Computational Thinking Education in Korea

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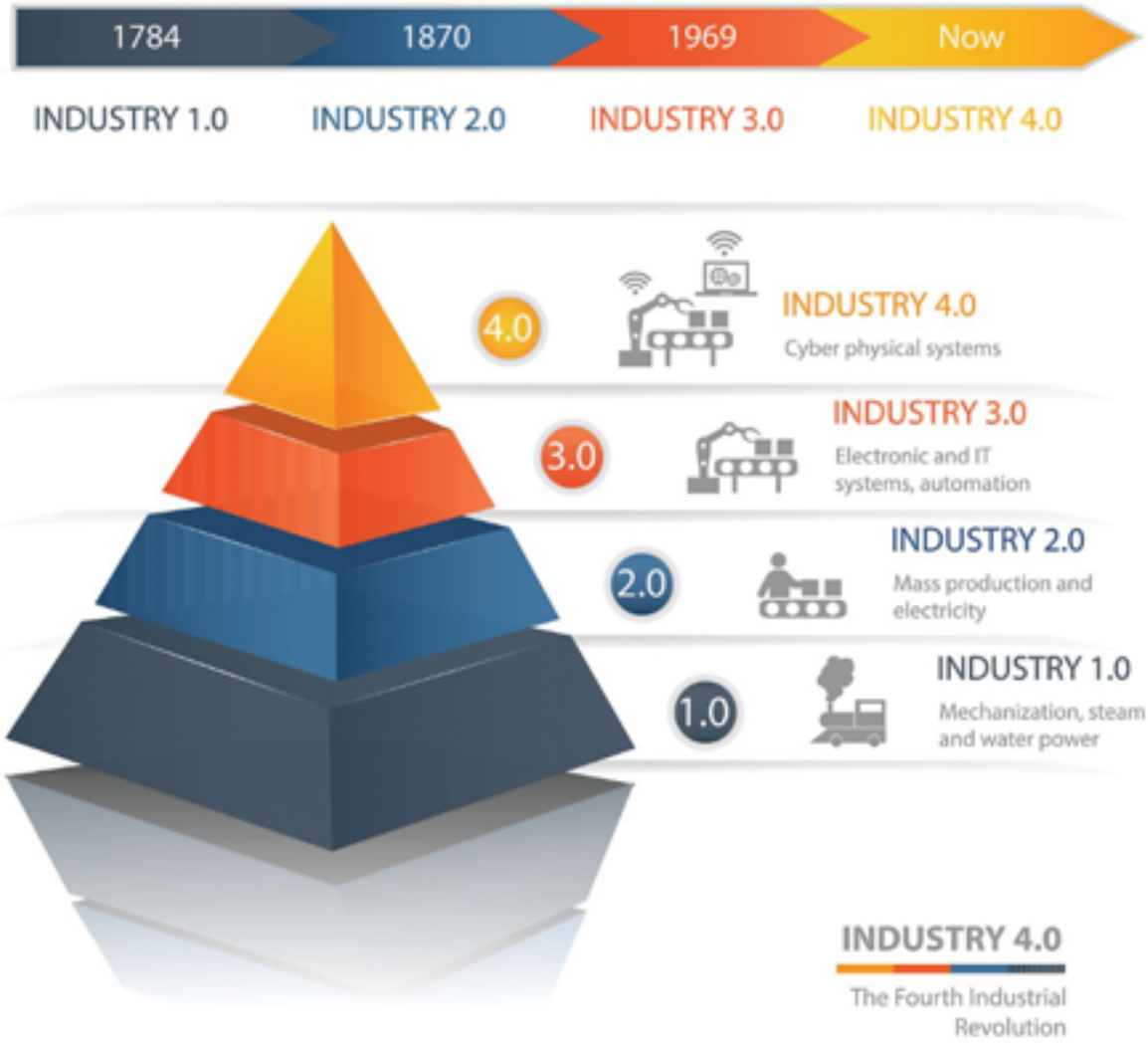
Why Computational Thinking?

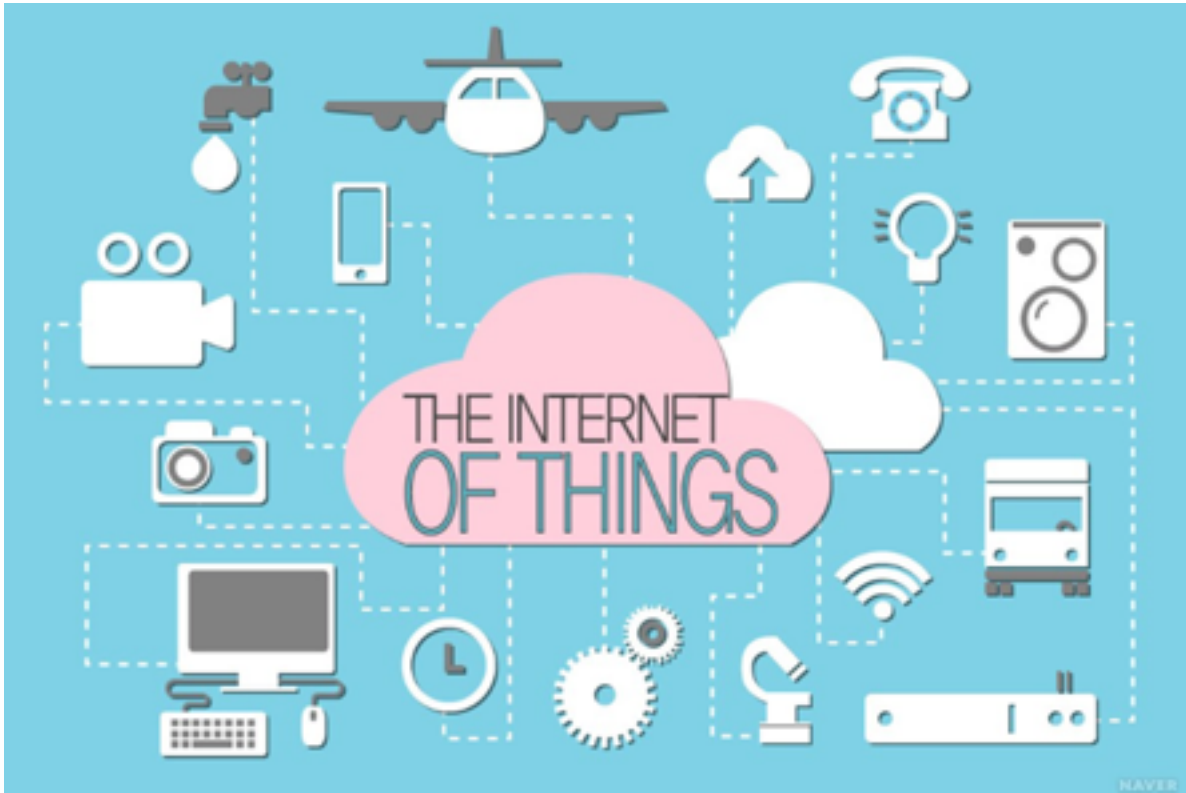
4th Industrial Revolution (Industry 4.0)

This revolution refers to an industrial change that is based on a "virtual physical system" that can intelligently control objects through a high speed network.



