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"*Burger.i.doo*"—An Innovative Education Game for the Assessment of Sustainability from Meat and Substitute Products in Science Education

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Abstract: How will we be fed in the future? Without a doubt, the recent development has to undergo a change, to stick to the aims of sustainable development. Modern agriculture is in the compulsion of its consumers' behaviour and the constantly growing amount of food required for feeding the world population. This nutrition is taken into individual responsibility, but to be able to make decisions regarding sustainable nutrition, educational work is required. By determining the environmental impact of different ingredients, Burger.i.doo contributes to the *Education of Sustainable Nutrition* and empowers its gamers to gain and extend their knowledge about the consumption of capabilities. It is designed for students aged 14 to 18. The aim is to create the most sustainable burger, which is measured in five categories: greenhouse gas emission, water consumption, land use, price and taste, by comparing the different categories of vegan, vegetarian, pescetarian and different meat options of burgers. To evaluate the impact of the game, a survey was conducted. It shows that the key targets of the construction of the game are fulfilled: the gamers had fun, learned about the impact of food on the environment and the game had a positive influence on their environmental consciousness.

Keywords: education game; nutrition; education for sustainable developments; nutritional impacts

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1. Introduction

There are 7.8 billion people who need to be fed in 2022 [1], thus the demand for food is greater than ever. With increasing economic prosperity, a large part of the population can be fed on animal products [2]. For this purpose, approximately 82.1 billion farm animals are kept worldwide [3]. At the same time, nutrition has become a social discourse, contributing to a steadily growing proportion of vegetarian or vegan diets, especially among the younger generations. In general, global growth in sales of substitute products is forecasted [3]. Although the substitute products are mostly produced by large corporations in the meat industry, one of the reasons given by citizens for not eating meat is that they do not want to support the meat industry. Therefore, increasing numbers of people are dedicated to a meat-free diet, which may be one reason for the increasing sales of substitute products [4]. Although the value of produced meat products in Germany remains stable at EUR 38.6 billion, its value equals hundred times the value of produced substitute products [5]. In 2022, worldwide sales of the meat industry of up to USD 1071 billion are forecasted [6]. In addition to social, health and ethical reasons, the impact of nutrition and livestock farming on the environment is unmistakable. Considering the Sustainable Development Goals (SDGs) declared by the UN, nutrition has an important role in achieving a sustainable world. This is, for example, aiming to protect the climate and oceans, preserve biodiversity and end poverty and hunger [7].

2. Relevance of Nutrition for Sustainable Development

Nutrition plays a key role in sustainable development. Many naturally occurring processes of the earth's system are destabilized by anthropogenic influences. The planetary boundaries, shown in Figure 1, demonstrate that in several fields the safe space for action has been abandoned and that there is a high risk of serious consequences [8]. Nutrition is relevant for many of these fields, as it impacts biochemical flows and land-system change because of intensive agriculture. Especially large-growing animal farms and nitrogen-rich manure as well as fertilization of monocultures affect the biosphere integrity [9].

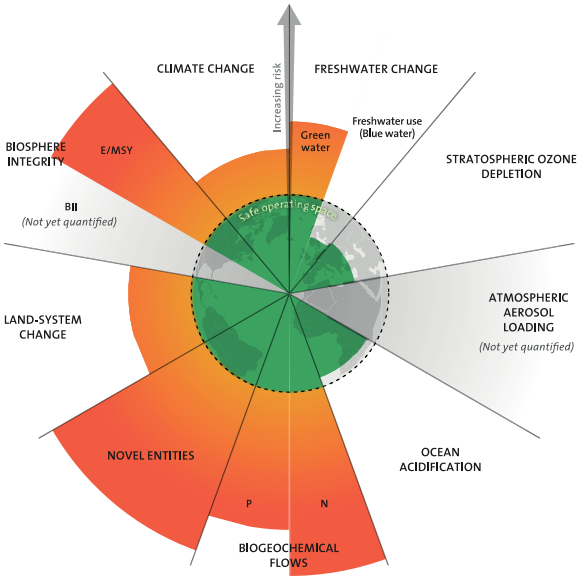

Figure 1. Planetary boundaries. Figure from Azote for Stockholm Resilience Center, based on analysis in [7]. Nutrition is relevant for biochemical flows, land-system change, biosphere integrity, climate change and freshwater change.

One important impact factor is the basis of our diet. Animal products require more resources than plant products because, for example, forest areas are largely cleared for animal feed and only about 40% of the harvest remains for human food [4]. By following a plant-based diet, much of the harvest could be used directly for human food; thus, less total land would be needed [10]. In Figure 2, the environmental impact of different products on greenhouse gas emission, land use and water use is compared. The water footprint differs depending on the base of the diet. It is important to note that the water footprint is divided into three categories: green, blue and grey [11]. While green water describes naturally occurring rain and soil water and is sufficiently available, blue water describes ground and surface water, and grey describes the kind of water that is polluted during production and must first be purified before it can be sent back into the cycle [12,13]. The total water footprint is much higher for animal products than for most plant products; nevertheless, especially nuts have a high water footprint as well [14]. The blue and grey water footprints, especially of cattle and pigs, are particularly high and this water cannot be reused in the natural water circle [14]. Due to the globalization of the world market, this resource consumption does not only take place in the destination country of animal products. Instead, rainforests are often cleared in the southern hemisphere to grow soy for animal feed or to keep large herds of livestock [15]. Furthermore, in southern Europe, the cultivation of vegetables in arid regions leads to the use of blue water to irrigate greenhouses, resulting in increased drought and water scarcity in the affected regions [16]. Another aspect associated with food is the emission of greenhouse gases (ghg). In the European Union, the food sector is responsible for 10.55% of the ghg emissions [17]. If the sustainability of food is considered, land use and water consumption should be considered in addition to ghg emissions, expressed in CO_2 equivalents. In the general discourse on

