Doughnut as a Sustainability Education Tool in Central Asia

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Introduction:

In 2013, President Nursultan Nazarbayev, of Republic of Kazakhstan enacted the Concept of Transition of Republic of Kazakhstan to Green Economy. The document calls for inclusion of green topics in elementary programs, yet, little has been done to create a curriculum that could be integrated, even with the rapidly approaching 2020 Strategic Plan deadline submission. Green Economy sustainability education plan is projected to engage students in “green topics and provide the promotion for sustainable living and behavior change”, “implant environmental protection ideas”, and “increase population’s awareness of the issues of resources usage and environmental problems”.

Although schools provide topics related to nature and the environment, at this point no formal curriculum has been established. It may seem that education is the “end all solution”- but it’s also part of the problem. Even if more environmental topics were available in schools, many misconceptions and misunderstandings are still encountered by the students, potentially at the fault of the “experts” who disseminate relevant information. At the moment, educational models are constructed on the market-based approaches and further drive the growth of an unsustainable society. This study aims to explore the common misconceptions that are observed among young children. Additionally, it introduces and tests the concept Doughnut Economics, and how it could be used in as an experimental learning approach, in order to provide a deeper understanding of sustainability among school children.

The study aims to answer the following questions:

1. What common misconceptions about planetary boundaries and social foundations exist among students?
2. Does the game approach facilitate better understanding and resolve the misconceptions?
3. Is Doughnut Economics and appropriate and dynamic model to use with children and in sustainability education?

**Background:**

In order to ensure rational use of resources, cooperation between nature and society must be formulated. However, nature and society are often separated, and even in the economic sense, nature and the environment as seen as externalities. Therefore, public participation and understanding of resource use and maintenance is important for continuous sustainable development of society - locally and globally. Learning institutions are responsible for providing and disseminating understanding of environmental issues and sustainable practices. However, most of the topics related to sustainability are grouped within the sciences and geography, leaving the scientists at the epicenter of expertise and communication to the learners. Meyer and Land, suggest that students can find certain ideas and concepts within a discipline difficult to understand and these act as a barrier to deeper understanding of a subject. The divide between experts and learners leads to a formation of a variety of misconceptions and misunderstandings, eroding the validity of the scientific justification of concepts of sustainability.

Fien and Elliot challenge the dominance of scientific paradigms in relation to sustainability. Robottom and Hart argue that formal education is characterized by the materialist worldview, spurred from the scientific revolution, and places the human species on the pedestal of ethical right to control and manipulate nature. Therefore, applications of natural sciences are used to argue the rational avenue to objective knowledge and influence educational inquiry, thereby affecting the structure of environmental education. Robottom and Hart believe that environmental education should not only be structured on scientific premises.

Apart from the ability to understand the information, scientific knowledge is an issue of access, especially in non-western societies. Although scientific research information is not heavily censored, most of the foreign publications are in English and only a small percentage of learners have the ability to speak English.

Furthermore, since sustainability calls for societal transitions and actions, such information can be perceived as a form of propaganda, especially in post-soviet states. These challenges lead to the establishment of a weak form of sustainability, instead of strong sustainability, which

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aims to be supported by the overall community\textsuperscript{14,15}. In order to develop strong sustainability, personal change and community development lead individuals to realize sustainability needs on their own, evoke feelings for ecological well-being, and provide lessons of sustainable living.

Leshner\textsuperscript{16} argues that use a two-way dialogue about what individuals consider the most concerning issues in their community with no need for scientific engagement. However, this could cause a gap in information, in a space where those gaps have never been filled. Such approach does not ensure the public's understanding of the science and could lead to misguided or unsustainable life-choices\textsuperscript{2}. A dynamic and interdisciplinary sustainability education\textsuperscript{3} is argued to be able to tackle the challenges of misunderstanding, misuse, and distrust in sustainability.

Environmental education (EE) has the task of transforming attitudes and behavior of the entire society. Sustainability and environmental education is designed to provide understanding and fill “gaps in knowledge” and lead to the implementation of competent environmental decisions. According to Stevenson\textsuperscript{17} sustainability education should have two implications.

