	0.17	1.797 +
Agricultural political interest		3.48	0.59	3.28	0.64	−0.33	−3.145 **
Assessment simulation supervising team				3.31	0.46		
Participants' evaluation of simulation game	**General contentment**			3.15	0.40		
	Learning effects			2.84	0.67		
	Motivation effect			2.75	0.67		

1 = strongly disagree, 2 = somewhat disagree, 3 = somewhat agree, 4 = strongly agree. Cohen's d: small effect |d|≤ 0.2; medium effect |d| ≤ 0.5; strong effect ≤0.8. Significance t-test: *** $p < 0.001$; ** $p < 0.01$; +, $p < 0.1$; ns, $p > 0.1$.

In addition, the significant effects on internal efficacy and subjective knowledge, as well as the non-existent effect on the general attitude towards the new FO, were controlled if they were similar in all subgroups. As one of the goals of the game is to inform and educate farmers and residents about the new FO without taking a side in the conflict, it is crucial that all major participant groups be affected similarly. Without looking into the subgroups, it is also possible that farmers gain a more negative view of the FO and that residents perceive it more positively, which could increase conflict. However, both effects neutralize each other, so overall one would see no effect.

By controlling subjective knowledge and internal efficacy for the subgroups (see Table 7), the student group stands out as they have strong knowledge and efficacy gains. This is not unexpected, as the topic is still furthest away from their everyday-life reality and they have the lowest score on subjective knowledge and internal efficacy in the pre-test. Furthermore, the fact that the experts did not gain any knowledge or efficacy throughout the game is logical as they were already experts on the new FO. This notion is expressed by their high scores on the pre-test. The effects on subjective knowledge and on internal efficacy are both similar for farmers and residents with a significant middle-sized effect on knowledge, and a small but not significant effect on internal efficacy, which might be due to the small sample size. Overall, the game educates farmers and residents equally; the strongest effect is on students, but they also have the lowest pre-test value of all participation groups.

Table 7. Mean value (M) and standard deviations (SD) in the pre- and post-test; effect size of changes (Cohen's d) and significance (t-test) for subgroups regarding subjective knowledge and internal efficacy.

Measurement Models	Pretest		Posttest		Cohen's d	T-Test
	M	SD	M	SD		
Subjective knowledge farmers	3.17	0.42	3.42	0.34	0.65	3.151 **
Subjective knowledge students	2.81	0.47	3.22	0.45	0.89	6.592 ***
Subjective knowledge residents	2.86	0.74	3.26	0.43	0.66	3.296 ***
Subjective knowledge experts	3.36	0.55	3.40	0.46	0.08	0.471 ns
Internal efficacy farmers	2.92	0.39	3.03	0.35	0.30	1.353 ns
Internal efficacy students	2.71	0.32	3.00	0.34	0.88	7.133 ***
Internal efficacy residents	3.01	0.61	3.13	0.43	0.23	1.679 ns
Internal efficacy experts	3.12	0.39	3.08	0.48	−0.09	−0.295 ns

Cohen's d: small effect |d| ≤ 0.2; medium effect |d| ≤ 0.5; strong effect ≤ 0.8. Significance t-test: *** $p < 0.001$; ** $p < 0.01$; +, $p < 0.1$; ns, $p > 0.1$.

Equivalent to the main group comparison, there is no change in attitude in any of the subgroups, which strongly supports the second hypothesis. This makes clear that the game has not been developed to, and will not, influence participants' points of view on the FO (see Table 8). Experts and residents have a slightly positive view of the FO, and farmers, as expected, a slightly negative attitude, as the new ordinance is a threat to their business. All subgroups are generally content with the simulation game, students slightly more and farmers slightly less.

Table 8. Mean value (M) and standard deviations (SD) in the pre- and post-test; effect size of changes (Cohen's d) and significance (t-test) for subgroups regarding the attitude towards the fertilizer ordinance and the mean value of the general contentment of the simulation game out of the participants' view.

Measurement Models	Pretest		Posttest		Cohen's d	T-Test
	M	SD	M	SD		
General attitude toward the newfertilizing ordinance farmers	2.33	0.53	2.35	0.62	0.04	0.372 ns
General attitude toward the newfertilizing ordinance students	2.61	0.36	2.67	0.41	0.16	0.868 ns
General attitude toward the newfertilizing ordinance residence	2.76	0.50	2.79	0.44	0.06	0.429 ns
General attitude toward the newfertilizing ordinance experts	2.75	0.64	2.66	0.54	−0.15	−0.737 ns
General contentment of the simulation game farmers			2.94	0.39		
General contentment of the simulation game students			3.33	0.34		
General contentment of the simulation game residents			3.18	0.35		
General contentment of the simulation game experts			3.17	0.54		

Cohen's d: small effect |d| ≤ 0.2; medium effect |d| ≤ 0.5; strong effect ≤0.8. Significance t-test: ns, $p > 0.1$.