food sustainability, reference is often made to only one of the three factors [18]. For example, nuts are reported to have high water requirements, while beef is reported to have high ghg emissions [14,19,20]. A common scale is often absent. In addition to the impact of diet on the environment, current dietary patterns impact other societal factors. Food is inequitably distributed in the world. Due to this, overconsumption in developed countries and the resulting rampant "obesity epidemic" [21] in contrast with poverty and hunger in developing countries occurs. The current COVID-19 pandemic and climate change will further exacerbate these problems, thus action is needed [22].

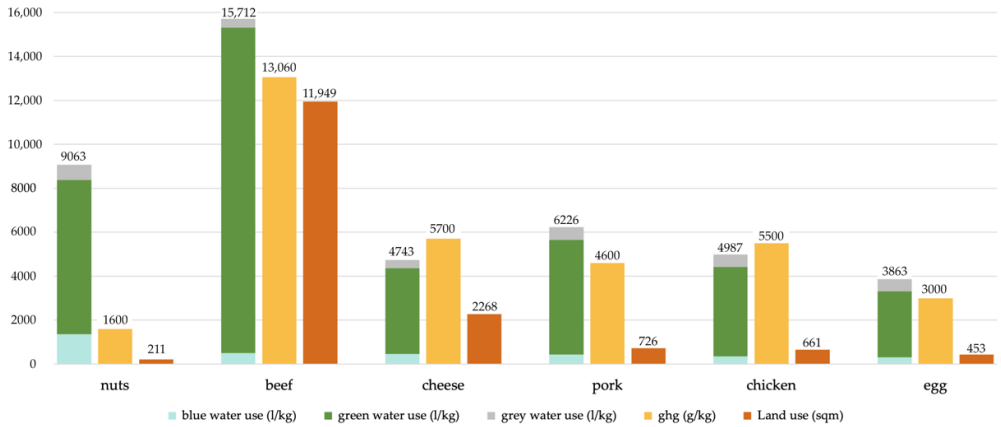

Figure 2. Environmental impact of nuts, beef, cheese, pork, chicken and eggs. Water use (blue, green, grey and total), greenhouse gas emissions and land use of selected products. The data were collected from several publications [10,11,14,19,23].

3. Education for Sustainable Development and Educational Plans Focusing on Nutrition

To limit the use of resources and consequently create a basis of life for future generations, the problems of the current development must be recognized and communicated. Therefore, the relevance of education for sustainable development (ESD) is unmistakable. It represents an educational foundation that accompanies students on their way to sustainable development [24]. Sustainable nutrition [24] is considered from five dimensions (health, environment, economy, society and culture) which are in line with the UN's 2030 Agenda and SDGs [25]. These are addressed in the game by focusing on sustainable consumption (Goal 12) and living on land (Goal 15). The idea of the game is to consider the nutrition-affected dimensions of the environment and society by evaluating water consumption, land use, ghg emission, price and taste of different burgers. Moreover, the game and the subsequent discussion can be used to focus on the dimensions of economy and culture indirectly, for example by examining the results from the perspective of a changing food culture or the sales of the substitute product market. It is also possible to expand the game by including health factors, such as the use of antibiotics or critical nutrients. The game was designed for use in a learning laboratory and supplements the experimental development of the topic of meat and meat substitute products with an evaluation station. Furthermore, it offers a wide range of possible applications, especially for ESD in science lessons. In order to stick to the SDGs and the global action program on ESD a new framework is given by the UNESCO [24]. In particular, this framework emphasizes the empowerment of transformative action. This requires education that addresses not only the cognitive but also the social and behavioural dimensions of the necessary changes and enables people to make reflective decisions [24]. In order to do this, the game is based on the educational standards for the STEM subjects given by PISA and contributes to strengthening assessment skills in particular. Specifically in the game, students should evaluate options for action, and make decisions regarding scientific aspects based on socially accepted and personally relevant values and norms, to justify and reflect on them. It is also anchored that students assess

and evaluate the effects and applications of biology in terms of sustainable development from an ecological, economic, political, and social perspective. This contributes to scientific literacy which is requested by the sub-competences of PISA in 2018. Moreover, one of the global competences of the 2018 PISA studies is to take action for collective well-being and sustainable development [26]. According to this, all learners should be acknowledged to promote sustainable development and lifestyles. The game empowers its players to focus on the role of nutrition in climate change and on the impact nutrition can have on the environment. Despite it being crucial to educate young people about the environmental impact of nutrition, there are limits to the scope of personal action to impact the environment through one's diet [27]. Political decisions that can offer sustainable options at more attractive prices or enable farmers to ensure sustainable food production can be more significant [28]. In addition, global players, with a lion's share of the sales market, play a significant role in the prominent placement of products in supermarkets. However, as the purchase decision of everyone symbolizes to the sales market that sustainable food is in demand, our personal decision can contribute to focusing the global players on more sustainable food, as shown for example by the sale of substitute products and thus an even larger assortment of them in the supermarket [29].