1. It should be structured and designed to present the plurality of environmental ideologies through a process of “inquiry, critique, and reflection”, after which students would be able to formulate their own set of environmental beliefs and values. Each student should be able to pursue actions on their own that they deem to be necessary and ethical.\textsuperscript{18}

2. Since environmental improvements are often political movements, students should be able to act on those reforms by making adequate political choices. Therefore, environmental education should provide components of political and legal processes, and political advocacy for full participation in environmental reforms\textsuperscript{18}.

The heavy emphasis on confining environmental and sustainability topics within the scientific domains limits the implication and ability of sustainability topics to belong in the interdisciplinary domain. Robottom and Hart\textsuperscript{7} argue that part of the problem is keeping the topics in the scientific space. Some models have been developed to incorporate EE into school learning material.

Sterling\textsuperscript{18} suggest that education for sustainability must (1) drive to understanding of interdependence of all life on this planet, (2) increase awareness of economic, political, social, cultural, technological and environmental forces, (3) develop people’s awareness, competence and attitudes, and (4) establish further need for integration of topics.

More formally, Huckles\textsuperscript{19} defines nine components of education for the environment

1. Knowledge of the Natural Environment and its Potential for Human Use
2. A Theoretical and Practical Grasp of Appropriate Technology
3. A Sense of History and Knowledge of the Impact of Changing Social Formations on the Natural World
4. An Awareness of Class Conflict and Social Movements
5. Political Literacy
6. An Awareness of Alternative Social and Environmental Futures
7. An Understanding of Ideology and Consumerism
8. Involvement in Real Issues
9. Tentativeness and Optimism

There should be a greater emphasis on teaching about the environment, for the environment, and in the environment. Different researchers such as Palmer\textsuperscript{20}, Sterling and Cooper\textsuperscript{21}, and Uzzell\textsuperscript{22} adopted concepts of above mentioned components in structures of sustainability education within organization planning of \textit{About, For and Through /In /From} environment (Fig, 1). According to Palmer\textsuperscript{20}, the model consists of two subsystems - formal and informal education - both of which include the three above-mentioned components. The description of the components given below is done on the basis of the definitions and descriptions found in the works by Palmer\textsuperscript{20}, and Sterling and Cooper\textsuperscript{21}.

![Diagram of 3-dimensional model of environmental education by Palmer.](image)

\textbf{Figure 1. A 3-dimensional model of environmental education by Palmer.}

Education About the environment is usually a part of formal education and has an empirical character. The main aim is to develop knowledge about nature, environment and the systems using investigative and discovery approaches, its values and the complex interactions of the elements of the natural and human systems.

Education In/From the environment sees nature as a tool and resource of the learning process in order to develop research activities of a child, to form the individual experience, to develop a wide range of skills of investigation and communication. It has the ability to provide materials for learning in variety of subjects and derive a medium for enquiry and discovery. This component is a part of both formal and informal education.

Education For the environment emphasizes the development of reflection informed concern for the environment. This has heavy emphasis on development of personal ethics, sense of agency and responsibility. Its aim is to form positive caring attitude towards the environment.

Furthermore, this Palmer uses the model to address dimensions of learning. They help further define and refine the aims of EE and has been seen in contents of National Curriculum for Schools in England (1990). The following guidelines help provide a range of knowledge, skill, and attitude.

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| Knowledge and Understanding | Natural processes that take place in the environment  
|                           | Impact of human activities  
|                           | Past and present environments  
|                           | Environmental issues  
|                           | Local, national and international legislation  
|                           | How humans live, livelihood and the environment  
|                           | Environmental inter-dependence of individual, groups, and communities  
|                           | Conflicts that may arise with environmental issues  
|                           | How environment has been affected by past issues  
|                           | Planning, design, aesthetic  
|                           | Importance of effective action  
| Skills                    | Communication  
|                           | Numeracy  
|                           | Study  
|                           | Problem-solving  
|                           | Personal and social  
|                           | Information technology  
| Attitudes                 | Appreciation, care, and concern for other living things  
|                           | Independence of thought on environmental issues  
|                           | Respect for belief and opinions of others  
|                           | Respect for evidence and rational argument  
|                           | Tolerance and open-mindedness  

Similar structures have been proposed by Giolitto which suggest a static model according to which there are three dimensions in environmental education: cognitive, ethical and “action” dimensions. Sterling and Cooper also presented similar models, which included categories mentioned in the Tbilisi Declaration.

