Adaptation of Systems Thinking in the K-12 International Baccalaureate Program

Abstract — We live in a time when we need a holistic view of the world of which we are a part, and which we affect and are affected by. It is therefore important for us to learn, and teach others, to see the world from this perspective. In this paper, examples will be given of learning activities compatible with national and international education programs that seek to encourage a systems thinking approach and to develop a new way of understanding. The different activities presented here are suitable for various age groups. For each activity, behavior over time graphs, stock flow diagrams, causal loop diagrams and ladders of inference were developed and used as systems thinking tools. During these activities, it was observed that the children were capable of viewing events with the tools provided, understanding these tools and using them to engage with the subject matter. As a result, they were found to respond more clearly to the questions contained in the International Baccalaureate inquiry program and to be enthusiastic about taking action as individuals. Three of the activities were related to the environment and developed awareness about it.

Key words — Systems Thinking, K-12, International Baccalaureate (IB), Primary Years Program (PYP).

1. INTRODUCTION

Data from cross-sectional studies of children support the view that biological development drives the movement from one cognitive stage to the next for the stages of sensorimotor, preoperational, and concrete operations. However, not all individuals automatically move on to the formal operations stage. Data from adolescent populations indicate that only 30-35% of high school seniors attain the cognitive development stage of formal operations.[1] For most adolescents and adults to attain this stage, a special environment is required.

The Program for International Student Assessment (PISA) results confirm this assertion. In line with the data from research about the percentage of adolescent populations in the formal operational stage, PISA results show that nearly three-quarters of students from the EU have difficulty in abstract thinking. However, some countries (like Finland, with 40%) have much higher percentages of abstract thinking students.[2] As we know that thinking skills are equally distributed among countries, the higher percentages of abstract thinkers in some countries may constitute evidence that these skills can be developed.

It can therefore be argued that an innovative approach that creates a special environment for abstract, scientific thinking, starting from pre-school, is needed to improve the education system.

Systems thinking (ST), a well-known and established method for understanding the structure and leverage points of complex problems, has a great potential for developing students' questioning, critical thinking, communication, collaboration, decision making and problem solving skills – in other words, their abstract thinking skills.

The United Nations Economic Commission for Europe Steering Committee on Education for Sustainable Development [3] lists ST first among the competences required for educators in education for sustainable development. Together with ecoliteracy and moral education, ST is also among the top educational priorities in the State of the World report of the Worldwatch Institute.[4]

The International Baccalaureate (IB) is a non-profit foundation offering educational programs for K-12 education. As of 2020, IB programmes are being followed in over 5,000 authorized schools world wide.[5] IB aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect. ST, with its highly relevant tools for building knowledge by making connections through inquiry. fits easily into the IB curriculum.

This practitioner study aims to share our experience in the use of an ST approach in the Primary Years Progamme (PYP) of the IB. Activities incorporating this approach were implemented in one of the 83 schools that follow IB programmes in Turkey. The contribution made by this study is to provide an example of the adaptation of ST tools for use within an internationally accepted K-12 education program.

1. THE INTERNATONAL BACCALAUREATE AND SYSTEMS THINKING

IB is an international program that we follow at our school. We also carry out planning based on the Turkish national curriculum [6]. There are PYP outcomes that we should reach in our lessons resolutely. We teach six units (namely: who we are, where we are in place and time, how we express ourselves, how the world works, how we organize ourselves, sharing the planet) throughout the year. The key concepts (form, function, causation, connection, perspective, responsibility, change) guide us in implementing these units. We also design our inquiry programs according to these themes. In this way, we create an environment in which students can become individuals with the specified learner profile attributes.

It was meaningful for me to combine ST with the PYP curriculum because I can easily fit it into my lessons and benefit from it. The important point here is to identify the similarities between ST and the curriculum. There are key concepts that complement each part of the iceberg. We use these concepts to make understanding and questioning more visible. In fact, every concept raises an issue that brings us into contact with ST tools. For instance, the key concept "change" maps perfectly onto the "patterns of behaviour" layer of the iceberg visual [Figure 1], while "causation" and "connection" correspond to the "structure of the system" layer .
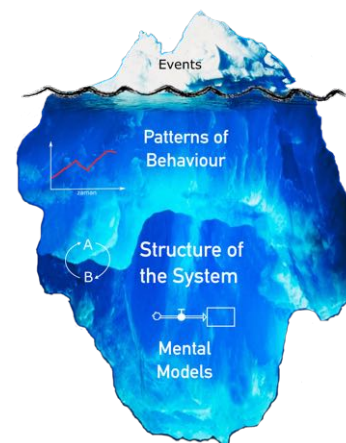