This is a significant development against the increasing globalization and continuously available food: although in western countries every food is permanently available, students should learn to perceive and question their consumption and impacts on the environment. Therefore, it is important to weigh different influences, such as the origin and season of food against each other and to make decisions that suit personal values. The ability to choose between several options and find the most suitable option personally and for the environment sticks to the goals of scientific literacy [30]. In the game, students expand their competencies in these areas by identifying and evaluating the impact of certain ingredients and discussing a reasoned judgment about the sustainability of their burger. At this point, educational games link the students' life and the classroom as well as theoretical and practical elements [31]. Overall, the educational game offers a chance to stimulate an active discussion, in which evaluative and communicative competencies are promoted. The playful approach to a relevant topic of the future is particularly suitable for linking sustainability and nutrition with the student's life. The simple design of the game is beneficial for use as an introduction to a teaching sequence. By picking up the students from their everyday habits and creating the burgers according to their ideas in the first round of the game, the students are enabled to deal with their personal eating habits. The values of the burger from their daily diet may lead to a moment of shock, as especially the values for water consumption of food are rarely communicated. This situation can cause an intrinsic motivation to deal with the causes of resource consumption and create a higher awareness of the problem [32]. The advantage of such a learning game in contrast to class discussions is the high activation and action orientation. Each player must create a burger. In addition, each player receives his or her own burger card, which minimizes the possibility of imitating the other player's burger creation. Furthermore, the high activity of the students during the game can lead to a better memorization of the conveyed content and can be taken for granted in the future as connectable prior knowledge for the lessons [33]. In addition, *Burger.i.doo,* as a group game, provides a basis for a discourse on the resource consumption of food and is suitable as a cornerstone for a discussion based on it. A suitable context for this discussion would be the diet of the future or participation in the school cafeteria meal plan. The multidimensionality of the resources in the game serves as a cornerstone for expanding the ability to reflect by not only referring to individual values, as is often practised in everyday life.

4. Burger.i.doo

The game *Burger.i.doo* was developed based on the background outlined above. The idea is to let the students create the most sustainable burger. There are five categories for

evaluation: CO_2 equivalent, water consumption, land use, price and taste. The burger with the best overall scores wins.

4.1. Development and Background

The idea for *Burger.i.doo* grew out of the motivation to enable the evaluation of the sustainability of different forms of nutrition. The game not only addresses the CO_2 value of food but also embeds the factors of water consumption, land use, price and taste in order to shed light on several dimensions of sustainability. The decision for a burger as a dish is based on the high combination possibility of the ingredients, the personal relevance, and the advantage of comparing the resource consumption of diverse products.

To design the ingredient cards, the most common ingredients of a burger were selected as well as all conventional meat and meat substitute products. The selection of ingredients was based on the ingredients listed on the menu of the most common fast food and burger restaurants in Germany. Common serving sizes were identified and used for researching the data. To generate the game data, values for CO_2 equivalent, water use, land use and price were researched. For products consisting of one ingredient, various publications exist on resource consumption with differentiated values listed in some cases [14,19,20,23,34,35]. Products based on multiple ingredients are sometimes not listed in the literature. For this case, the game data were obtained from the values of the individual ingredients. Only approximate values could be determined, since, for example, the type of production, country of origin and preparation method are difficult to include in the calculation. In terms of water consumption, in particular, the difficulty is to combine the green, blue and grey categories into one value in order to make appropriate comparisons between the products. For these reasons, averaged values from different sources were generated for each ingredient. The listing can be found in the Supplementary Information.

To enable the players to read up on the background of the different categories, an e-book was created, which contains further information in addition to the rules of the game.

4.2. Game Structure

The game consists of two different game boards, game pieces, multipliers, burger cards and ingredient cards that were created independently (Figure 3). In the middle of the game setup is an information board (Figures 4 and 5). On the information board are fields for storing the ingredient or burger cards, as well as a legend explaining symbols and a QR code to the e-book. In addition to concise explanations of the categories taken up in the game.

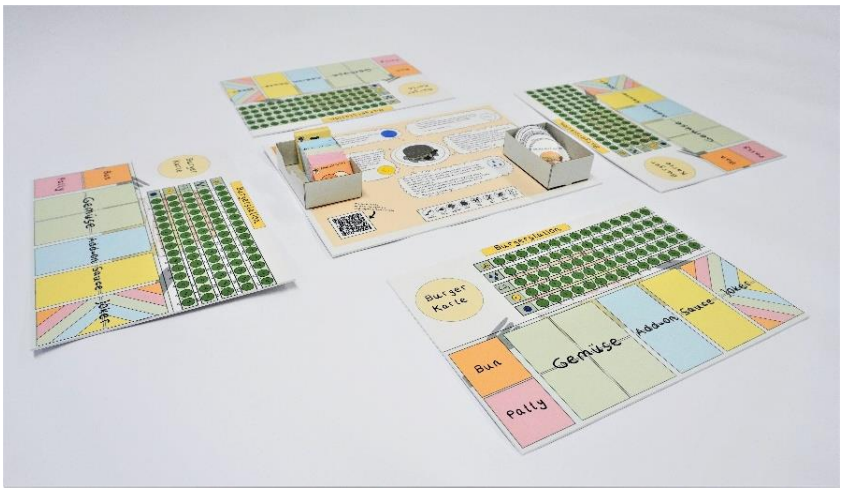

Figure 3. Game setting.