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Games

The above-mentioned models only provide guidance for what EE and SE should address, but traditional educational tools are difficult to apply and effectively interconnect all of the nuances. Some sustainability topics may require mature understanding, and will therefore be difficult to translate to students in elementary education. Due to the interdisciplinary nature of sustainability topics, they are challenging to teach in a traditional "teacher to student" engagement, within the purely theoretical sense. Palmer advocates the necessity of using a dynamic, not static variant of the model that takes into account individual peculiarities and personal experiences of students. In this case three areas of the model are spheres, which rotate constantly. The other difference is that the key element of the model is "formative influences." This element can become more important than the influence of the formal educational programs because it represents the combination of personal experience and formal education. Without taking this factor into account it is impossible to develop a sufficient level of knowledge, skills and values which will form environmental ethics and awareness.

Ammar and Wright argue that active participation and learning can help students understand the different linkages. Csikszentmihalyi presents the correlation between learning and enjoyment and Bellantyne notes that students who enjoyed their environmental education activities they took part in were likely to understand and discuss the takeaway messages outside of the classroom. Therefore, games could improve understanding and awareness of sustainability issues and solutions among schoolchildren.

According to various studies, games that require active participation, role-play, critical thinking, discussion, and reflection can promote engagement, deeper understanding, further topic retention, and cultivation of empathy.

Learning is at its best when it is active, goal-oriented, contextualized, and interesting. Therefore, instructional environments should thus be interactive, provide ongoing feedback, grab and sustain attention, and have appropriate and adaptive levels of challenge—i.e., the features of good games. Therefore, games that are played in classrooms could potentially be an innovative tool to present the interdisciplinary SE.

Doughnut Economics:

Gough views the current educational structure as outdated by 200 years, coming from the age of Hume and Smith. Raworth, also states that economics remained the same for 200 years and argues for a need for a 21st century economic approach in order to live in a sustainable world. She states that viewing economics as a consistent model of growth is not sustainable and will not allow us to prosper in a world within these changing times. Raworth therefore,

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combines the idea of economic development and its interaction with planetary boundaries\textsuperscript{33}. In order to present a model that guides us to rethink economics on a sensible level. She argues that not everything can or should be left to the market, and that the “rational actor” model is problematic and will not help eliminate inequality, climate change, or pollution. The model helps reframe some of the most pressing sustainability problems and present them in a way that requires a multi-dimensional, system thinking approach.

Economics, apart from being the “mother tongue” of public policy, it’s also the basis of educational models. With all the EE models out there, incorporating Doughnut Economics within Palmers “In, For, and About” EE model, in conjunction with application of experiential gaming could be the potential solution to communicating the interdisciplinary of sustainability. 

Methods:

Sampling

Students in Fourth Grade were selected because the year constitutes under primary school at the Republic of Kazakhstan. According to Sterling, education for sustainability can be presented in two stages, and fourth grade is under the second stage. Different sampling methods were considered prior to the experiment, including workshops with teachers and monitoring their ability to translate the information. However, a variety of obstacles were met before the sampling protocol was established. First, public schools were difficult to access and required additional approval from the Minister of Education. Due to time constraints and lack of willingness of school participation, private schools were approached instead. Although limited responses were obtained, “Aray” in Almaty was willing to collaborate on the study. Due to the fact that only one section of each grade exists in the school, grade 4 was selected as the subject of study (based on size and age) and the students were split into two groups based on student schedules.

The fourth grade students were assessed on the basic background in the planetary life cycles and ecology. It was established that they had understanding of common ecological issues of Kazakhstan, like pollution and its effects and other planetary boundaries (as described in Doughnut Economics). However, sustainability topics are not part of the formal school curriculum and therefore the knowledge gap existed between terminology and concept understanding among students.

The class was split into two uneven groups due to class scheduling of elective classes. The 12 person group became the test group (since an even number was preferred) and the 7 person group remained as the control. Both groups received identical pre-activity questionnaires, administered by the teacher. Students were notified of the purpose of the activity and were carefully explained that participation is mandatory and they are not required to provide any identifying factors.