Figure 1. Iceberg Visual for Systems Thinking

2. SAMPLE ACTIVITIES

2.1. LORAX (FILM)

Theme: Sharing the Planet (An exploration of rights and responsibilities in the struggle to share finite resources with other people; access to equal opportunities, peace and conflict resolution.)
Key Concepts: Change, Causation, Responsibility, Connection
Learner Profile Attributes: Thinkers, Principled

As part of the "Sharing the Planet" unit, we worked with 3rd grade students on the movie Lorax. The movie tells the story of a man who destroys trees and builds a factory and creates a town with no trees left. First we watched the movie and tried to understand the changing situation. We discussed the developments that affected the course of events. Using our first concept (change), we decided on what was changing and looked at how it changed. There was a gradual increase in the total volume of thneeds (products made with trees) produced. The students then pointed out that the developments also affected the trees, so we also looked at the change in the trees [Figure 2]. Finally, we looked at the connection between the two situations [Figure 3]. Here we started to see and elaborate the cause and effect relationship [Figure 4]. Examples of the students' work are presented in Figure 5. At the end of the lesson we talked about our responsibilities and sought an answer to the question of what we can do. I observed the actions of the students themselves and discovered that some of them had wanted to plant trees when they went home. Others started watering the trees in our yard. What we tried to achieve was to create awareness, both as a system and as a human being, and we succeeded in doing so.
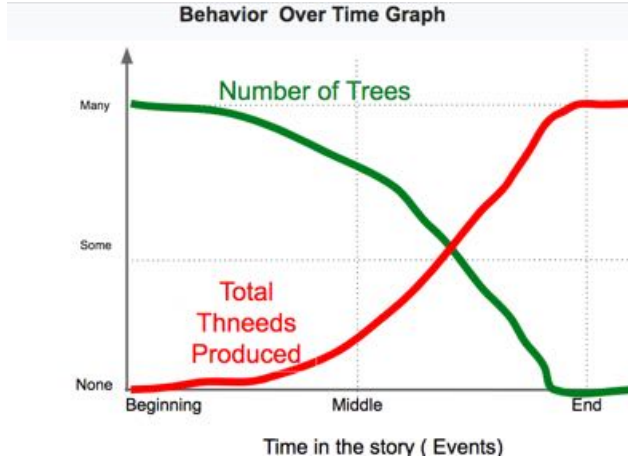
Figure 2. Behaviour Over Time (BOT) Graph of Total Thneeds Produced and Number of Trees
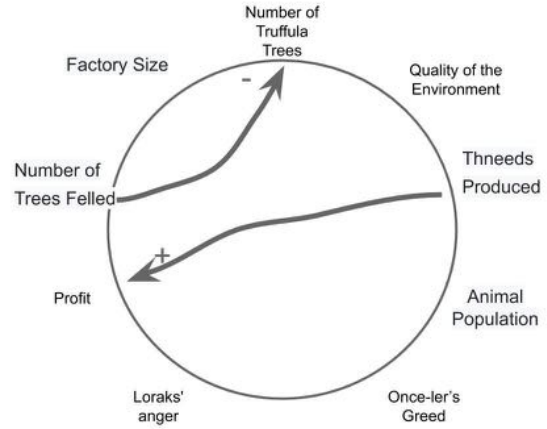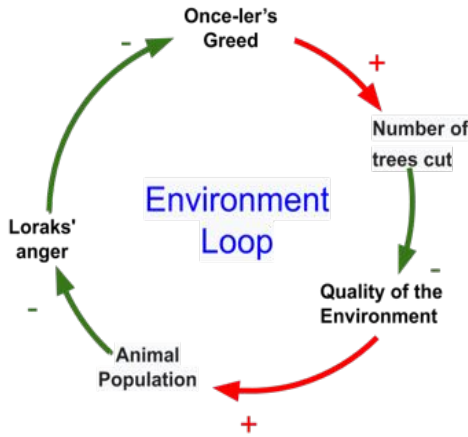