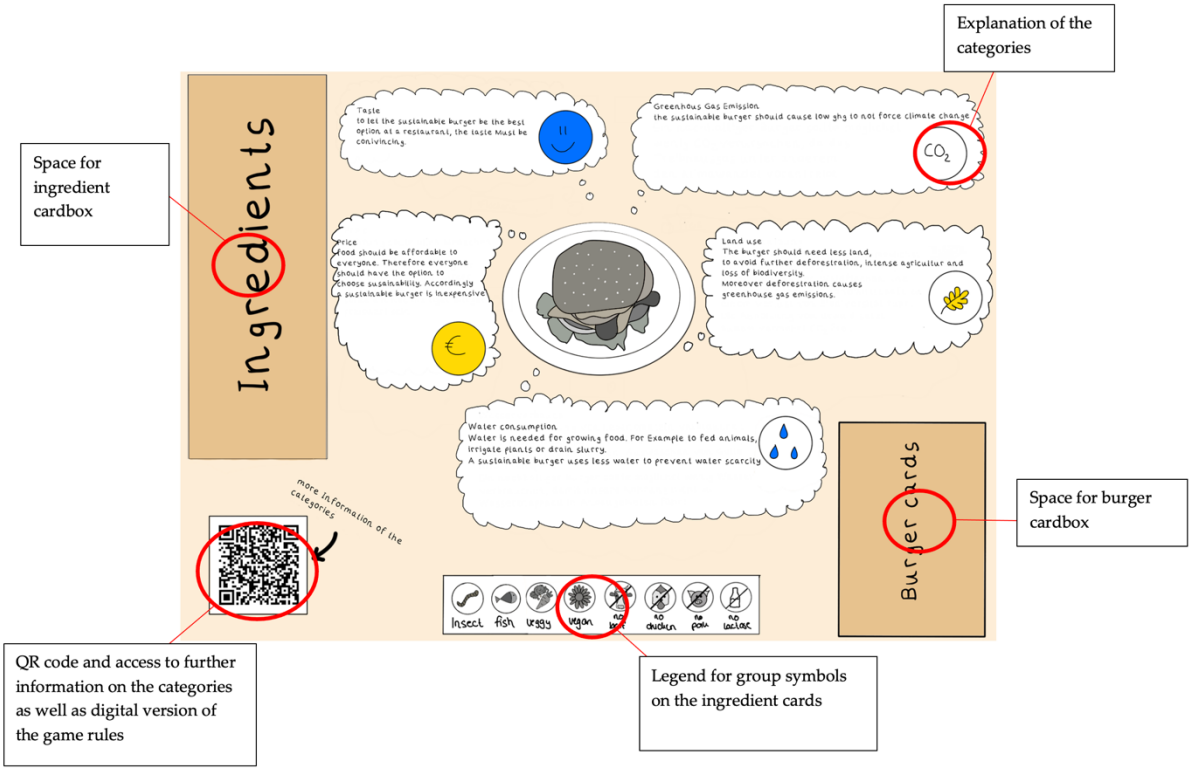

Figure 4. Explanation of the game board.

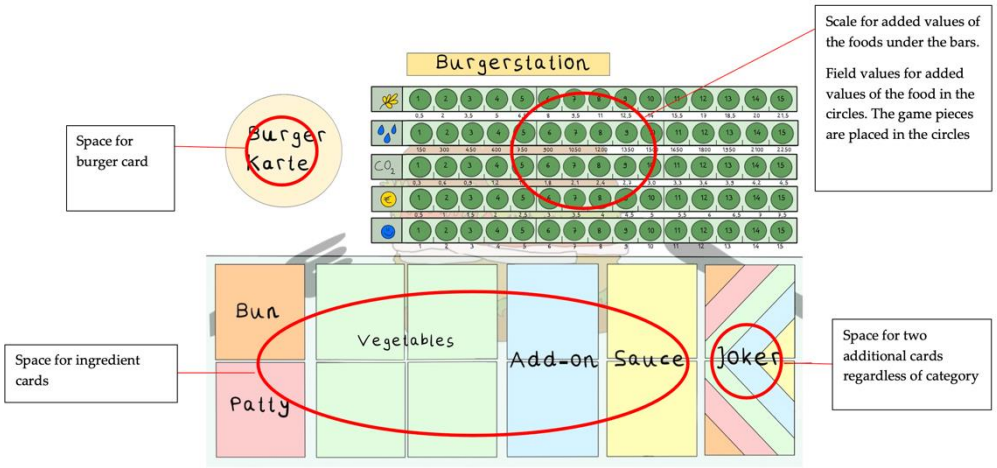

Figure 5. Explanation of the burger station.

Each player gets their own playing field, the so-called "burger station" (Figures 5–7). There are three areas: space for the burger cards, storage for the ingredient cards and a scale for transferring the values. Each category has 15 fields in the scale with linear values that are adjusted to the level of the ingredient values. To further increase the range of values, there is an option to multiply a scale by a factor of two. For example, a double beef patty and a veggie patty differ in water consumption with a difference of 100 L and 3700 L. The multiplicator makes it possible to represent each burger creation in values.

The 24 burger cards consist of a front and back side (Figure 8). The front side shows the name of the burger and its drawing. On the back is an instruction on how to build the burger.

Figure 6. Burger station with cards on the front.

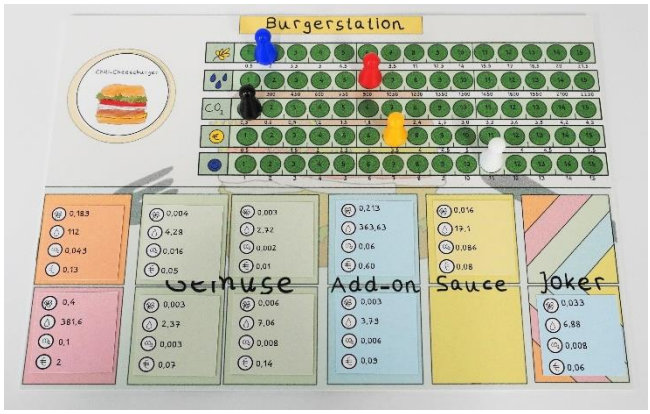

Figure 7. Burger station with cards on the back.