“virtual physical system” : IOT

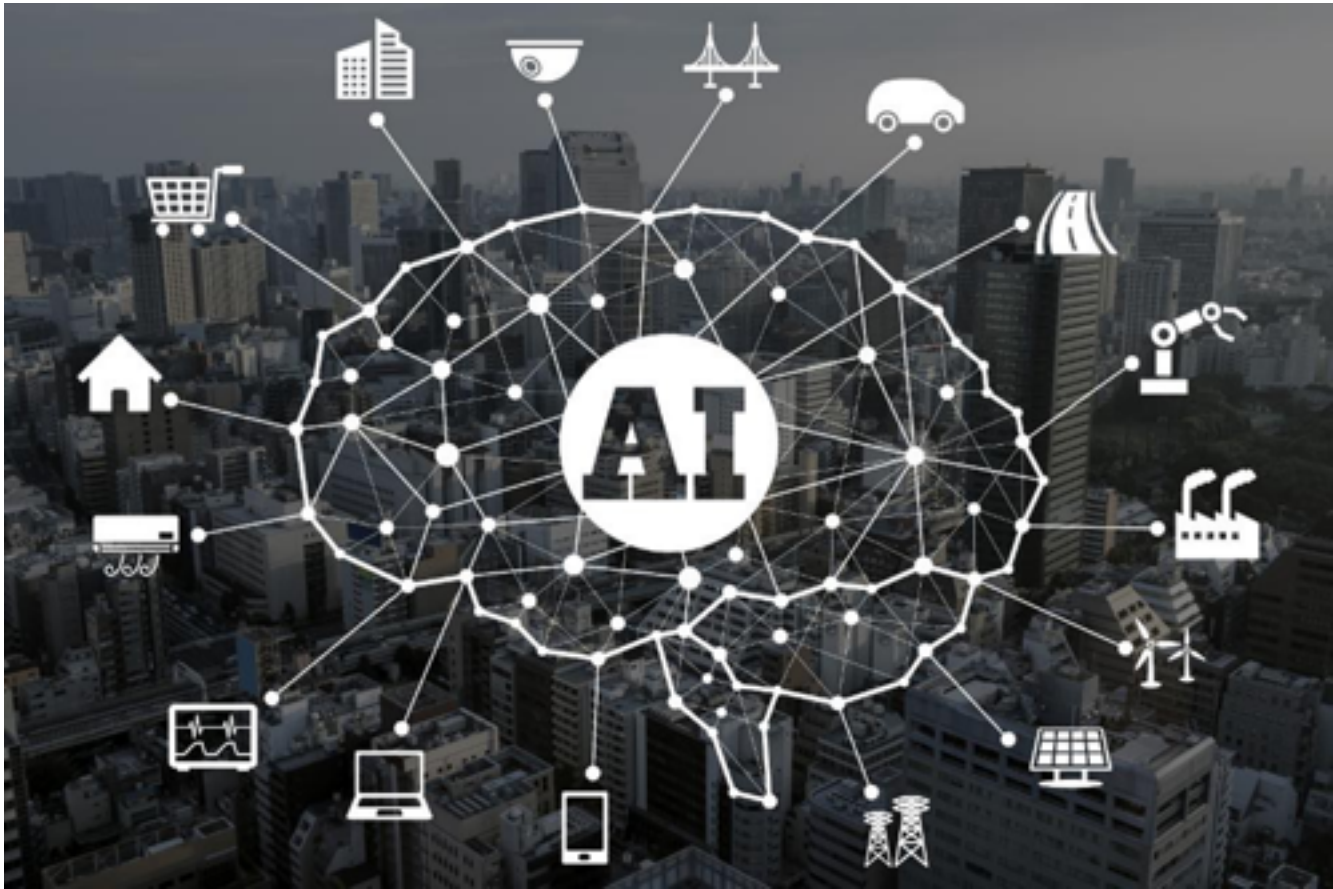
IOT(Internet of Things) refers to the connected internet system of tangible or intangible objects for providing new services that individual objects could not provide.



AI (Artificial Intelligence)

AI is “a system to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation”

Kaplan Andreas; Michael Haenlein (2018) Siri, Siri in my Hand, who's the Fairest in the Land? On the Interpretations, Illustrations and Implications of Artificial Intelligence. Business Horizons, 62(1)



Self-driving Car

A self-driving car is a vehicle that is capable of sensing its environment and moving with little or no human input. It combine a variety of sensors to perceive their surroundings to identify appropriate navigation paths, as well as obstacles and relevant signage

Virtual Reality(VR)

VR is a cutting-edge technology that allows people to experience real life in a computer-generated virtual world.

It can be used through HMD, which is a display device that is mounted on the head.

Simulation equipment training pilots to fly fighter jets

Key competencies operating "VPSs"

- The most important key competency for operating "virtual physical systems":
  - Computational Thinking Ability: Competency for communicating between human and machine
- Nurturing computational thinking ability of students is essential for booming up the 4th industrial revolution.
- It should be a goal of education.
- Like many other countries, Korea introduces "computational thinking" from elementary school as compulsory.

Computational Thinking

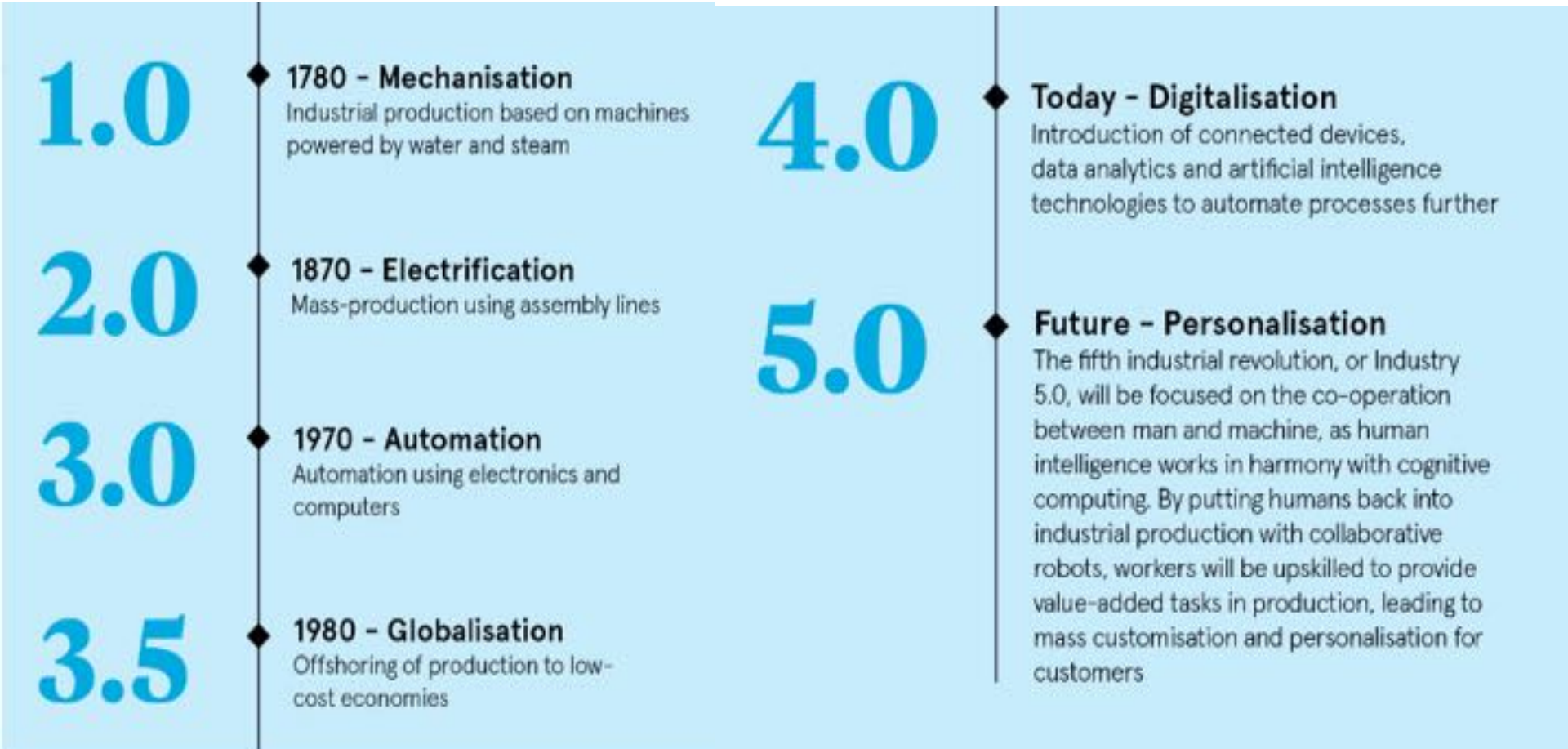
- Computational thinking is a problem solving process to design some kinds of "procedure" or algorithm with or without programming language
- How to make students think procedurally and efficiently in problem solving situations.
- Korea puts weight on algorithm with programming language.
- "Coding" from elementary school: "Coding fever" like LOGO in 1980s and 90s.