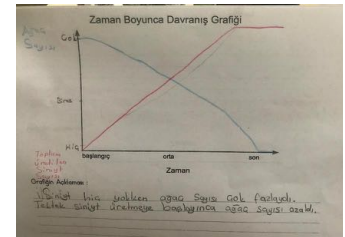Figure 3. Connection circle for Lorax

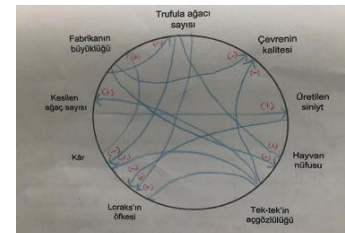

Figure 4. Causal Loop Diagram of Lorax

Figure 5. Student's Work on Lorax

2.2. COMPOST

Theme: Sharing the Planet (An exploration of rights and responsibilities in the struggle to share finite resources with other people ; access to equal opportunities, peace and conflict resolution.)
Key Concepts: Function, Responsibility, Form
Learner Profile Attributes: Inquirers, Caring

For the 'Compost' activity, a six-week project was created because there were six weeks left until the school's summer break. First of all, I conducted a pre-assessment to explore the children's perspectives and previous learning.

I did this using the ladder of inference [Figure 6]. Here, we aimed to find out what the children thought about garbage. Everyone wrote the same phrase under the ladder: "I see a bucket of garbage." The result was not surprising: one student's assignment contained the words "I'm running away from the garbage" in capital letters. My aim was to change this perception. First, we read a book in the classroom about what compost is and discussed whether we could make it. I shared the stages of the project with the children and we started collecting garbage. At this stage, we collected a lot of waste from homes and the school cafeteria and started to build a heap [Figure 7]. The next step was to measure the temperature of the heap every day and create the appropriate conditions. We recorded the temperature of the heap on a table every day. Later we used this information to create a graphic [Figure 8].
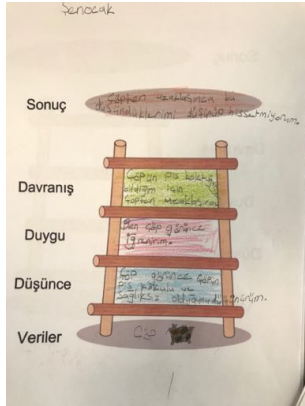

Figure 6. Ladder of Inference

Figure 7. Preparation of the Compost Heap

A story was developed to help the children understand the transformation in the soil better. One of our high school students drew the pictures for the story. For this story, we used ST tools and analyzed the change in the soil. We created a stock flow diagram showing how the transformation occurs [Figure 9]. The students realized how dead plants come back to life and become usable. Finally, we made a final assessment using the same ladder of inference. The results were very gratifying because everyone had writen the same thing: "I make compost". As a final step, we sent a letter to the children's parents, asking them whether their children's attitudes to garbage had changed and whether they had done anything about compost at home. Many of the parents said that they were now separating the garbage for compost, and that the activity had been very useful. As a result, we obtained a sack of soil and we used it for growing new plants in our school garden.
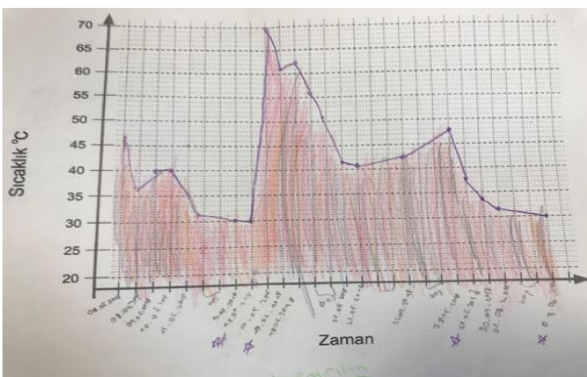

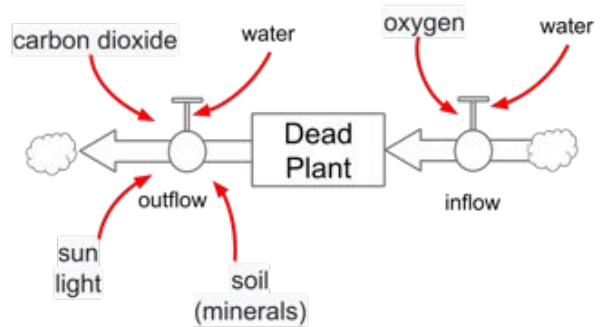*Figure 8*. BOT Graph of the Temperature of the Compost Heap

Figure 9. Stock-Flow Diagram of a Dead Plant

2.3. RAINBOW FISH (BOOK)

Theme: Who We Are (An inquiry into the nature of self; beliefs and values; personal, physical, mental,social and spiritual health; human relationships including families, friends, communities and cultures; rights and responsibilities; what it means to be human.)
Key Concepts: Perspective, Causation
Learner Profile Attributes: Caring