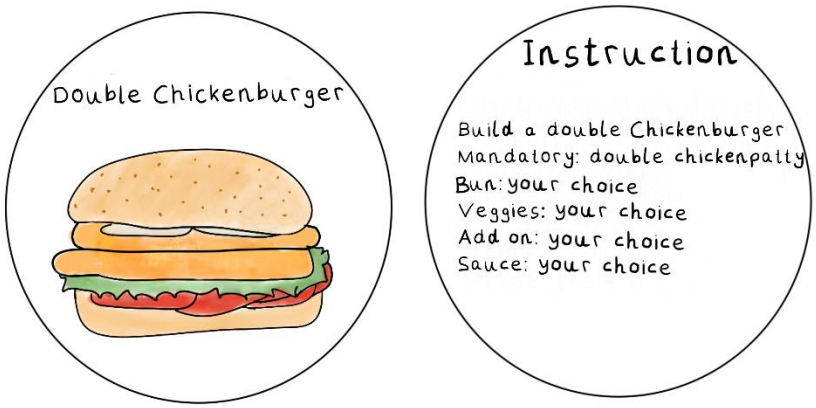

Figure 8. Example of a burger card. Left: front side of the card. Right: back side of the card.

Each burger consists of a bun, a patty, at least one vegetable and a sauce. Optionally, one more add-on can be chosen. There is usually one mandatory ingredient given, all other ingredients are freely selectable. Two additional ingredients can be added to the burger via a joker field, regardless of their category.

The ingredient cards are divided into the five components of the burger and can be distinguished from each other by a colour code (Figure 9). They also consist of a front and a back. On the front, the name of the ingredient, the mass, references to animal ingredients and a drawing are shown, as well as a symbol for membership in the groups: vegan, vegetarian, fish, beef, chicken, pork and insect. Dairy products are also indicated if they

are lactose-free. On the back of each ingredient card are the values for land use, water consumption, CO_2 equivalent and price, based on the mass of the respective ingredient.

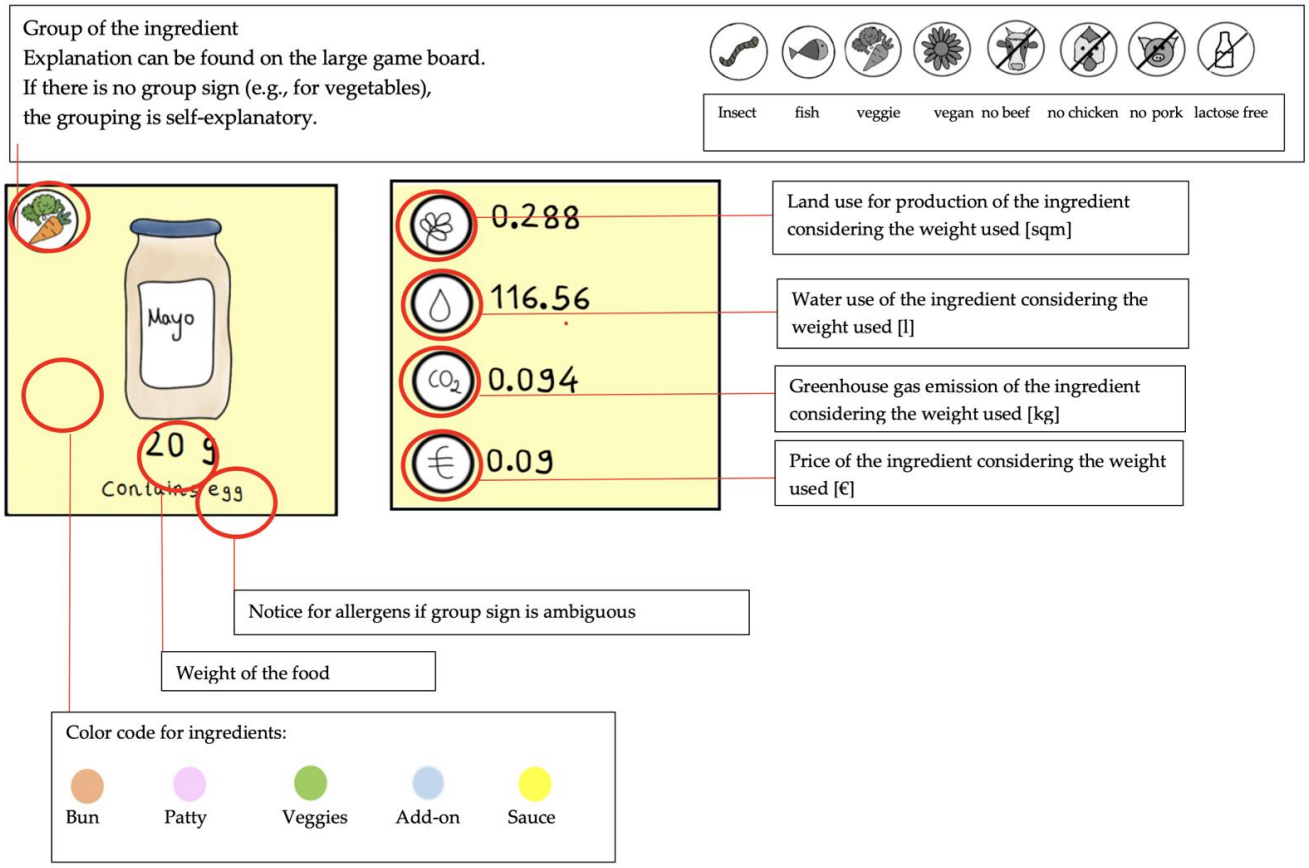

Figure 9. Explanation of the ingredient cards.