Coding fever in Korea

We have more than hundreds of Coding Private Institutes for elementary and high school students in Seoul.

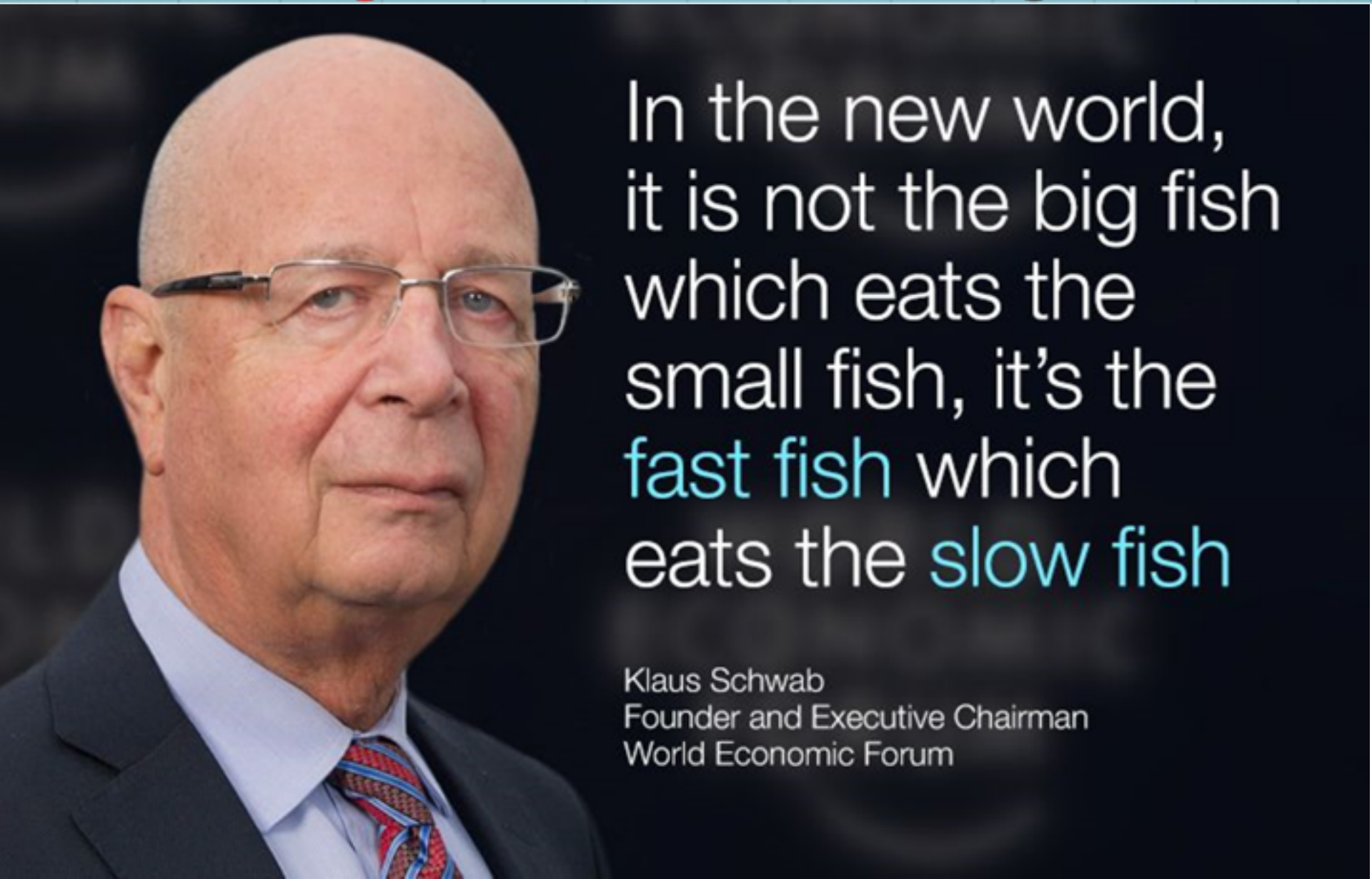
Rapid Society Change

- Industry 4.0 starts to move rapidly towards Industry 5.0 when the society begins to allow customers to customize what they want.



Faster fish rather than big fish!!

Smart thinking rather than lots of knowledge



Cognitive Skill in Industry 4.0

- What does smart thinking mean in Industry 4.0?
- If the "change of technology" is achieved, the robots equipped with AI will be responsible for a lot of human activities.
- Instead, human beings must have the ability to support cognitive skills like critical thinking, creativity, and problem solving for the use of technology.

Soft Skill in Industry 4.0

- The 4th industrial revolution' will lead to a change in the job world.
- Lifelong learning becomes important because the speed of vocational and knowledge destruction is very rapid.
- In the new society, human soft skills such as challenging adventure and networking must become more important.

Learnability in Industry 4.0

"In the 4th Industrial Revolution, the *Learned* will be disrupted by the *Learner*. We are focussed on building *Learnability* as the core skill set for the future workforce"

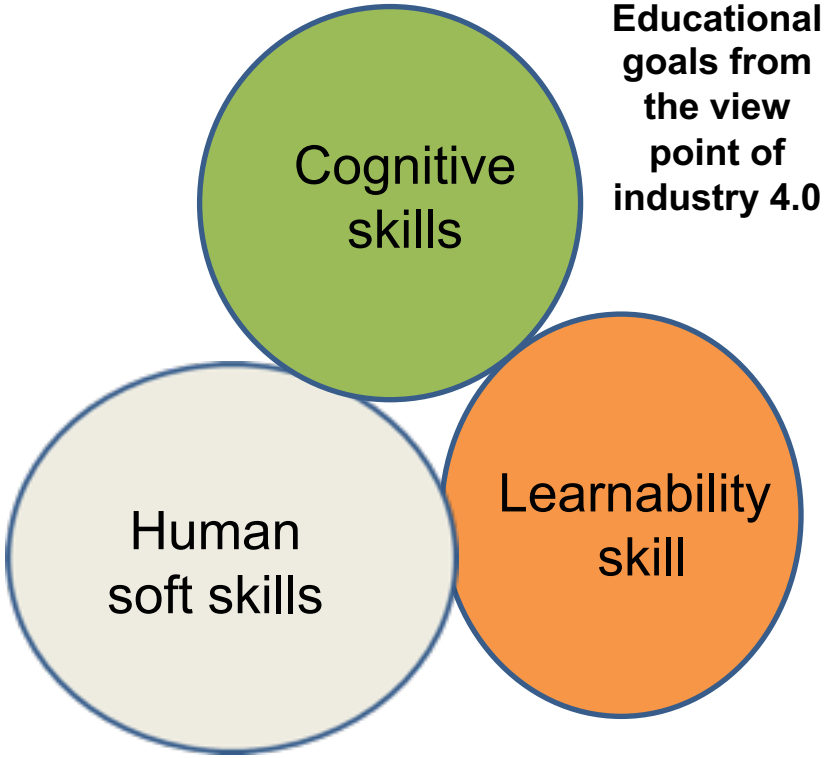
- Karl Mehta,
Founder & CEO, EdCast
@ World Economic Forum'17 in Davos.

