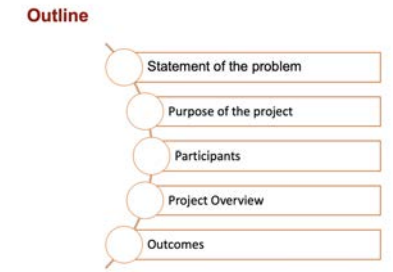
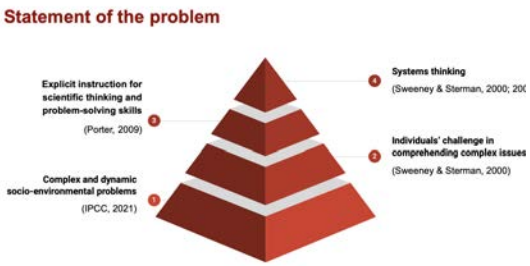
Environmental Education with Systems Thinking and the World Climate Game Project

Speaker Notes

1  	Today we will present our findings on “Environmental Education with Systems Thinking and the World Climate Game Project” to you. The project was supported by the United Nations Development Programme (UNDP) and developed by the Systems Thinking Association in Turkey, a research university, and a middle school partnership.
2  	Here, you can see our presentation outline. I will start from presenting problem that we addressed in this project. Then, I will present the purpose of the project, participants, description of our project and the outcomes.
3  	In recent years, the world has been dealing with many serious and complex problems such as climate change and health problems like COVID-19. However, people have difficulty in coping with these complex systems. Systems thinking is recognized as crucial to understanding climate science and coping with climate change which requires the understanding of complex and dynamic systems. Comprehending how climate systems work and its complexity, it requires examining the whole system with stock and flow structures, various feedback processes, linear and nonlinear relationships among components, and time delays. Therefore, it is important to integrate the system thinking approach to climate change education.

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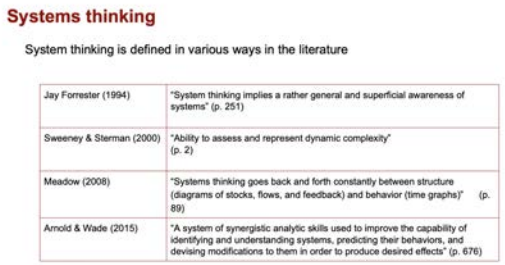

Here, we can see the various system thinking definitions in the literature. Jay Forrester, one of the pioneers of system thinking, defines system thinking as making reliable inferences about behavior by developing an increasingly deep understanding of underlying structure. Sweeney and Sterman, on the other hand, focused on the ability to assess and represent dynamic complexity. Meadows focused on the use of systems thinking tools and Arnold and Wade focused on the use of systems thinking skills.

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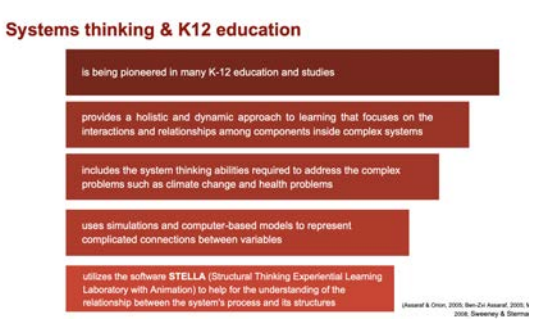

System thinking as a teaching method is being pioneered in many K-12 education and studies.

The system thinking approach provides a holistic and dynamic approach to learning that focuses on the interactions and relationships among components in complex systems at various levels.

System dynamics, which was found on the concept of change, uses simulations and computer-based models to represent complicated connections between variables.

The software STELLA helps with the understanding of the relationship between the system's process and its structures.

STELLA models helps us to see the relationships between the variables.