7.5. Limitations

All statistical analyses were computed in IBM SPSS 25. Due to the small sample size of n = 90, we abstained from latent data analyses in Mplus, as the required sample size of around ten participants per item used in constructs was not met for more elaborated constructs such as the assessment of the simulation game [43]. For the multiple regression analyses, we used ordinal-scaled data, (e.g., for interest in agriculture politics), as quasi interval-scaled data, following the assumption that the participants perceived the answers in the Likert-scaled items as answers with the same distance [44]. Measurement invariance bamong the relevant subgroups (farmers, residents, and students) was not tested, as the subgroups were too small. In total, there were between 25 and 30 participants per subgroup.

The expert group was even smaller, and therefore the subgroups did not meet the recommended n = 100 [45] for a feasible measurement of invariance.

In addition, it was not possible to conduct a follow-up survey to research the long-term effects of the game because many participants were not willing to participate in another survey. To date, only two simulation games could be conducted, thus, the sample size was too small to draw any general conclusions. However, as a pilot study, the results can offer some leads on the advantages and acceptance of simulation games as a tool for education for sustainable development in rural areas.

8. Conclusions and Outlook

The new fertilizer ordinance is an ongoing and very controversial topic in Germany, especially in the strong agriculture-orientated regions of Lower Saxony. On the one hand, farmers are affected negatively by the consequences of the new regulations, as they have to fertilize considerably less and endure higher administrative burdens. On the other hand, the protection of drinking water in polluted areas must be a priority for the society as it affects their health and well-being. Given the situation, and regarding Geurts, Duke and Vermeulen [9], a simulation game can help to bring different interest groups back to discussions, to spread information about the new ordinance, and to reduce ongoing tensions. Furthermore, it allows participants to look at the problem from a different perspective and it emphasizes the importance of finding compromises in this field of agricultural politics.

For the present study of the simulation game, we formulated four research questions and conducted a small intervention study. The game proved to be a helpful tool for spreading knowledge about the new fertilizer ordinance and helped to increase participants' internal efficacy for the topic. Their attitudes toward the new ordinance were not affected, and therefore it could be used as an unbiased method of knowledge transfer about this controversial topic without picking sides. All participant groups assessed the simulation game very positively, and after playing it they expressed a better understanding of other positions in the conflict and could more clearly see the difficulty of the problem. They also realized the importance of finding a compromise. Additionally, the communication within the game was seen as very positive and oriented toward compromise.

Therefore, our findings support the assumptions of Civic Education regarding the benefits of digital simulation games (see) [12,13,16], and also the policy simulation research of Geurts, Duke and Vermeulen [9]. The presented results give a fitting example of agriculture and sustainable education through a simulation game and the simulation game is shown to be a valid instrument to educate and train farmers. These findings support the use of simulation games in agriculture education and training, similar to the work of Dionnet, Kuper, Hammani and Garin [1] and Pruksakorn, Kiratiprayoon, Uttaranakorn, Sukreeyapongse, and Dumrongrojwatthana [2].

The research on this topic should not stop here, as further intensive research is necessary in the field of simulation games in agriculture education and local conflict resolution. Simulation games can be used as a tool to inform people about new laws that may lead to social controversies. As this study is only a small intervention study, further studies with control group design and follow-up surveys are needed to measure the long-term effects, and to compare effects of the simulation game with other educational tools. Complementary qualitative interviews could help to discover more about the mechanics of the game. In addition, the messages between the participants of the game must undergo a more profound analysis.

Overall, the results are very promising for the field of blended learning and digital simulation games and give an example of how to accompany education about new legislation with a simulation game.

Author Contributions: Conceptualization, S.I. and G.W.; Data curation, S.I.; Formal analysis, S.I.; Funding acquisition, G.W.; Methodology, S.I. and M.O.; Project administration, G.W.; Supervision, K.D., O.M., and M.O.; Writing—original draft, S.I. and G.W.; Writing—review and editing, K.D., O.M., and M.O. All authors have read and agreed to the published version of the manuscript.

Funding: Conception and first trials were funded by the Promotional Fund of Germany's Development Agency for Agribusiness (Landwirtschaftliche Rentenbank). The implementation of the simulation game was supported

financially by the Lower Saxony Ministry for Food, Agriculture and Consumer Protection. We acknowledge support from the Open Access Publication Funds of the University of Goettingen.

Conflicts of Interest: The authors declare no conflict of interest.

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