Abstract

Positive effects of elective courses on Systems Dynamics and Systems Thinking in Ege University Medical Faculty on students' perspective and PISA results showing insufficiency in abstract thinking has encouraged the design of a project aiming to increase the capacity of teachers to deliver students' academic and lifetime benefits by developing questioning, critical thinking, communication, collaboration, decision making and problem solving skills.

Systems Thinking, a good candidate for improving abstract thinking by visualizing behaviour and structure of systems, is being gradually adapted to kindergarten and primary school programs of participating schools in Turkey for last 5 years.
A yearly routine of introductory training, followed by implementations supported by volunteer facilitators and, sharing results in a symposium and on a web site is established. After two years of implementation and sharing, a volunteer teacher has the opportunity to become a volunteer facilitator.
By this way, we were able to disseminate systems thinking in two dimensions: increasing number of teachers on same grade level and, incorporating teachers from new grade levels. We develop content for a new grade level through collaborations with different organizations including universities and NGO's.
We want to share our experience and get opinions and suggestions

Presentation

Thank you...

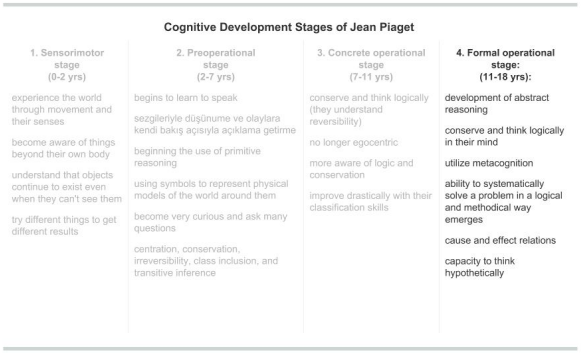
I want to share our experiences about dissemination of systems thinking through K-12 schools in Turkey for last 5 years.

We see this as a diffusion process. A kind of contamination for the better.

You won't see anything complex in this presentation. This might be a little weird for a conference about complexity. But from a constructivist point of view, we are trying to build capacity to cope, or dance, with complexity using blocks of simplicity. For the simple reason that nearly half of our objects of interest does not know how to read.

So this presentation is a proposal for a method, a method for dissemination of systems thinking in K-12 education.

Here is the theoretical introduction to the problem statement...

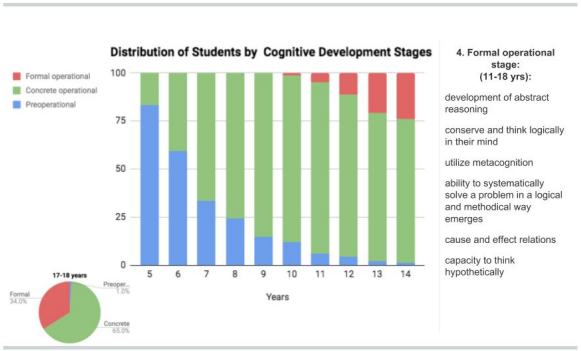


Jean Piaget was one of the most influential researchers in the area of developmental psychology. He formulated the four stages of intellectual development as sensorimotor, preoperational, concrete operational and formal operational[1]. In earthly terms these are; infancy, toddler and early childhood, elementary and early adolescence, adolescence and adulthood.

He proposed abstract thinking begins in formal operational stage. In other words, he argues that development of abstract reasoning cannot begin until a person gets 11 years old.

This argument restricts beginning of systems thinking concepts before secondary school.

But actually real problem is much bigger...



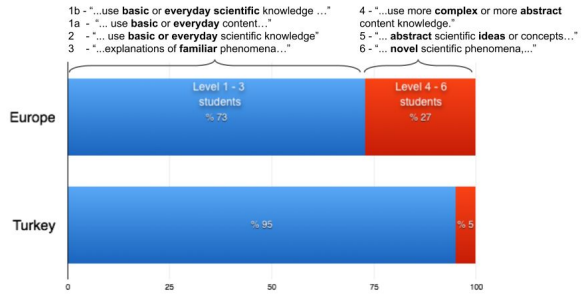
Many studies found Piaget's classification of stages as partially true[2].