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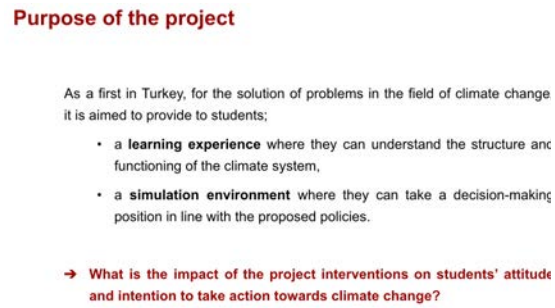

The purpose of our project was to provide students;

- a learning experience where they can understand the structure and functioning of the climate system,
- a simulation environment where they can take a decision-making position in line with the proposed policies.

We would like to explore the impact of the project interventions on students' attitude and intention to take action towards climate change.

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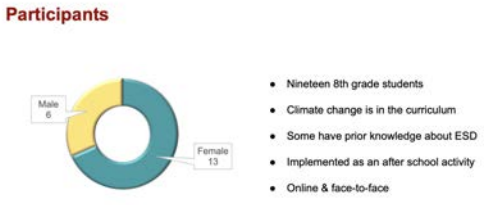

Our participants consisted of a total of nineteen students, six of them were male and 13 were female. All of the students are in the eighth grade, volunteered to participate in this study. Some of them have prior knowledge about the systems thinking approach. This study was implemented online and face to face after school hours.

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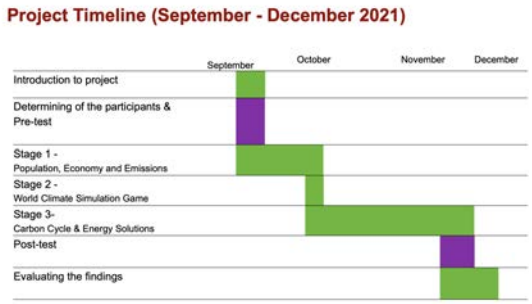

In September 2021, we had our initial meeting with the students. Then, we determined our participants among those who volunteered and implemented our pre-test.

Then, we started with Population, Economy and Emissions models in Stage 1 and continued with World Climate Simulation Game Carbon Cycle & Energy Solutions in Stage 2 &3 from October to the end of November.

We implemented our Post-test in December and started the evaluation of the findings.

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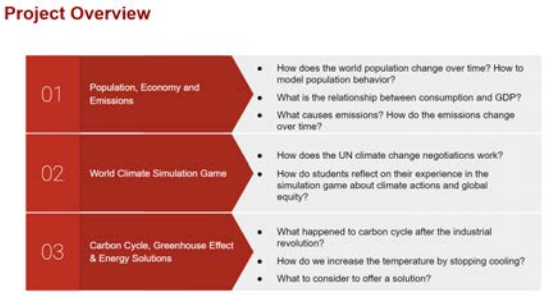

The project included three stages:

The first stage was a preparation step for the World Climate Simulation Game. Here, we aimed to discuss world population change over time and the mechanism behind it. Also, we looked at the production-consumption cycle and drew relations between countries' GDP, wealth, and consumption. Lastly, we put an emphasis on different countries' contributions to emissions.

In the second stage, by playing the world climate simulation game, we aimed students to experience how UN climate change negotiations work. We were also interested to see how do students reflect on their experiences in the simulation game about climate actions and global equity.

In the last stage, we aimed to dig deeper into the climate change problem and raise students' scientific knowledge on climate dynamics. We examined the carbon cycle before and after the industrial revolution. We looked at how the greenhouse effect stops the earth's cooling. And lastly, we run sessions to discuss the possible solutions.

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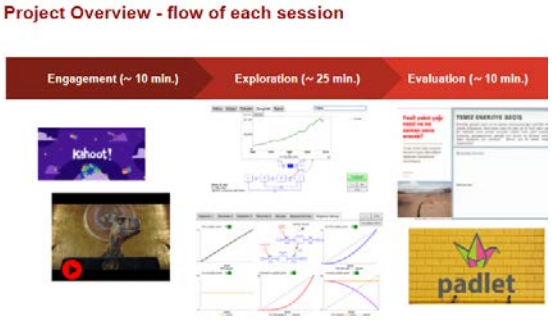

In each session, we followed a lesson structure that starts with an engagement activity, continues with exploration, and ends with an evaluation. For the engagement part, we used different videos on climate change & climate politics as well as interactive applications like Kahoot. For the exploration, we used the stock-flow diagrams and behavior over time graphs on Stella Online. For the evaluation, we created either worksheets specific to the session's topic or used reflection applications like Padlet.