edcast

Educational goal from the view point of Industry 4.0

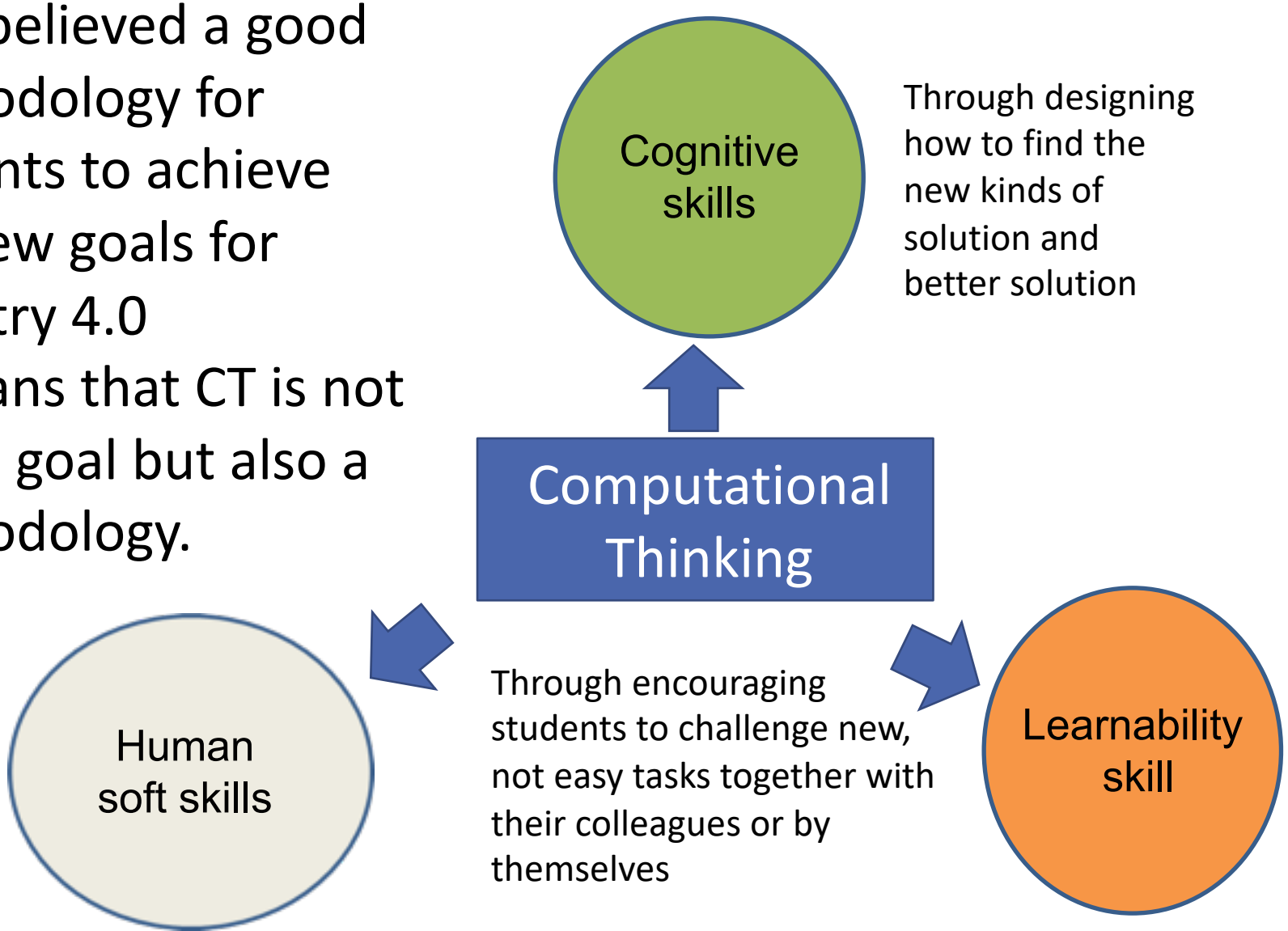
- For sustainable development of the 4th industrial revolution, the most important factor is to train students with new kinds of skills:

  - Cognitive skills such as critical thinking, creativity, and problem solving
  - Human soft skills such as challenging adventure and networking
  - Learnability as new skill to learn from surrounding world by oneself



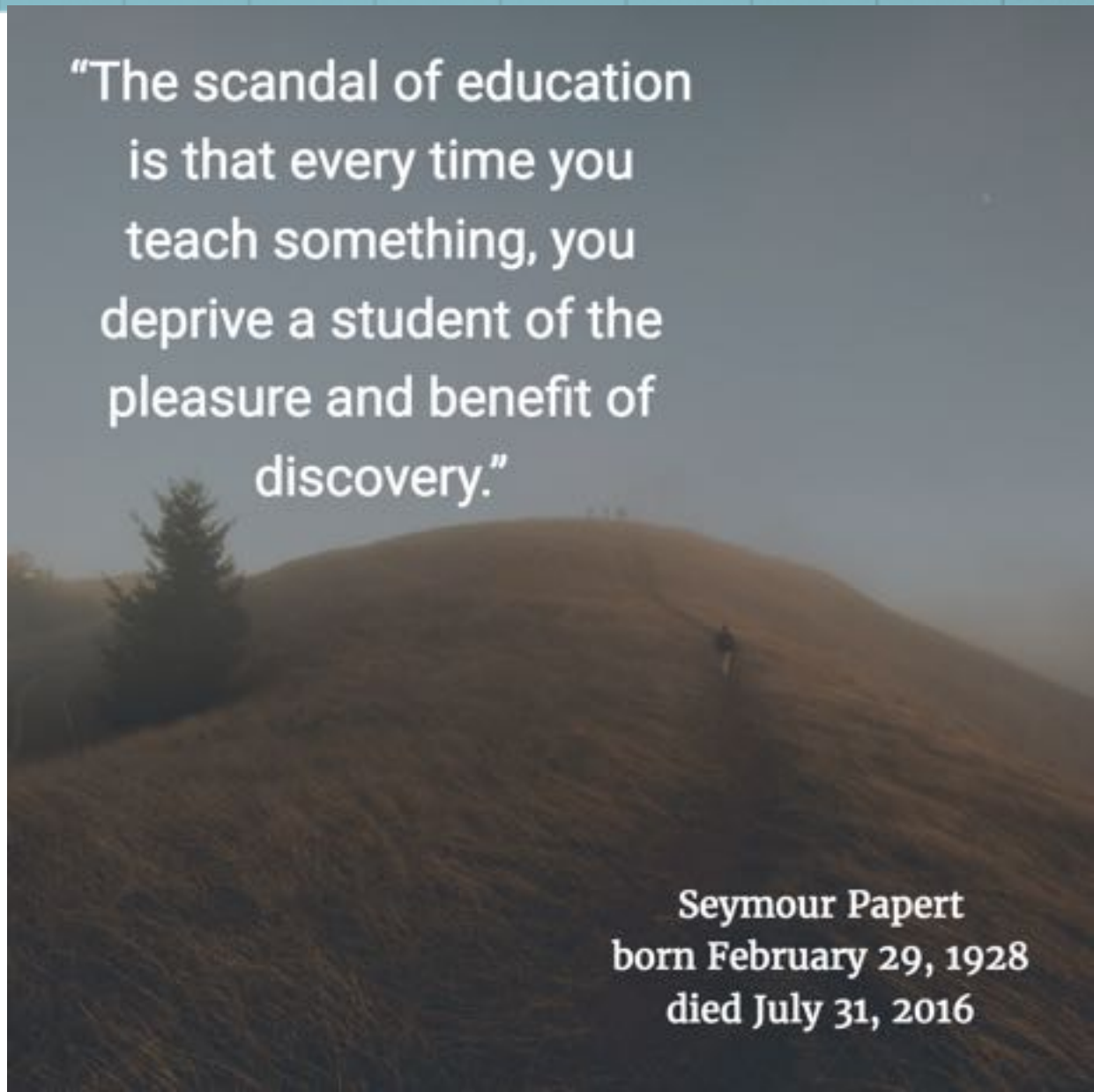
Computational Thinking for "New Goals"

- CT is believed a good methodology for students to achieve the new goals for Industry 4.0
- It means that CT is not only a goal but also a methodology.



Computational Thinking for “impression and meaning”

Computational thinking could make students to feel pleasure (impression) in learning and benefit of discovery, (meaning for learning) based on what teachers teach.



Crisis: Few Impression and meaning

- "Crisis": Korean students has few "impression and meaning" in their learning process.
- Students are exhausted in learning mathematics because of so much pressure in memorizing and drilling formula and skills at school and such an effort in learning does not give them any meaning.