This graph is from a 2003 study[3]. It shows that formal operative stage or abstract thinking does not show up for 11 year olds all at once. Actually, according to this study, only 5 % of 11 year olds is in this stage. For 14 year olds only a quarter of the students is in the formal operative stage.

The pie chart shows what happens in the end: Only one-third of the adults can think in abstract terms. That is two-thirds of the citizens in a democracy cannot understand the more complex issues facing them in life.

This is a problem.

PISA 2015
Levels of proficiency



We can see a similar situation in PISA results.

PISA (The Programme for International Student Assessment) is a triennial international survey that evaluates education systems worldwide by testing the skills and knowledge of 15-year-old students. It is a worldwide organized study by OECD (Organisation for Economic Co-operation and Development).

In 2015 over half a million students, representing 28 million 15-year-olds in 72 countries and economies, took the internationally agreed two-hour test. Students were assessed in science, mathematics, reading, collaborative problem solving and financial literacy.

Seven levels of proficiency are described in PISA: starting from 1b "with basic or everyday scientific knowledge", ending with 6 "interrelated scientific ideas and concepts", proficiency required for levels gradually increase[4]. Proficiency in abstract content knowledge starts with Level4. In other words first 4 levels, 1b thru 3, different levels of everyday content knowledge is measured. Starting from Level4, more complex, abstract scientific ideas or concepts to explain unfamiliar phenomena is measured.

In PISA 2015, percentage of students from European Union having results Level4 and over is 27.2%[5] Attesting data from research about percentage of adolescent populations in formal operational stage, PISA results show that nearly three-quarters of students from EU have difficulty in abstract thinking.

As you can see, the situation is even worse for Turkey. Only 5% of 15-year-olds in Turkey seems to reason formally.

This is also a problem: Not as big as the previous one, but it's a good place to start from.

Ministry of National Education
Pre-School
Education Program

Outcomes of Cognitive Development

1. Pays attention to an object/situation/event.
2. Makes estimation about an object/situation/event.
3. Remembers what she perceives.
4. Counts objects.
5. Observes objects or entities.
6. Pairs objects or entities according to their properties.
7. Groups objects or entities according to their properties.
8. Compares objects or entities according to their properties.
9. Sorts objects or entities according to their properties.
10. Applies intsructions about poisiton in a place.
11. Measures objects.
12. Identify geometric shapes.
13. Identify symbols of daily life.
14. Forms patterns with objects
15. Comprehends part-whole relation.
16. Does addition and substraction using objects
17. Infers cause and effect relation.
18. Explains concepts about time.
19. Produces solution to problematic situations
20. Prepares graphics with objects/symbols
21. Recogizes Atatürk and explains his importance for Turkish people

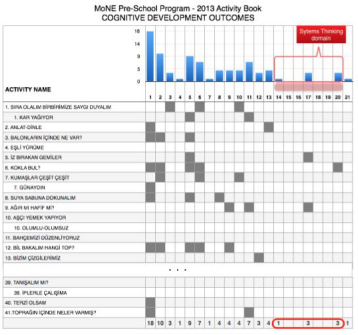
So we started from preschool education.

These are expected outcomes from cognitive development in preschool determined by Ministry of National Education of Turkey[6].

You can see in the table that from 14 to 20, outcomes demand more abstract thinking. These are the target outcomes we choose to address with systems thinking.

And there was also an opportunity in these outcomes.

Ministry of National Education
Pre-School
Education Program
Activity Book



This is the Activity Book published, distributed and recommended by the ministry to use in preschool education in Turkey[7].