Now, we will have a closer look into the models and applications that we used in each stage.

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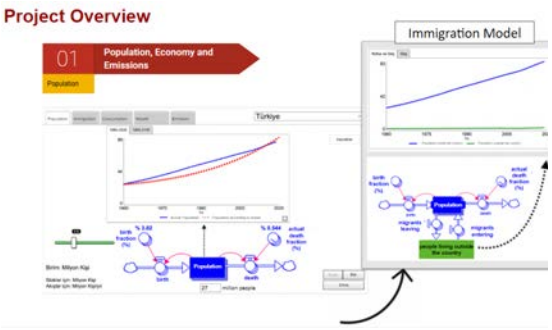

To understand the behavior of the population over time, we started with a simple stock-flow diagram. Here, the death fraction is fixed for each country on the model, however, the initial value for the population and birth fraction are adjustable.

Students tried to form a population graph that looks like the actual population graph.

(Click) Not only birth and death but also Immigration is needed to be considered for the population dynamics. Students explored immigration behavior for different countries.

- Usually, students in middle school discuss the consequences of climate change in terms of biodiversity and sea-level rise; however, they are not enough acknowledged about the effects of climate change on daily human life and politics.
- Here, we also took their attention to the term "climate refugees".

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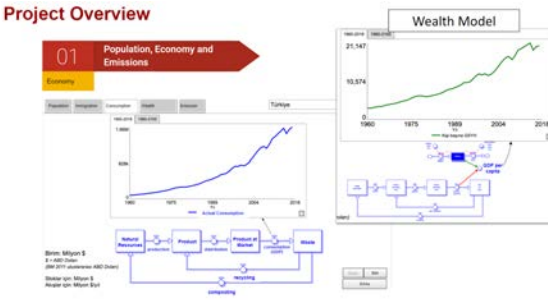

To give a basic understanding of the economy, we used a stock-flow diagram that shows the production-consumption cycle. We mentioned GDP here as equal to consumption. This means that a country with higher GDP also has a higher consumption.

We connected the population model here to introduce the term "wealth". Students compared different countries and discussed how two countries can have the same economic growth but not the same wealth.

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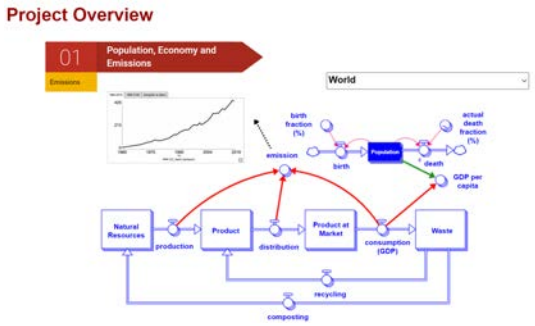

At the end of this stage, we showed a graph to have students' attention on the non-linear increase in CO2 emissions. Then we discussed the reason for this behavior by using the same stock-flow diagram we used earlier.

Each of the flows in the production-consumption cycle contributes to the CO2 emissions. Here, our main point was to show that every action such as transportation or shopping produces CO2.

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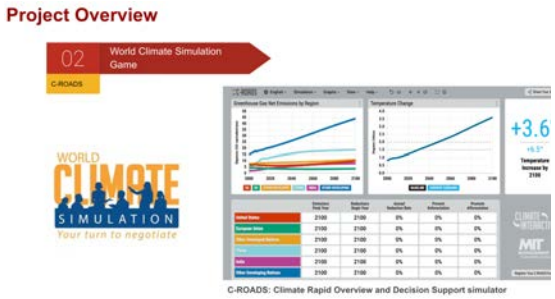

We played the World Climate Simulation Game that was developed by Climate Interactive, the MIT Sloan Sustainability Initiative, and the UMass Lowell Climate Change Initiative.