We carried out this activity with 1st graders as part of our first unit (Who We Are). We chose a book about sharing, which was our main idea, in order to help establish new friendships. The book tells of a fish that doesn't want to share its scales with anyone, and of how other fishes help it to change. We determined what changed in the course of the story and examined this change. We considered the levels of happiness of the rainbow fish and the other fishes and tried to make connections between the events [Figure 10]. Since the children had not yet learned to read and write, we used only pictures and graphics. We analyzed why the rainbow fish lost friends and how she got more friends again with the aid of a stock flow diagram [Figure 11]. Before we did this, we played a game to understand the stock flow diagram better, and animated the diagram [Figure 12]. We chose a child to be the rainbow fish and turned the book into a drama [Figure 13]. This helped the 1st graders to understand the means used. It also helped to make the situation more concrete for them.
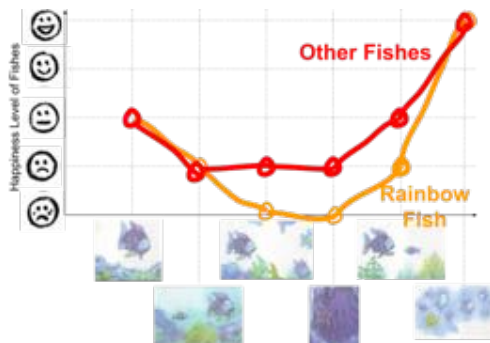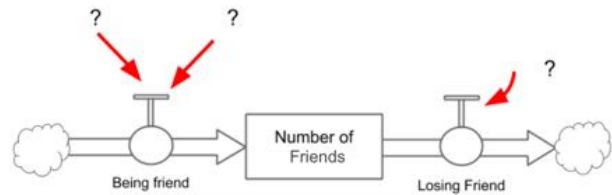

Figure 10. BOT of Happiness Level of Rainbow Fish

Figure 11. How to Make Friends

Figure 12. Rainbow Fish Drama

Figure 13. Stock-Flow Game

2.4. **ICE AGE 2 (FILM)**

Theme: How The World Works (An inquiry into the natural world and its laws; the interaction between the natural world (physical and biological) and human societies; how humans use their understanding of scientific principles; the impact of scientific and technological advances on society and on the environment.)
Key Concepts: Change, Causation
Learner Profile Attributes: Knowledgeable, Principled, Caring

We conducted this activity as part of our fourth theme, "How the World Works". Our main idea was resources and climate. We organized a cinema day and went and enjoyed the movie. When we returned to the classroom, we tried to identify key points about the movie. We did the color-symbol-image activity, which is one of the thinking routines, and we thought about the details that could help us to ask questions about the movie. Of course, the children identified what changed in this movie very easily, because the whole movie was about it. They found the melting of large glaciers and the dangers which it creates for living things very interesting. Together, we listed the events in the movie. Then we looked at the change in the water level in the valley. We saw how this change affected the animals using a single graph and specified the link between the two changes [Figure 14]. We observed the reasons and the results by creating a stock flow diagram [Figure 15]. We then started the inquiry phase. Throughout the unit we talked about what the reasons why the world is changing could be and what influence people have on these factors. We combined these disccussions with science experiments. It was a good way to start an inquiry.

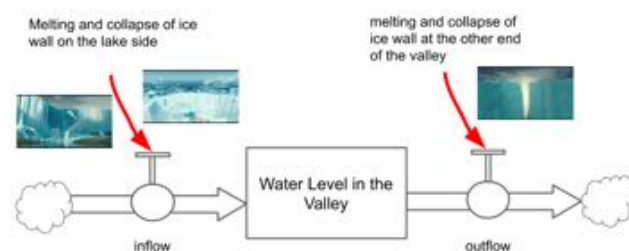***Figure 14***. *BOT of Happiness and Water Level in Ice Age 2*

Figure 15. *Stock-Flow Diagram of Water Level in Ice Age 2*

3.   **CONCLUSION**

All the activities were carried out using ST tools in the context of PYP themes. This approach was observed to provide the children with very good guidance for starting their inquiries and seeking answers to their questions. The students were observed to find the subjects more enjoyable when using systems thinking tools. The conclusion was reached that the approach supports permanent learning. The activities showed that ST can be associated with the themes and outcomes of the PYP of the IB.

4. REFERENCES

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