Following the completion of questionnaires, a few days later, each group received the same formal lesson on sustainability, which was based on the concepts of Doughnut Economics and presented by the researcher. Following the lesson, the test group received the Doughnut Game followed by an activity that was completed in pairs, while the control group only received the activity, which was completed by each child individually. Both sections received identical post-activity questionnaires administered by the teacher. The lesson, game, and questionnaires were all completed during school hours.

Post-activity questionnaires were completed by 19 students. Some students were excluded due to absences related to vacations and illnesses, as described by the class teacher.

Class demographics were as following:

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th>Test group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Girls</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 1: Class Demographic

Some of the limitations included the samples size, however it would not have been appropriate to pick students from different years or from different schools. Also, results presented by the group of students participating may not reflect the knowledge and
understanding of all students in Kazakhstan, since the research was conducted with a private school. However, this specific private school was selected versus higher-end private schools, like the International Schools, Nazarbayev Intellectual Schools, or Hallie Barrie, because the student demographic reflected most of the middle class citizens based on location and tuition price. Since this is a private school, although, it was considered to be the most accessible one in the city based on location and price (citation), it is still not representative of public schools in Almaty city or rural areas. Further studies would include samples of different public and private schools in various districts of Almaty City. However, due to the limitations presented by this short term project and the fact that schools in Kazakhstan end in the middle of May, data collection window was only limited to Oxford Universities post-Hillary term academic break.

Prior to administering questionnaires, testing the game, and conducting interviews all participants were provided with relevant information regarding the study and were asked to provide consent according to rules and regulation imposed by the Aray private school and University of Oxford’s Central University Research Ethics Committee procedures (Appendix A). The procedures were instated in order to ensure the safety of participants, especially since most of them were under the age of 18, as well as the safety of the researcher.

**Taxonomies**

Given the goal to measure understanding of sustainability concepts with the Doughnut Economics structure, the first step was taken to identify and define the baseline understanding of planetary boundaries and interaction with social foundations among students.

Bloom taxonomy was used to analyze responses for pre-activity and post-activity questionnaires.

Doughnut Economic concept was used to structure the questionnaires and the game, based on the theories discussed in the previous section. However, due to the time constraint of this project and interference with the current school curriculum, only limited days were provided for access to interaction with children. Because of that, only 10 of the concepts of Doughnut Economics were tested, which were derived based on questionnaire response, observation, and cultural and local understanding.

The following concepts were tested:

<table>
<thead>
<tr>
<th>Social Foundations</th>
<th>Planetary Boundaries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>Climate Change</td>
</tr>
<tr>
<td>Water</td>
<td>Air Pollution</td>
</tr>
<tr>
<td>Energy</td>
<td>Plastic Pollution</td>
</tr>
<tr>
<td>Work and Income</td>
<td>Biodiversity Loss</td>
</tr>
<tr>
<td>Health</td>
<td>Freshwater depletion</td>
</tr>
</tbody>
</table>

**Table 2: Doughnut Economics Taxonomy**

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Questionnaire Design

Questionnaires were designed to use qualitative and quantitative methods and in order to better reflect the concepts of Doughnut Economics.

Art to Understand Sustainability

Standard multiple choice and long response questions were used in the surveys to provide easy analysis, however, even when well designed, it is difficult to gauge child’s full understanding of the topic. In order to provide a more in depth understanding and also eliminate mundane questioning and encourage participation, art components were added to questionnaires. In relation to understanding of planetary boundaries that they may experience, students were given the option to provide a drawing or diagram in order to express themselves in an engaging manner with the complex topics. The drawings also provided an insight to images that are often portrayed to children in relation to those topics35.

It’s important to note, that art based assessments are subjective and open to interpretation. However, art produced during questionnaires asked for specific planetary boundaries experienced by the children, and most of them were easily identifiable by the researcher. The interactions portrayed by the students with the planetary boundaries are open to further interpretations, but reminiscent of other responses provided in questionnaires. The drawings were used for further qualitative analysis to test consistencies among non-art-based responses.