It is a group role playing simulation of the international climate change negotiations. The game provides participants the chance to explore the risks of climate change and the challenges of negotiating international agreements to reduce greenhouse gas emissions. We played the six group version of the game, in an online environment and took approximately four hours.

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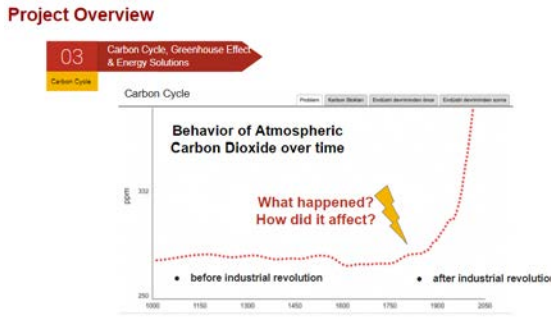

After the World Climate Simulation Game, we started the carbon cycle module with the behavior of atmospheric carbon dioxide over time. As you can see, there is a significant difference in carbon emissions (click) before the industrial revolution and (click) after.
Here, we discussed (click) what happened here and how it affected the carbon cycle.

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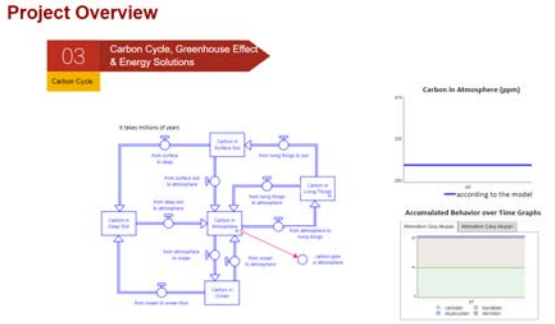

To better understand the increase in atmospheric carbon dioxide, we looked at the carbon stores in the Earth. To do this, together with students, we created a stock-flow diagram of the carbon cycle. This model shows the carbon cycle before the industrial revolution. Here, there is no human impact on the system.

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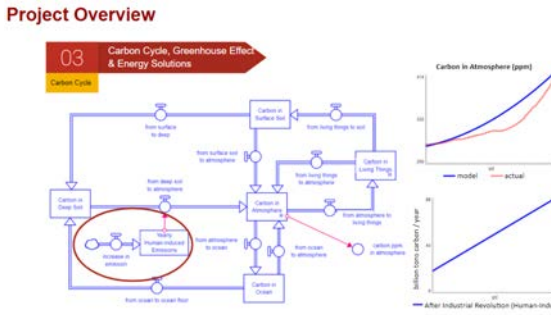

Here, you see the same model with human impact. Using this model, we aimed to show that human activities speed up the flow from deep soil carbon to atmospheric carbon. As a result, the amount of carbon in the atmosphere is constantly increasing.

After this session, we discussed why an increase in atmospheric carbon is an event that we emphasize all the time. This took us to the topic “greenhouse effect” and “global warming”.

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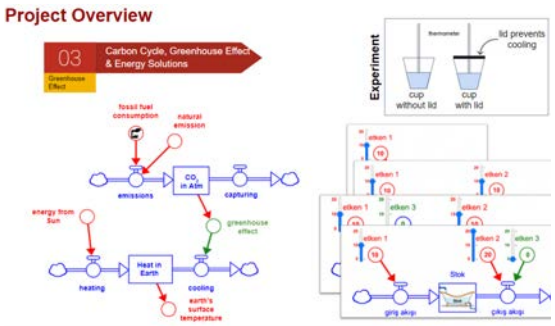

This was the model that we aimed to understand at the end of the session. Here, you can see that the greenhouse effect prevents cooling. To give this idea, we designed an insulation experiment in which students looked at the effect of putting a lid over a cup with hot water. In addition, to better understand the model we included some exercises on how different converters affect the flow and consequently the stock.