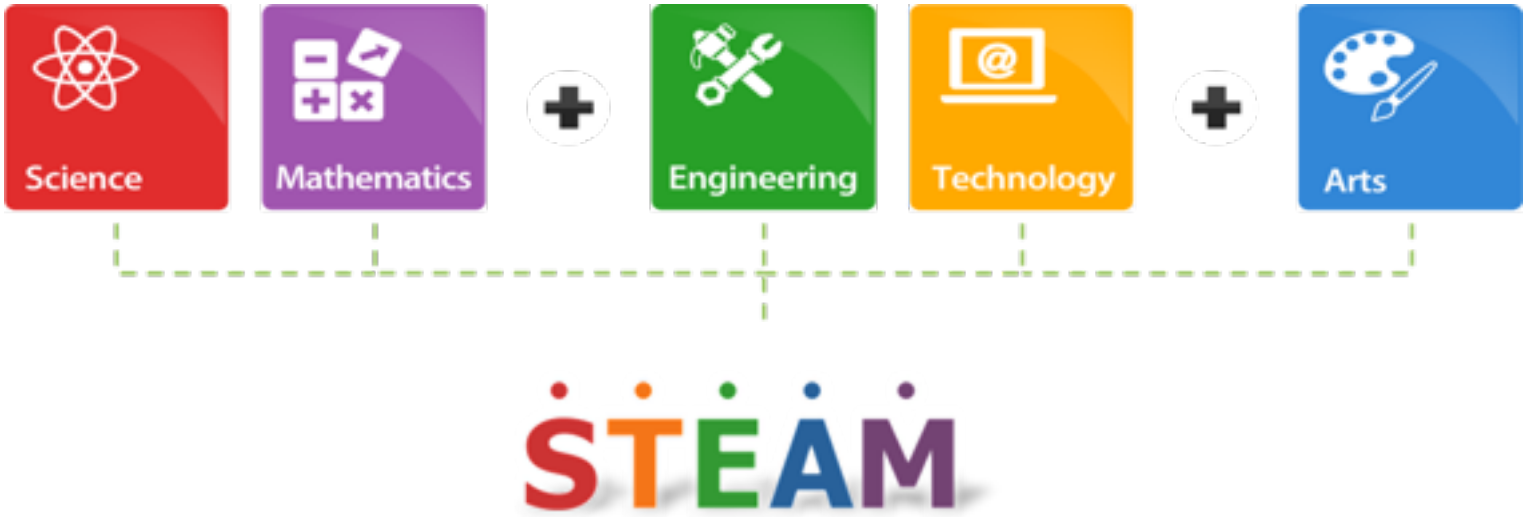
SuPoJa: students who dislike or give-up mathematics even though they study hard.

"Nurturing Creative Manpower" through Convergence

- Creativity is very important in 21st education
- I believe that creativity does not come from few "impression and meaning" in learning and "meaning and impression" do not come from "compartmentalization" between school subjects.
- STEAM is used as a methodology for "nurturing creative manpower" through Convergence!!

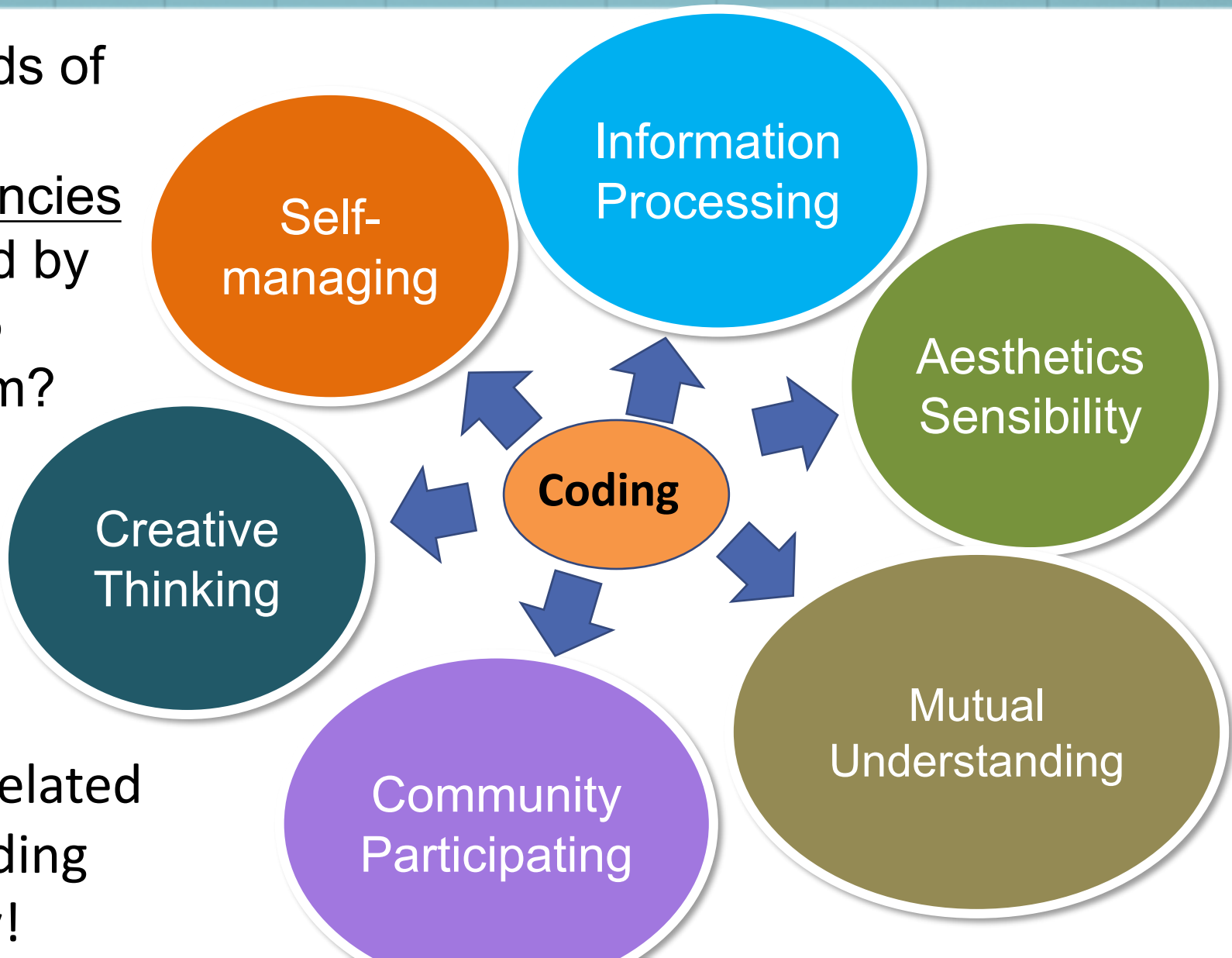
Computational Thinking in STEAM

Computational Thinking could also be a good methodology for STEAM education in the sense that all subjects of mathematics, technology, arts and science can be used for tasks of coding.



Core competencies aimed by Korean current national curriculum

What kinds of Core Competencies are aimed by the 2015 curriculum?



All are related with coding strongly!

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Computational Thinking Education in Korea

4 R in the Digital Era

- Reading, writing, Arithmetic and Programming are four basic skills for all students in the digital era.
- Does programming mean computer programming for even young kids to control a computer? Is it possible?

Can children control machine?

- It is yes according to constructionism by Papert.
- While constructionism is based on Piaget's Constructivism, he is emphasizing the actual construction of the subject:

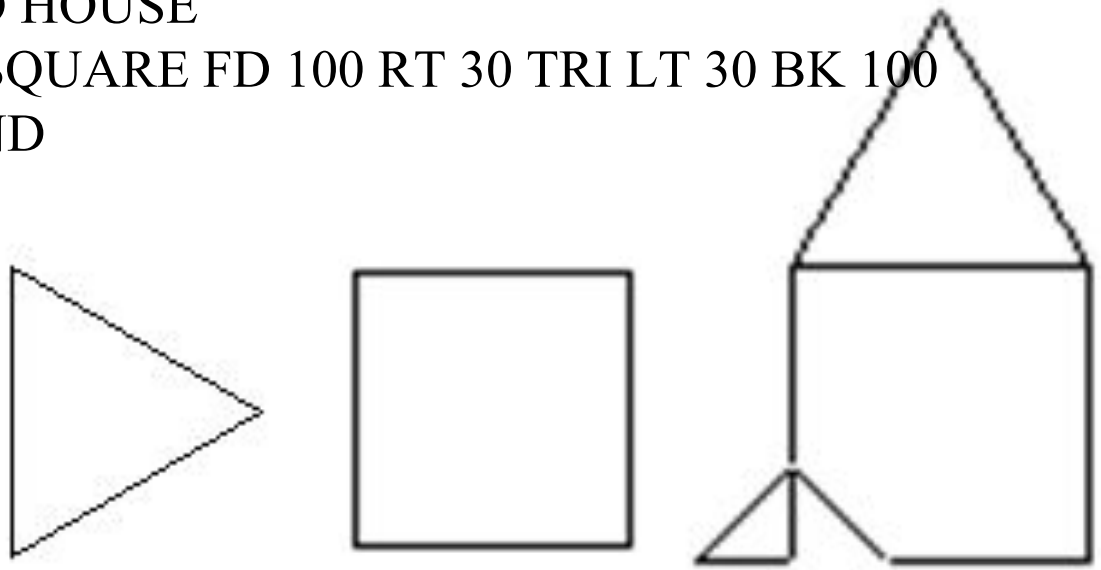
"Children learn best when they are actively engaged in constructing something that has personal meaning to them - be it a poem, a robot, a sandcastle or a computer program."