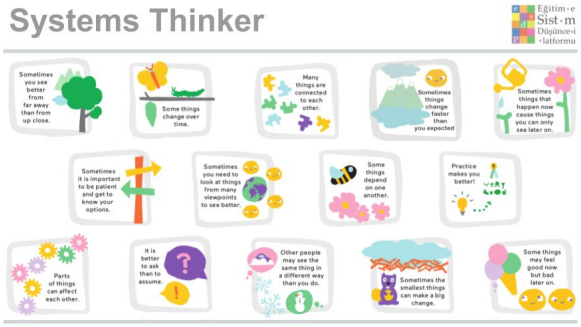
In the table each line is an activity. And gray squares show if related outcome is being met by the activity.

There are 41 activities and you can see least addressed activities are from 14 to 20.

Ministry of National Education in Turkey wants (or wishes) students to achieve outcomes about abstract thinking but does not give tools or strategies to reach these outcomes.

This "ends without means" situation is not specific to the ministry. From International Baccalaureate (IB) to The Turkish Foundation for Combating Soil Erosion, for Reforestation and the Protection of Natural Habitats (TEMA Foundation)[8], many institution wants (or wishes) students to achieve outcomes about abstract thinking but does not give tools or strategies to reach these outcomes.

We see this as an opportunity to introduce systems thinking.



At first we described what we understand who is a systems thinker.

We used Waters Foundation's 14 Habits of a Systems Thinker[9]. We translated them to Turkish and used some visuals of Linda Liukas[10] (a children's book author and illustrator).

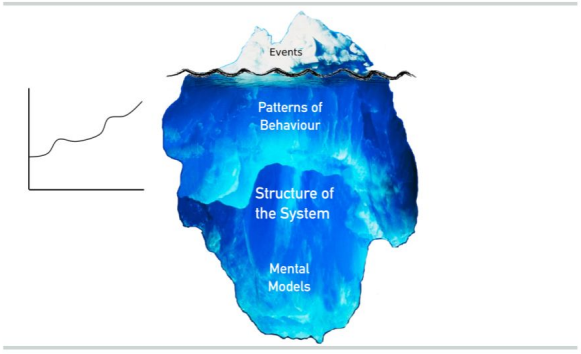
Each habit acted as a long term outcome of our program.

We used what we learned from Waters Foundation and Creative Learning Exchange in designing activities.

Iceberg analogy.

There are events on the surface.

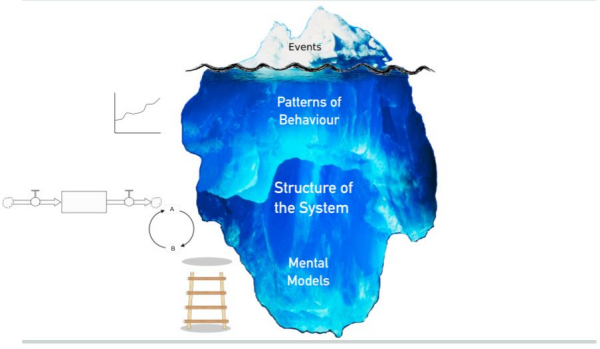
These are things that we see everyday, read in a newspaper or internet or a story book.



First thing to recognize is a pattern from these events.

A line graph is used to represent these patterns. Pattern is shown as a behaviour over time.

The behaviour might be anything from gross domestic product to happiness of an elephant.



After plotting the behaviour over time we go deeper and try to find the structure producing this behaviour.

Most often the variable of the BOT graph is taken as the stock of a stock-flow diagram. And by looking at the behaviour in the graph, events or factors that increased or decreased that stock are listed as flows.

If needed a second stock or if appears a causal loop diagram is introduced.

Then a couple of factors of the flow that are decisions or the actions in the structure are analyzed with ladders of inferences.

We use 3 or 4 step ladders adapted from Waters Foundations, Creative Learning Exchange and Society for Organizational Learning (SoL) in Turkey.

Here are some examples...