Lesson Plan Design

Observations were conducted. Analysis of post-soviet education model and topics covered during the year. Interviews with teachers were conducted to further understand year-long goals, especially in relation to sustainability. Overview of content learned in class by looking at whole term and whole year goals of the curriculum. Overview of the textbooks used by the students.

Game Design

Theories of game planning and design were used based on the literature in the above mentioned section. The actual game was designed with thought of future accessibility and application in mind. The game also included cultural and historical aspects, by engaging participants in storytelling used by the characters on the cards.

Game includes two sets of playing cards, each with a set of “planetary boundaries” or “social foundations”. Each card defines the terms using character interaction, local knowledge and rhetoric to convey the definition and some problems that may be associated with the term.

Each student receives a randomly selected card, and after examining the content is asked to pair with someone who has a card from a different set. The pairing is explained as either two problems that may compliment each other to find a better solution, or those where they see a further progression of the problem.

Sample pair may include: ENERGY and POLLUTION

Activity

After receiving the cards, students are asked to complete an activity which has three steps.

1. Identify the problems associate with each of the terms
2. How may you be able to solve both of the issues without causing damage to either one.
3. Present to the class
Interviews

Interviews were conducted with teachers and principal of private school Aray, with randomly selected teachers in Almaty city, Kazakhstan’s Ministry of Education and Sciences, and NGOs in order to gauge understanding and content of current sustainability material presented in schools.

Translations

Translations were carried out of all of the questionnaires and interviews by the researcher. It’s important to note that information could be lost, misunderstood, or misinterpreted in the process of translation from one language to another. In order to overcome the following barrier, additional translator was hired to provide a second profession analysis of the translations and approve for further data based analysis.

Mixed Method Analysis

The analysis aims to analyze the amount of students that have misconception about given planetary boundaries. Also, it aims to see whether or not students are able to connect topics of planetary boundaries and social foundations.

Results:

Results are collected based on the analysis of questionnaire responses provided by students at Aray Private School. Analysis included quantitative and qualitative overview of most common answers provided based on groupings of risk perceptions, pollution sources, pollution and work and income, pollution and energy industry, pollution participation, sources of climate change, understanding of climate change, biodiversity loss understanding, chemical pollution sources and outcomes. Due to the limits of this paper only some of the results are provided. Further results are available in the dissertation.

Pre Activity Risk perceptions:
Risk perceptions were gathered to understand where on scale of risk students feel in regard to each of the risks. They were asked to justify their answers.

<table>
<thead>
<tr>
<th>Types of risk</th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>air pollution</td>
<td>6</td>
<td>9</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>climate change</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>biodiversity loss</td>
<td>14</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>extreme event</td>
<td>10</td>
<td>6</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>plastic pollution</td>
<td>13</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 3: Risk Perceptions
Pollution Assessments

<table>
<thead>
<tr>
<th>Sources of Pollution</th>
<th>Num. Responses Pre Activity</th>
<th>% Pre Activity</th>
<th># of responses POST activity with GAME</th>
<th>% POST activity with GAME</th>
<th># of responses POST activity without GAME</th>
<th>% POST activity without GAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>9</td>
<td>47</td>
<td>10</td>
<td>83</td>
<td>6</td>
<td>86</td>
</tr>
<tr>
<td>Garbage</td>
<td>8</td>
<td>42</td>
<td>8</td>
<td>67</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Industry</td>
<td>10</td>
<td>53</td>
<td>7</td>
<td>58</td>
<td>3</td>
<td>43</td>
</tr>
<tr>
<td>Fire</td>
<td>5</td>
<td>26</td>
<td>1</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Smoking</td>
<td>5</td>
<td>26</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 4: Sources of Pollution

Several misconceptions were noted, like garbage (not discussed whether or not it’s burned), smoking, and fire (depending on what it’s burning). Increase in overall responses may be due to association of two negative aspects (garbage and pollution) and the linking of a negative outcome to a potential negative cause.

After a disruption, both groups saw a decrease in a misconception that smoking directly influences air pollution.