Seymour Papert (1928-2016)

SPC mode of LOGO

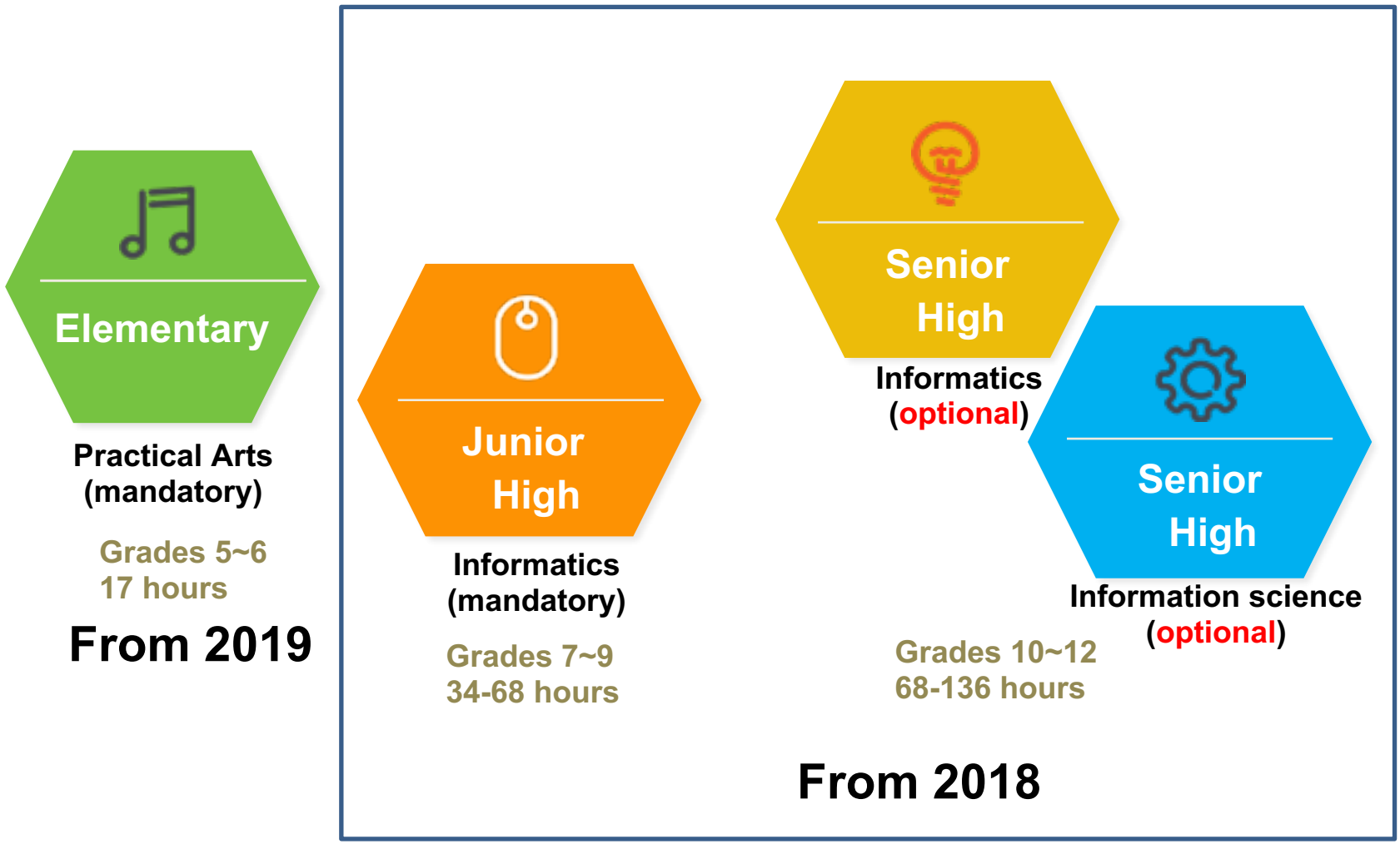
```
TO TRI
  REPEAT 3 [FD 100 RT 120]
END

TO SQUARE
  REPEAT 4 [FD 100 RT 90]
END

TO HOUSE
  SQUARE FD 100 RT 30 TRI LT 30 BK 100
END
```

Papert developed “LOGO” which is computer environment with SPC mode, not CPS



- Children can order computer to draw figures and teach words to computer by programming activities.

Computational Thinking under the current 2015 Curriculum



Elementary School

Activities focused on easy playing
using block-based programming language Entry

Junior High

Solving problems in daily life
using block-based programming language Entry

Senior High

Advanced contents related to career path
Using text-based programming languages Python or C++

Entry

- ENTRY is South Korea's programming language platform developed by the Entry Education Research Institute.
- It is a main block-based language used officially in Korea for elementary and junior high school students.
- It is similar to Scratch developed by Mitchel Resnick, MIT Media Lab, but much more easier.
- Visit play-entry.org to provide English version for learning, creating, and sharing.




Characteristics of Python

Python was developed in 1991 by Guido Van Rossum who is a Dutch computer programmer

- Strongly Extensible language
- Easy-to-use language
- Easy-to-understandable language
- Easy-to debug language
- Free and open source language
- Object-oriented language

Challenges

- We succeeded to introduce computational thinking education on the 2015 National curriculum
- It was very difficult to secure teaching hours on the national curriculum because it is a severe political game.
- However, it is a just beginning stage!!
- We have fatal problems for good computational thinking education
- No sufficient number of teachers
- Lack of the number of teaching hours
- No good STEAM materials for coding education