This is the first, and for the time being only, children's story book written systems thinking in mind[11]. It was written by one of the first preschool teachers trained by Sheri Marlin from Waters Foundation.

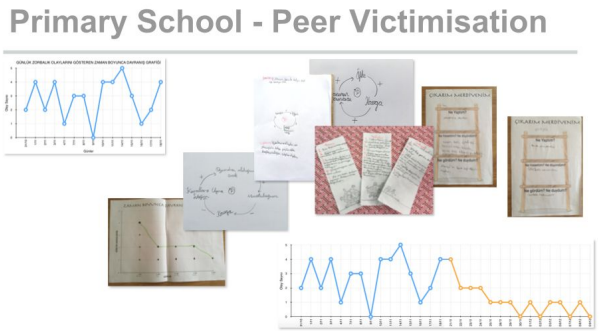
The story is based on relations between frogs and people living by a pond.

It is studied with different age groups. As you can see we gradually increase depth and range of tools used.

For the 4 year-olds only a simple BOT with 5 events on time axis and 2 modes of behaviour on y-axis is used.

For 5 year-olds both axises are more detailed and a stock-flow diagram is introduced.

And for the 6 year-olds ladder of inference and fixes that fail archetype is studied.



Story analysis is the favorite activity of teachers in using systems thinking in their classes. After systems thinking implementer training, first activity activity a teacher does is usually a story analysis.

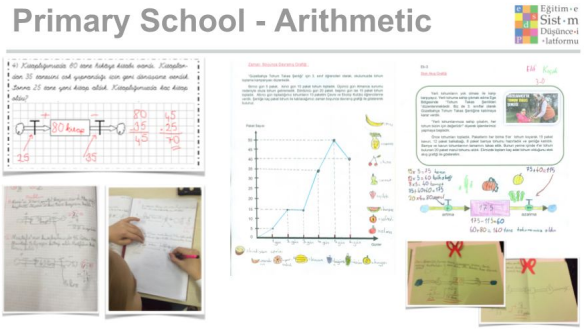
This is a different example from primary school. It's actually a subject of psychological counseling and guidance but studied by a classroom teacher.

He's working in school in a disadvantaged area of Izmir. Peer victimisation was a common problem.

After recording number of events for a period of time he shared the BOT graph with his 2nd grade students. And want them to record and plot the events day by day. This feedback alone had an affect on the behaviour.

Then, by drawing a stock-flow diagram and selecting number of events as the stock, they analyzed flows. They found some escalation loops, different ladders of inferences and proposed some solutions. Results can be seen in the graph.

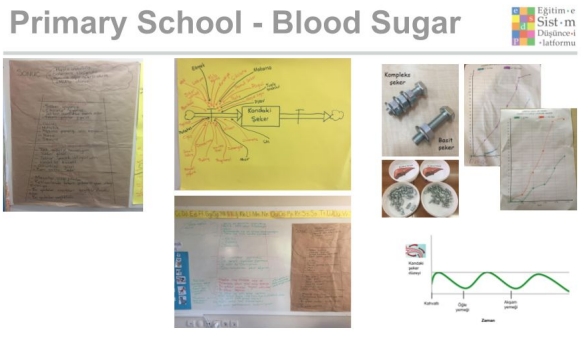
This was done last year, the behaviour sustained so far.



Another example is from math.

We use stock-flow diagrams to visualize arithmetic problems. By using stock's initial value as starting amount, and interpreting additions as inflows, subtraction as outflows, students from 1st grade to 3rd grade seem to understand these concepts much better.

Of course this is a static or a one-time flow version of the stock-flow diagram. In later grades we begin to introduce flow concept as a variable per time.