4.3. How to Play the Game

The game offers different game scenarios. Either the teacher or the students themselves can choose between the following scenarios:

- Everybody picks a random burger card;
- Everybody gets the same burger card;
- Every meat and meatless option has to be represented;
- Everybody can choose their favourite burger.

In every scenario, each person draws a burger card and places it on the corresponding field of the burger station. Then the ingredient cards are selected and placed on the ingredient squares, showing the picture of the ingredient. When all the ingredient cards have been selected, they can be turned over and the values of the different categories are added up. Four values are thus to be determined per burger, which are then transferred to the value scale. To facilitate this step, an accompanying worksheet is handed out, on which is a table for transferring the data. Each person's tokens are then placed in the appropriate spaces on the scale. Since not every individual value can be listed, values must be rounded appropriately to find a matching box. The lowest scale is for assessing taste subsequently, it is quite subjective. The gamers should rate the taste depending on how the burger would taste in real and if they would eat it in real life, this scale can be rated by the group in total at the end of the game. Since the best possible sustainable burger has the lowest possible field value, 1 is the best value and 15 is the worst on the taste scale. When all players have transferred the values, the burgers of the different participants can be compared. After determining which factors influence the sustainability of the burgers most, the participants can adjust the ingredients of the burgers in a second round.

4.4. Game Evaluation

Students are asked to identify and evaluate problems within the framework of the ESD concept in order to subsequently act appropriately [36]. In the course of the game, the students learn about the impact of ingredients on the food footprint by building their own burgers. In the second step, students can customize their burgers and change their ingredients. This allows them to see the direct impact of even individual ingredients. However, for a sustainable diet, it is not enough to consider values such as water consumption or land use. Furthermore, all people must be able to afford a sustainable diet. Therefore, the price of a burger is also included in the evaluation in the game. Finally, a discussion about the value of food can be held. In addition, the students are asked to evaluate how the theoretically created burgers would taste in reality. In a survey, 75% of young people said that they would like substitute products [4]. Thus, if a burger based on meat substitutes tastes similar to a meat-based burger, the choice may be in favour of the substitute product. The multi-layered evaluation basis for the most sustainable burger enables a differentiated view of the evaluation of products so that, future purchase decisions are also weighed on the basis of diverse factors. This can be seen as the transfer of the game to several different areas.

4.5. Example

Every person takes a burger card and puts it on the field in the top left of the game board "burger station". In this example, the player chooses a cheeseburger. On the back of the burger card is a description that cheese or vegan cheese is mandatory on the burger. All other ingredients can be chosen freely. Time by time the fields "bun", "patty", "vegetables", "Add-on" and "sauce" are filled with: sourdough buns, vegan cheese, lettuce, avocado, onion, veggie patty and hamburger sauce. After choosing these ingredients, the player turns the cards. On the back are the values for ghg, water consumption, land use and price. Then, the player puts the game figure onto the appropriate field. These points are then compared to the points of the other burgers in the game. In this example, the hamburger gains 46.5 points and the vegan burger 7 points. The details can be seen in Figure 10 and Table 1. The vegan burger wins. It can be figured out which ingredients are more responsible for a higher score than others. In the second round, the burger can be optimized and rated again.

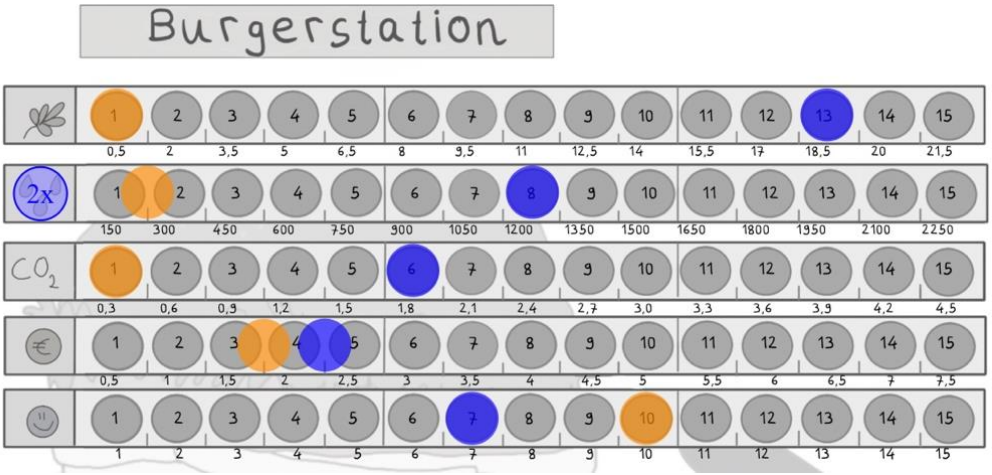

Figure 10. Game board filled with the examples from Table 1. Blue: hamburger. Orange: vegan burger.

Table 1. Example and comparison of the environmental impact of a beef-based hamburger and a vegan burger.