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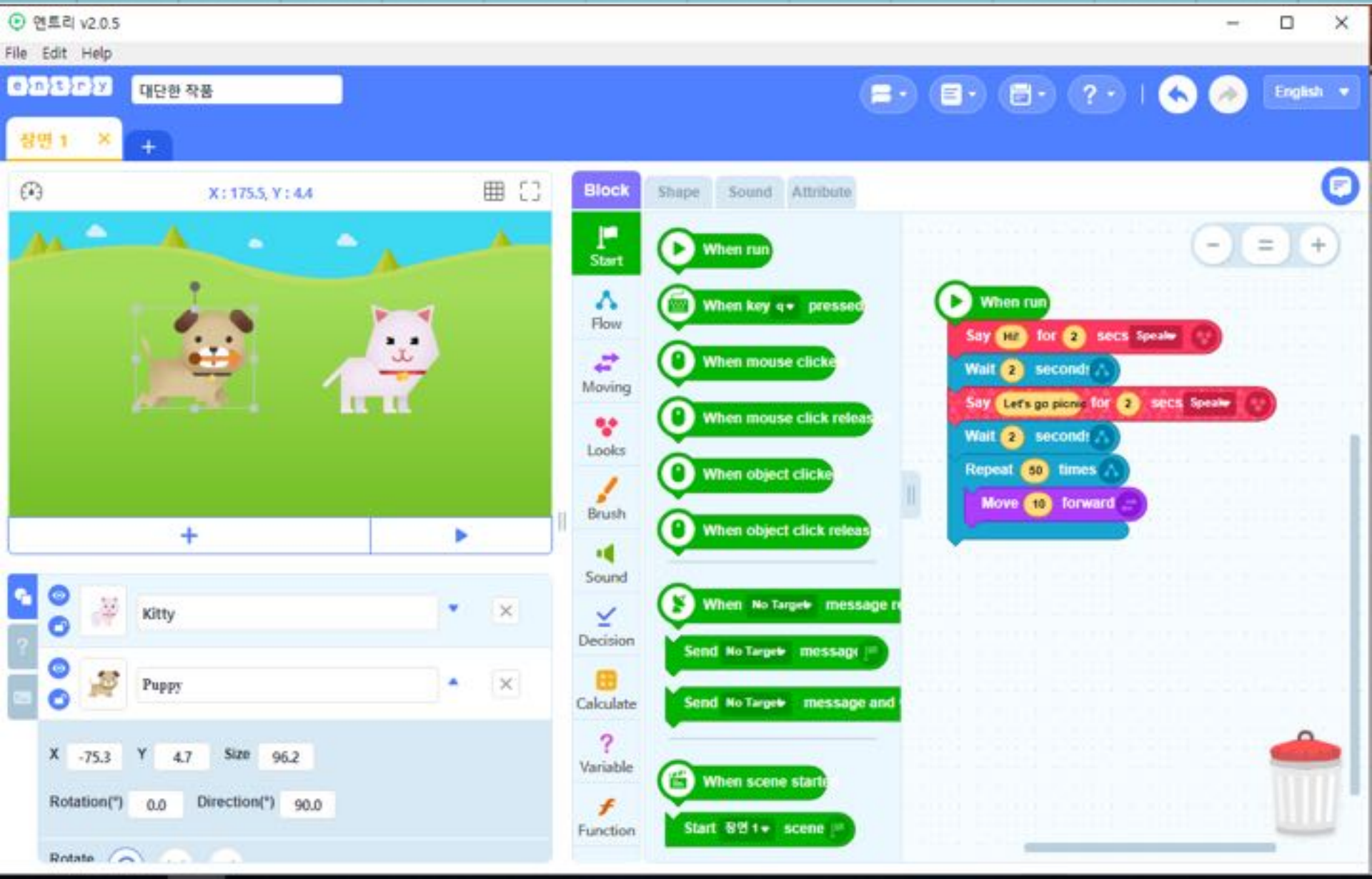
Some Examples of Computational Thinking Education

Example 1 with Entry



Example 2 with Entry

LED-bright-change

Example 3 with Entry

three-color-LED

Examples with Python(Spyder)

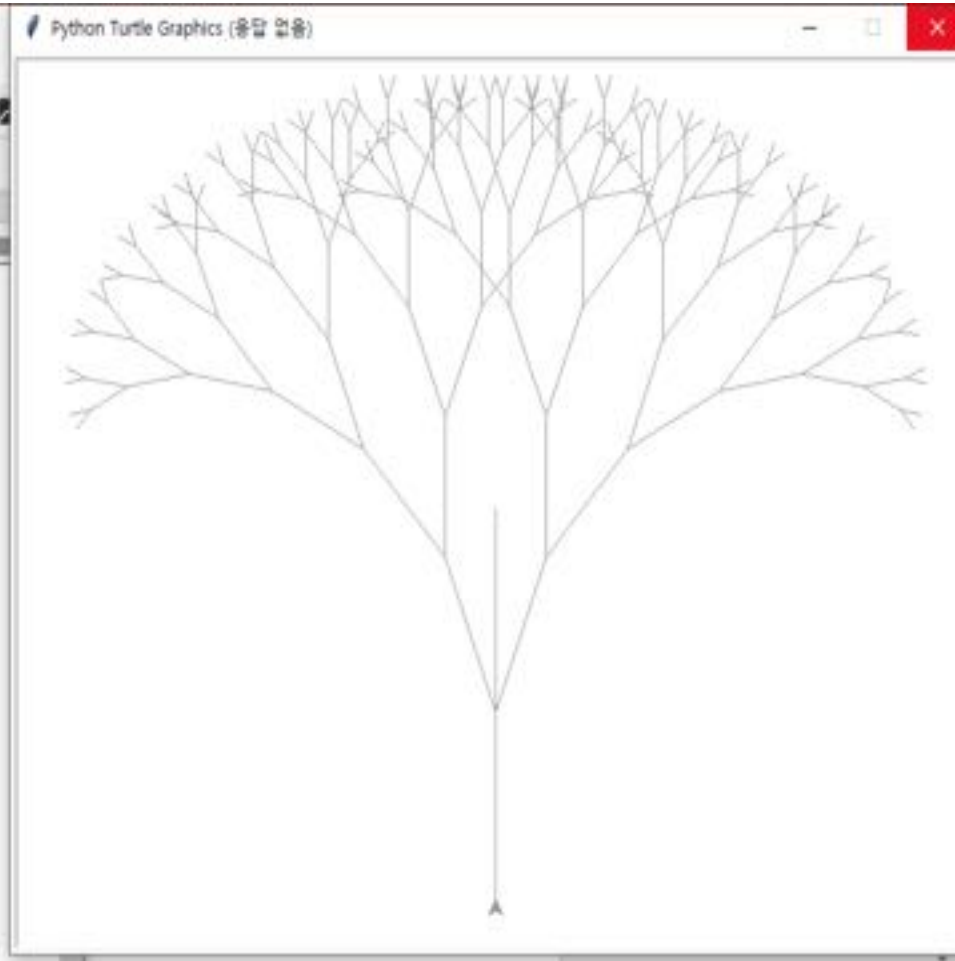
Spyder (Python 3.7)

File Edit Search Source Run Debug Consoles Projects Tools View Help

IPython console

Console 1/A

```
In [1]: from turtle import *

In [2]: def tree(length):
   ...:     if length>5:
   ...:         forward (length)
   ...:         right(20)
   ...:         tree(length-15)
   ...:         left(40)
   ...:         tree(length-15)
   ...:         right(20)
   ...:         backward(length)
   ...:

In [3]: left(90)

In [4]: backward(250)

In [5]: tree(120)

In [6]:
```



Example with Python(Spyder)

Spyder (Python 3.7)

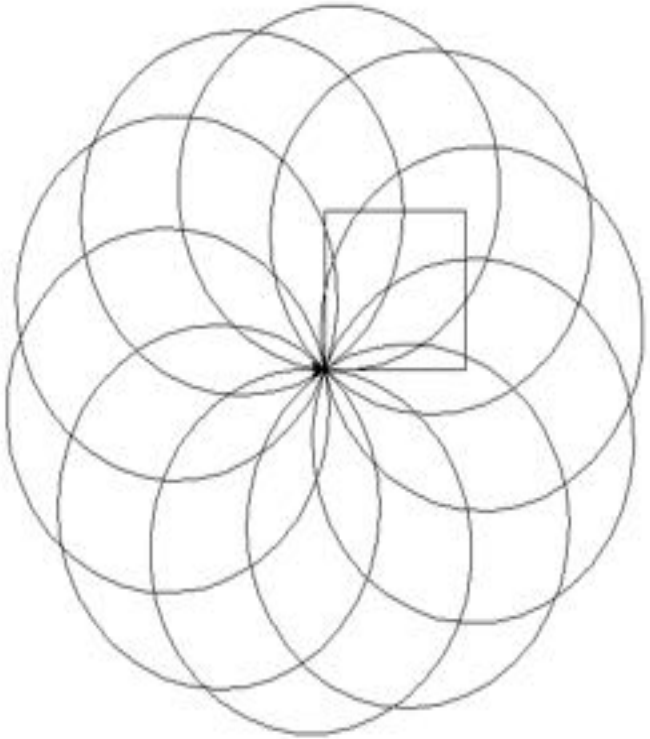
File Edit Search Source Run Debug Consoles Projects Tools View Help

Python console

Console 1/A

```
In [1]: from turtle import *

In [2]: forward (100)

In [3]: backward (100)

In [4]: for cnt in range (4):
   ...:     forward (100)
   ...:     left (90)
   ...:

In [5]: def circle():
   ...:     for cnt in range (36):
   ...:         forward (20)
   ...:         left (10)
   ...:

In [6]: for i in range(10)
  File "<ipython-input-6-90f3d452bb2a>", line 1
    for i in range(10)

SyntaxError: invalid syntax


In [7]:

In [7]: for i in range(10):
   ...:     circle()
   ...:     left(36)
   ...:

In [8]:
```

Turtle Graphics



drone.mp4

04

Conclusion

Why Coding?