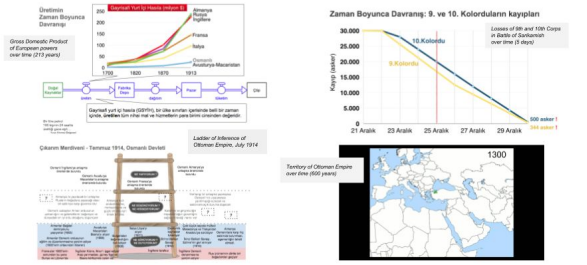
Last example from primary school is a 3 week activity about nutrition. There are many outcomes of healthy nutrition in every grade of the education system. So it is very easy to adapt this series of activities into school programs.

It is specifically designed around blood glucose.

It starts and ends with ladders of inference. We aim to see the change in perceptions of students before and after this series of activities.

Activities include BOT's basing on stories, stock-flow diagrams before and after an experiment about glucose content of foods or game showing effects of simple and complex sugars on blood glucose levels. Sugars are represented as bolts. Simple bolts have one nut, complex have 3-4 nuts, so it's hard to assemble them. A similar situation for metabolization of complex sugar.

Secondary School - World War I



This is the first activity developed for secondary school.

It is 4 hour lesson plan on First World War from the perspective of Ottoman Empire.

Economic reasons of the war is introduced by a BOT graph of Gross National Products of major fighting countries for 200 years. Gross National Product is presented schematically as a flow of production from natural resources to produced items in factories. The blue line is Ottoman Empire. A country that could not succeed transition to an industrialized society.

The ladder of inference below analyses Ottoman Empire's decision to enter war. Each student fills a semi-filled form of this ladder and discuss their reasoning.

The graph on the up right is a BOT graph for one of the tragedies of the WW1. It shows loss of 60.000 Ottoman soldiers in one December week. Most of the them by freezing. Here we also use ladder of inference for some decisions of Turkish War Minister Enver Pasha. Lastly, results of World War 1 is discussed with this animated graph. This BOT graph and animated map summarizes 600 year of history of Ottoman Empire.

Experience Sharing Symposiums

All of these lessons and activities are presented in Experience Sharing Symposiums by the teachers who implemented them.

As always, all work is on volunteer basis.

Symposiums are organized in schools that use system thinking tools and strategies. They sponsor costs like lunch, notebook, pencil.

We saw that such an event is very crucial in dissemination of systems thinking in education. It becomes a target for presenters and a very effective medium for teachers interested.

There is a slight risk of loosening of implementations as a result of the perception of reaching the target. We try to avoid this by continuing our monthly visits to the schools.

Teacher Training Loop

This training and implementation loop developed in time.

In August we organize a two-day systems thinking implementer training. First two trainings were given by Sheri Marlin from Waters Foundation. But in 2016 as a result of social unrest in Turkey we could not organize a training with Water Foundation.

With Waters Foundation's support, we developed our own training. As we did not have any experienced instructor, so we divide the work and give training to groups of teachers with teachers who had training as facilitators.

After one year of implementation and presentation of her work in the symposium, a teacher volunteers to be a facilitator assistant in these trainings. So symposiums became a source for both participants and facilitators.

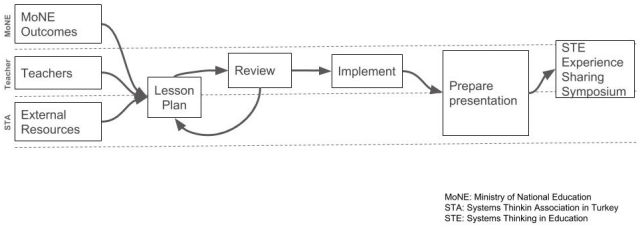
In time we made a major shift in our strategy to reach teachers.

In the beginning we visited schools and talked with administration. This was partly because first trainings were costly and we need their financial support. But when teachers started to transfer their knowledge and experience as volunteers, the need for financial support disappeared.

We still make visits to school administrators or founders to invite them to participate in the project but now our focus is teachers.

We see that a convinced teacher is the most important factor. Our strategy now relies on volunteer teachers spreading the news. Initially it takes time but it is much more effective and permanent.