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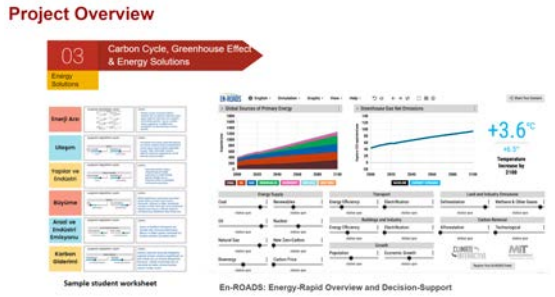


EN-Roads is a freely online simulator that provides the public with the ability to test and explore climate solutions. This simulator is very effective when used in group learning experinece. In that work, students decided the factors that increase the CO2 emissions and worked on decresing those effects. They created a scenario that successfully addresses climate change while considering implications across the economy, environment, and society.
Thus, students can quickly see the long-term effects of the global climate policies and actions they imagine.

20

Results

Initial findings from the quantitative data

	Pre-test	Post-test
Global climate change is happening today	84%	100%
Global climate change is a crisis today	90%	95%
Current global climate change is caused by human activities	90% (largely or completely) 10% (mostly)	90% (largely or completely) 10% (mostly)
Knowledge about the causes and possible effects of global climate change	65% (very good) 30% (moderate) 5% (limited)	95% (very good) 5% (moderate)

Initial project results revealed that at the end of the project all participants believe climate change is happening today and 95% believe global climate change is a crisis today. Participants’ views about human caused climate change did not change, all the participants believe current global climate change is mostly or largely caused by human activities.

At the beginning of the project, only 65% of the participants indicated they have very good knowledge about the causes and possible effects of global climate change. 30% indicated

they have moderate and 5% indicated they have limited knowledge. However, at the end of the project 95% of the participants indicated they have very good knowledge and 5% indicated they have moderate knowledge about the causes and possible effects of global climate change.

21

Results

- There was a significant difference in the **environment-centered attitude** of the students after the project interventions
  - Students developed an environmental attitude for the value they attach to nature, not for the importance and benefit it provides for people
- Students have a **future perspective** rather than a present perspective
  - 89% of the students stated that they think about the possible effects of clim change and shape their behaviors accordingly
- There was a significant difference in students' **willingness and belief in findin solutions** to climate impacts after the project interventions

Dunlap, 2008; Joireman et a

When we explore the participants' attitude towards climate change, there was a significant difference in the environment-centered attitude of the students after the project interventions. Students developed an environmental attitude for the value they attach to nature, not for the importance and benefit it provides for people.

Participants have a future perspective rather than a present perspective. 89% of the students stated that they think about the possible effects of climate change and shape their behaviors accordingly.

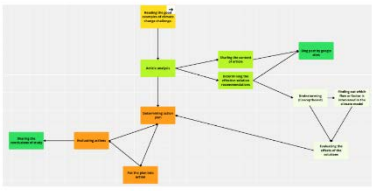
There was also a significant difference in students' willingness and belief in finding solutions to climate impacts after the project interventions.

22

Actions that resulted from the project

Student-related Actions

Started to the second phase of the project with the volunteered students



Teacher-related Actions

Started the preparation for a free onlir teacher training program with the materials developed in this project

(Environmental Education with Systems Thinki and World Climate Game)

At the end of that work, some of the volunteered students wanted to continue making actions about climate crisis because they noticed that their activities may expand more awareness in the struggling for climate crisis and so we started to the second phase. This part is based on article analysis and studying on good examples of climate change challenge. They are studying on determining effective solution recommendations.

Also volunteered teachers started preparation of a free online teacher training program consisting of videos about the content developed during the project and some challenging questions were added at the end of each video. By using those materials teachers will be able to to use system dynamics model and see the big picture of the climate crisis.