	Ingredient	Landuse (sqm)	Water Consumption (L/kg)	Ghg Emission (kg/kg)	Price (Euro)
Hamburger	Beef patty	17.04	1859.2	1.36	0.99
	Brioche bun	0.42	147.28	0.049	0.392
	Cucumber	0.006	7.06	0.008	0.14
	Tomato	0.004	4.28	0.016	0.054
	Onion	0.003	2.72	0.002	0.017
	Bacon	0.81	390	0.294	0.537
	Hamburger sauce	0.14	44.3	0.034	0.078
	Total	18.42	2454.84	1.763	2.208
	Points	13	16	6	4.5
vegan burger	Veggie patty	0.05	100	0.18	1.08
	Sourdough patty	0.189	112	0.049	0.21
	Cucumber	0.006	7.06	0.008	0.14
	Tomato	0.004	4.28	0.016	0.054
	Onion	0.003	2.72	0.002	0.017
	Hamburger sauce	0.14	44.3	0.034	0.078
	Ketchup	0.016	10.7	0.078	0.058
	Total	0.301	243.64	0.341	1.622
	Points	1	1.5	1	3.5

5. Feedback

5.1. Feedback Interest and Design

The importance of nutrition in the context of education for sustainable development is clearly outlined by the guidelines mentioned above. In order to generate an impact on knowledge of nutrition and behaviour, the game must be adopted by its target group—students. To verify this, a brief feedback questionnaire was conducted in 5 courses with a total of 80 students of secondary schools in northwest Germany.

These classes played the game in the context of a learning laboratory or in single school lessons. During the term of a learning laboratory, the game was part of station learning.

As the game is designed to promote evaluation skills in higher classes, our main interest consists of feedback from students in higher grades. To examine if the game is also appropriate in lower classes, 19 participants aged 13 to 14, named group 2, participated in addition to the main feedback interest of 61 students aged 16 to 17, named group 1. The survey included 9 items and a 6-point Likert scale. Disagreement fills the range from value 1 to 3—"Strongly disagree" was given value 1. Agreement fills the range from value 4 to 6—"Strongly agree" was given value 6. The questions asked were concluded in categories: fun in the game, comprehensibility, educational character, impact, suitability as a leisure game, general attitude toward educational games, and sustainability.

5.2. Results

Overall, the game scored very well in all questions. To check the general interests of the students in sustainability, they were asked to indicate whether sustainability is an important topic for them. The majority in both groups agreed with this statement (about 70% in group 1 and over 60% in group 2), with disagreement filling the range from value 1 to 3 and agreement filling the range from value 4 to 6. Both groups also understood the instructions and agree that such educational games should be used more in the classroom—over 80% in group 1 and 90% in group 2. In addition, the instructions were clear to group 1 with over 90% agreement, and most participants were aware of what to always do (over 80%). Moreover, the participants felt that they learned something about the sustainability of different foods, which is reflected in the agreement with the statement of about 80% in both groups. As an important criterion of games, Burger.i.doo was fun to the participants (over 80% in group 1 and 90% in group 2), although the game had less effect on participants

thinking more about their diet than before. Group 2 also disagrees with over 90% that the game should not be played again—in group 1, this is around 45%. Furthermore, in group 2, 70% can imagine playing the game outside the classroom. The graphical representation of the results can be seen in Figures 11 and 12.

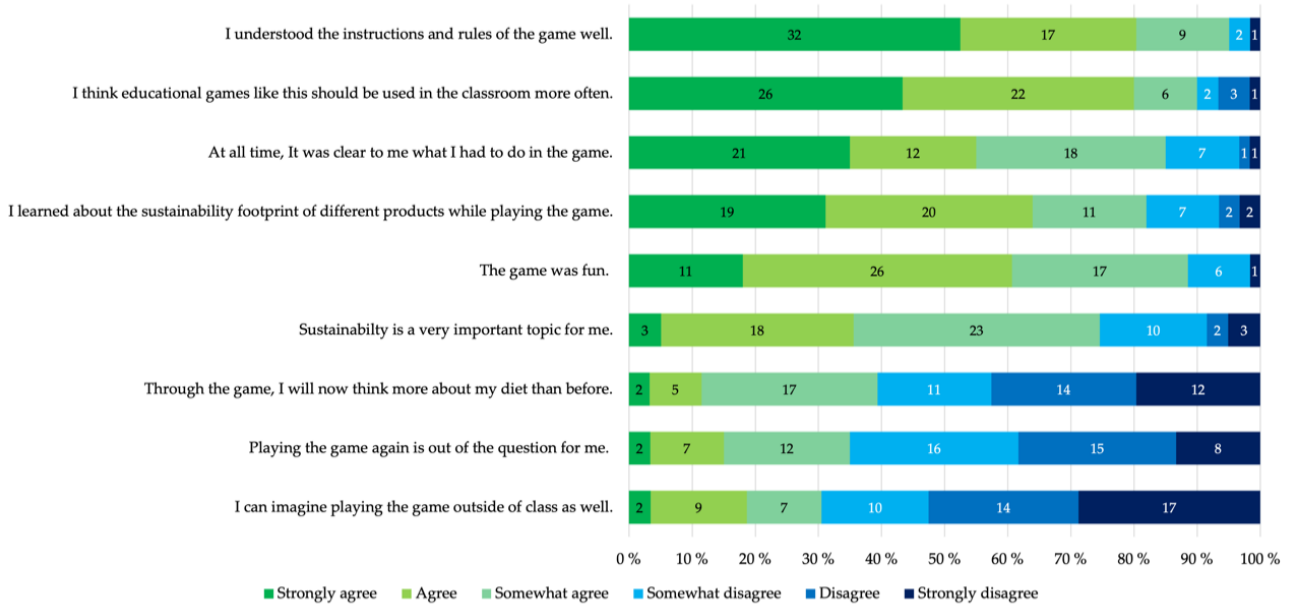

Figure 11. Feedback, group 1. N = 61 students aged 16 to 17. Shown are the absolute numbers of responses in bar charts as well as the relative share of the response in the total survey.