From design to share



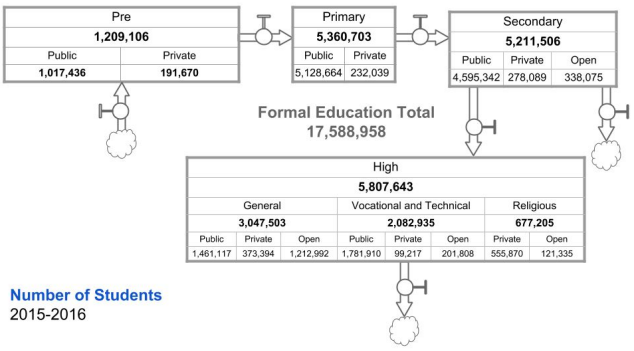
MoNE: Ministry of National Education
STA: Systems Thinkin Association in Turkey
STE: Systems Thinking in Education

Another important factor is design to share process.

Periodic support is crucial. We see that even the best training have a very little chance against pressure teachers face during semester.

So we, Systems Thinking Association with its volunteers of different backgrounds, make at least monthly, mostly weekly, visits to schools. We try to support the teachers by supplying resources and connections with other teachers.

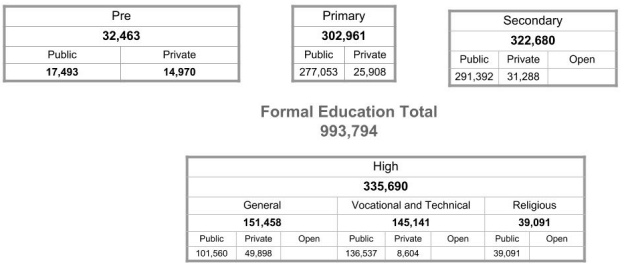
All work done is documented in Systems Thinking in Education web site.



Number of Students
2015-2016

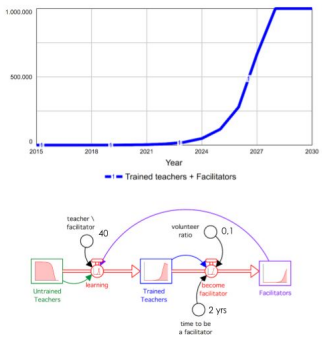
Our aim is to reach all of the K-12 students in Turkey[12].

This is 17,5 million students flowing thru the education system.



Number of Teachers
2015-2016

So we need to put about all 1 million teachers in education system to teacher training loop.



	learning	Trained Teachers	become facilitator	Facilitators
2015	40	9	0	1
2016	58	49	2	1
2017	155	104	5	4
2018	363	254	13	9
2019	871	605	30	22
2020	2.081	1.446	72	52
2021	4.972	3.454	173	124
2022	11.881	8.254	413	297
2023	28.388	19.722	986	710
2024	67.832	47.124	2.356	1.696
2025	162.080	112.600	5.630	4.052
2026	387.280	269.050	13.453	9.682
2027	333.988	642.878	32.144	23.135
2028	0	944.723	47.236	55.278
2029	0	897.486	44.874	102.515
Final	0	852.612	42.631	147.389

A very (ridiculously) simple model shows that this can be done in 15 years.

If each facilitator instructs 40 teachers and 10% of trained teachers volunteers to be facilitator and it takes 2 years to be a facilitator, capacity growth will allow to train 1 million teachers.

So far we are reaching yearly goals in the table. But in a few years we must be collaborating with Ministry of National Education in Turkey.

But we need to be competent and big enough to be realized.

Currently we are in the process of planning with academicians from major universities in Turkey working on SD/ST to increase capacity of teachers through workshops, assessments and evaluations.

to learn is to change
and real change comes from within
that's why we do not see ourselves as sculptors
we see ourselves as gardeners if not foresters

thank you.

www.EgitimdeSistemDusuncesi.org

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