Pollution and Connection to Social Foundations

Work and Income

<table>
<thead>
<tr>
<th>Connection to Work and Income</th>
<th>Connected</th>
<th>% Connected</th>
<th>Not Connected</th>
<th>% Not connected</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRE Activity</td>
<td>13</td>
<td>68</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>POST Activity with game</td>
<td>9</td>
<td>75</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>POST Activity without Game</td>
<td>1</td>
<td>14</td>
<td>3</td>
<td>43</td>
</tr>
</tbody>
</table>

Table 5: Pollution and affects on Work and Income

Most of the participants connected the work and income to the person’s well being in relation to their capacity to be able to perform at work.

More students in the POST with Game group saw the connection and were able to adequately describe it versus in the POST without GAME group.
Health

For pre activity, all 19 participants agree that pollution is somewhat tied to health impacts. However, there of the participants think it’s because of viruses that are spread via pollution.

For post activity it remained the same that all of the participants prioritized health impacts in relationship to pollution

Energy Access

The question asked whether or not participants understand the connection between energy production, whether it’s heat and electricity, and the ties to air pollution. The results are as following:

<table>
<thead>
<tr>
<th>Energy Access</th>
<th>Connected</th>
<th>%Connected</th>
<th>Not Connected</th>
<th>%Not connected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre - Activity</td>
<td>7</td>
<td>58</td>
<td>11</td>
<td>37</td>
</tr>
<tr>
<td>POST Activity with GAME</td>
<td>5</td>
<td>42</td>
<td>5</td>
<td>42</td>
</tr>
<tr>
<td>POST Activity without Game</td>
<td>4</td>
<td>71</td>
<td>2</td>
<td>29</td>
</tr>
</tbody>
</table>

Table 6: Energy Access and Pollution

The following results might be to the fact that children do not connect the smoke stacks that they see to the products that are produced at the factories where those smoke stacks exist. This means that there is a lack of connection in understanding between how the energy is produced and from which products it is produced. Most of the responses in all of the groups said they were connected but they did not adequately describe the connection.

Participation in Pollution

<table>
<thead>
<tr>
<th>Participation</th>
<th>Participate</th>
<th>%Connected</th>
<th>Not Participate</th>
<th>%Not connected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre - Activity</td>
<td>1</td>
<td>5</td>
<td>6</td>
<td>32</td>
</tr>
<tr>
<td>POST Activity with GAME</td>
<td>5</td>
<td>42</td>
<td>7</td>
<td>58</td>
</tr>
<tr>
<td>POST Activity without Game</td>
<td>1</td>
<td>14</td>
<td>6</td>
<td>86</td>
</tr>
</tbody>
</table>

Table 7: Participation in Pollution Activities
During Pre-Activity survey, when asked if any of the participants contribute or participate in the action of air pollution, only one of the participants responded that they do. The answer was concluded due to the fact that they take a car to school on the daily basis. However, in the Post-Activity questionnaire, the GAME group received a higher percentage of responses of students who believe they participated in pollution due to riding a car. This maybe also due to the fact that more students saw the link between cars and pollution.

### Climate Change

#### Causes/Sources

<table>
<thead>
<tr>
<th>Sources of Climate Change</th>
<th>Pre Activity Amount</th>
<th>Pre Activity %</th>
<th>Post Activity with Game Amount</th>
<th>Post Activity with Game %</th>
<th>Post Activity without Game Amount</th>
<th>Post Activity with Game %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factories/industry</td>
<td>3</td>
<td>16</td>
<td>5</td>
<td>42</td>
<td>2</td>
<td>29</td>
</tr>
<tr>
<td>Cars</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Earthquakes</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Garbage</td>
<td>2</td>
<td>11</td>
<td>2</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Minerals/resource extraction</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>25</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Rockets</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>58</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>law breaking</td>
<td>2</td>
<td>11</td>
<td>2</td>
<td>17</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>extreme weather</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>polluting nature</td>
<td>3</td>
<td>16</td>
<td>3</td>
<td>25</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>killing animals</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>melting</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Table 8: Sources of Climate Change**