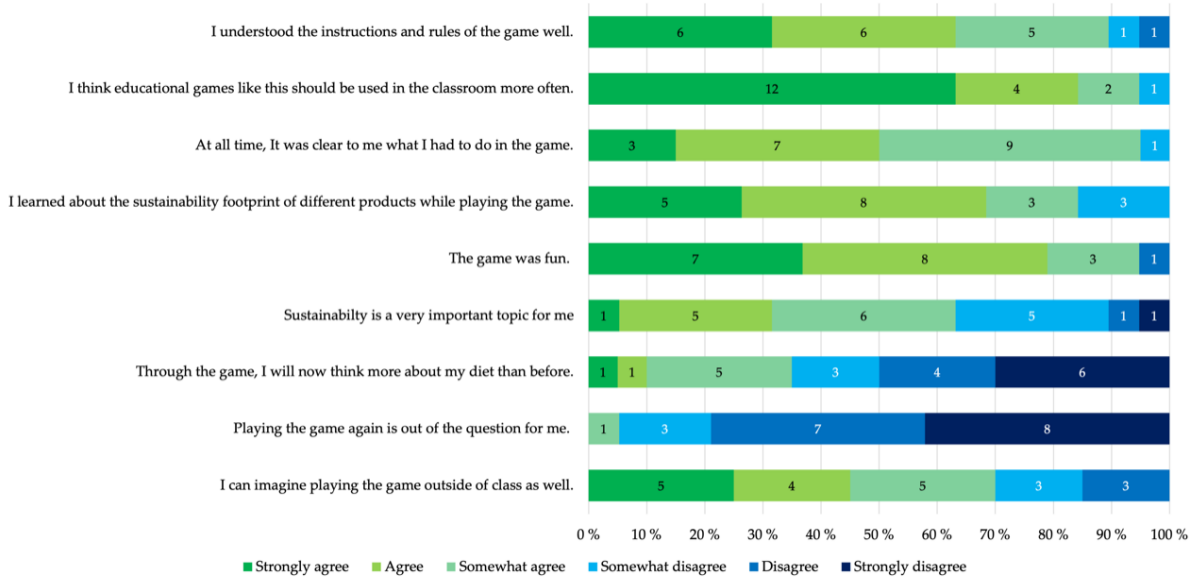

Figure 12. Feedback, group 2. N = 19 students aged 13 to 14. Shown are the absolute numbers of responses in bar charts as well as the relative share of the response in the total survey.

5.3. Discussion

The differences in the comprehensibility of the game can be explained by the design. The game was designed for students aged 16 or older. However, the evaluation of group 2 shows that the game is also suitable for younger students with a few adaptations.

The low effect on future nutritional behaviour can be explained by the students' indication about sustainability being an important topic for them. Accordingly, it is possible that they already pay attention to a high level of sustainability with regard to their diet.

However, the game is only a brief intervention and, thus, may not support critical thinking about dietary behaviour in the long term. Moreover, other studies show, that environmental consciousness does not lead to environmental performance automatically [37]. In addition, the game does not address health and ethical factors because it only focuses on the impact of food on the environment. However, health and ethical factors in particular, such as animal welfare, can help students rethink nutritional behaviour [38]. Therefore, the categories health and ethics may be added, although the multi-faceted nature of the categories makes it difficult to evaluate, and thus the environmental factors are pushed into the background. Another option would be to develop a second version of the game in which health and ethics are put into focus. The advantage of this would be that each version of the game would not be overwhelming in itself and an emergent character in the design is possible. Summarized, based on the feedback from the students playing the game, we assume that the players gain evaluation skills in the context of comparing different meat and substitute products. To generalize this finding, further evaluation is required.

6. Outlook and Conclusions

The educational game *Burger.i.doo* was developed to shed a light on the direct impact of nutrition on the environment and to create a basis for discussion on which sustainable nutrition can be addressed in the classroom. The educational game makes an important contribution to education for sustainable development and can be used interdisciplinarily in the classroom and beyond. *Burger.i.doo* can be used within the framework of ESD in science subjects, such as chemistry lessons or in the social sciences, in order to train cross-curricular competencies for evaluating the sustainability of nutrition. In chemistry lessons, more in-depth subject-specific references are suitable, for example, for the CO_2 equivalent or the greenhouse gas effect, whereas in social science lessons, for example, politics, an affiliation to the topic of globalization and its consequences can be mentioned.

The data collected show that *Burger.i.doo* leaves a positive impression on students. The appreciation of the design and the idea behind the game is high so this can be assessed as enriching for lessons. Only the influence of the game on future nutritional behaviour is medium according to the short-term intervention. Nevertheless, this score can be improved by designing a second version of the game taking health and ethics into account, or by establishing this reference more strongly in an evaluation and transfer of the game to everyday contexts. Furthermore, critical nutrients such as vitamin B_{12}, fat and sodium could be added to increase the holistic education in nutrition.

Supplementary Materials: The supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15010213/s1, Reference [39] is cited in the supplementary materials. The file templates for the game (board, cards, instructions) can be found at the following link: https://sync.academiccloud.de/index.php/s/43CLHEssVfOBGTf.

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