#### Climate Change involvement

<table>
<thead>
<tr>
<th>Climate Change</th>
<th>Pre Activity Amount</th>
<th>Pre Activity %</th>
<th>Post Activity with Game Amount</th>
<th>Post Activity with Game %</th>
<th>Post Activity without Game Amount</th>
<th>Post Activity with Game %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Change is a positive</td>
<td>2</td>
<td>11</td>
<td>0</td>
<td>0</td>
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<td>0</td>
</tr>
<tr>
<td>I do not experience climate change</td>
<td>9</td>
<td>47</td>
<td>5</td>
<td>42</td>
<td>5</td>
<td>71</td>
</tr>
<tr>
<td>I do experience climate change</td>
<td>5</td>
<td>26</td>
<td>6</td>
<td>50</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>I do not know about climate change</td>
<td>4</td>
<td>21</td>
<td>1</td>
<td>8</td>
<td>2</td>
<td>29</td>
</tr>
</tbody>
</table>

**Table 9: Climate Change Understanding**
Discussion and Conclusion

The following analysis and experiment design were based on literature provided in the earlier section. It’s important to note that literature is mostly western-based, and has been used for studies in the UK or the US. The author acknowledges that and therefore has attempted to make the concepts more culturally relevant to the East through the design of the game.

In relation to current academic standing on EE in Kazakhstan, according to the interviews conducted among teachers at Aray school and with the Ministry of Education and Science of the RK (MESRK), there is no formal environmental and sustainability education model in place for public or private schools. On the elementary level, the topics are addressed in Poznanie Mira (World Discovery), which is a science based course. This course is administered once a week, totaling 33 hours/year. Furthermore, the topics mostly cover plant and animal life, which may explain the high concern for plants and animals from the children surveys (90% response in all cases). According to MESRK, there is also vospitanie, which is translated to fostering or disciplining, which should theoretically work on instilling sustainability ideas and practices. It is generally done during klassni chas (classroom hour) and led by the teacher. There are eight mandated topics that are discussed during klassni chas, one of which is "environment, sustainability, and technology." Since this is also implemented once a week, throughout the year children, receive about 8 hours/year of sustainability discussion during klassni chas. Overall, the topics of discussion total to 41 hours/year. However, in the interview with Shymkent Deputy of School Education, the deputy mentioned that the quality and content of material provided during the klassni chas is not regulated and it’s at the teacher’s discretion to design the lessons on sustainability and provide adequate information to the students. It was mentioned that there are no recommended or approved books on those topics by the ministries, so it’s left for teacher’s own time to learn and design the lessons.

According to results provided, it’s evident that the teachers provide a lot of the information and also misconceptions. For instance, the high rate of response to climate change causes being “rockets” is caused by teacher providing the information in between the lesson conducted by the researcher and the time of survey collection. Since the response is seen in both groups and the following statements regarding climate change and rockets were never communicated during the lesson or during the game, and upon a follow-up interview with the teacher it was revealed that the classroom teacher provided that information.

Additionally, misconceptions regarding garbage and pollution connection could be seen because it’s perceived to be a central issue in relationship to waste disposal. At the moment, there is no waste management or recycling in place, and therefore there is no culture to repurpose or to stress garbage separation. Also, often, it ends up not in the garbage dumps, and streets are polluted with rubbish.

Most of the students engaged their understanding of the concepts of planetary boundaries in relationships to the impacts it may have on animals. They presented a strong empathy and concern for animals. However, only some have shown it towards plants as well. This was especially seen in relationship to biodiversity, where most of it was related to loss of animals versus a loss of plants.

Concerning questions posed by this study, (1) the common misconceptions are based on garbage and waste disposal. Also, there is evidence that shows little connection between electricity production and pollution or climate change. Lastly, students found anything labeled as unacceptable by society, like smoking, to also be a cause of a big issue like pollution.
(2) Students who were engaged in the game proved to have better responses in relation to the misconceptions. They also provided more extensive, detailed answers, and many showed a further connection between several planetary boundaries and social foundations. For instance, a student was able to connect climate change to biodiversity loss and to further impact on food production, which was not seen in any responses before the game.

(3) Doughnut Economics is a model that has the capacity to engage several concepts of social foundations and planetary boundaries in order to provide a more holistic understanding of sustainability.

Doughnut Economics as a sustainability education is indicated to be an adequate platform to provide a holistic understanding of sustainability concepts. The impact is especially evident when representing the concepts in a gaming format, which not only provides an interactive perspective on the topic but also an engaging learning moment that allows the student to connect information in an inquisitive and critical manner.