Mark Zuckerberg

When I was in the sixth grade in elementary school, it was a very simple reason that I first started learning programming. I wanted to make something that I could enjoy with my sister

Bill Gates

Computer programming widens the scope of thought, makes you think better, and gives you the power to think about new solutions on all topics, regardless of the field.

Why Coding?

Barack Obama

Steve Jobs

Today, understanding of computer science has become a must. Our national competitiveness depends on how well we can teach our children this.

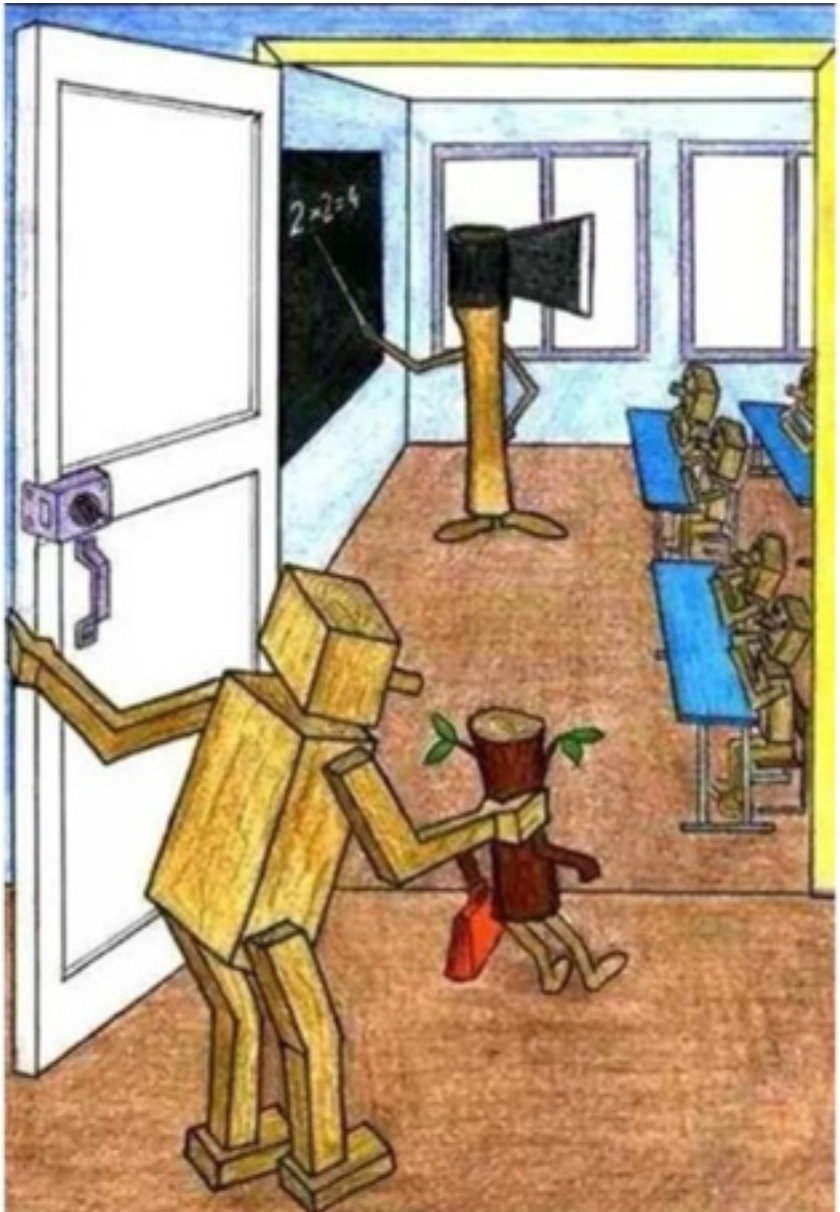
Everyone living in this country must learn computer programming. This is because it teaches you how to think.

Coding is important!!!

But, …

Tradition of Uniform education

- Currently, we found some tradition of uniform educational system is still alive in most of all classrooms.
- It was driven by government in order to propel rapid economic development planned by government since 1960.
- At that time, we needed a “good worker” with basic skills in math and science for mass production in the 2nd industrial revolution.



Key educational concept for the Industry 4.0?

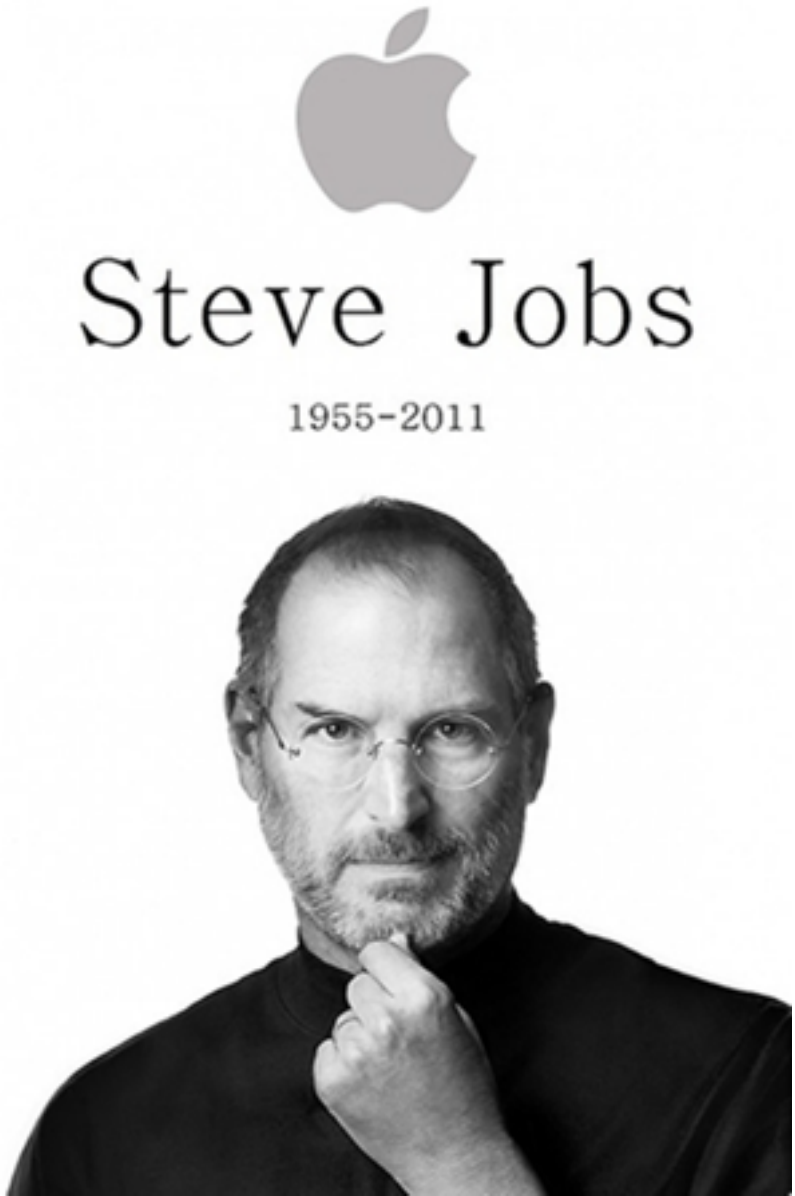
"Convergence Education"

- It is because the revolution is based on the network.
- Network can be established by convergence!!
- Students' converging aptitude must be trained into a habit during their school age!!

But, how to make them?

Educational Innovation

- In the new society, the model figure is Steve Jobs who had innovative mind on technology as well as artistic design sense.
- But, how to nurture such kind of innovative mind and artistic design sense in school?
- Educational Innovation!!
- Is it possible in the current school system?



Interdisciplinary Teacher Education

- We need the new approach for training teachers for computational thinking education in the 4th revolution era.
- In the compartmentalized situation we cannot train teachers with converging mind well.

Pre-service teachers in each department do not have remaining energy for studying other subjects besides their major subjects.

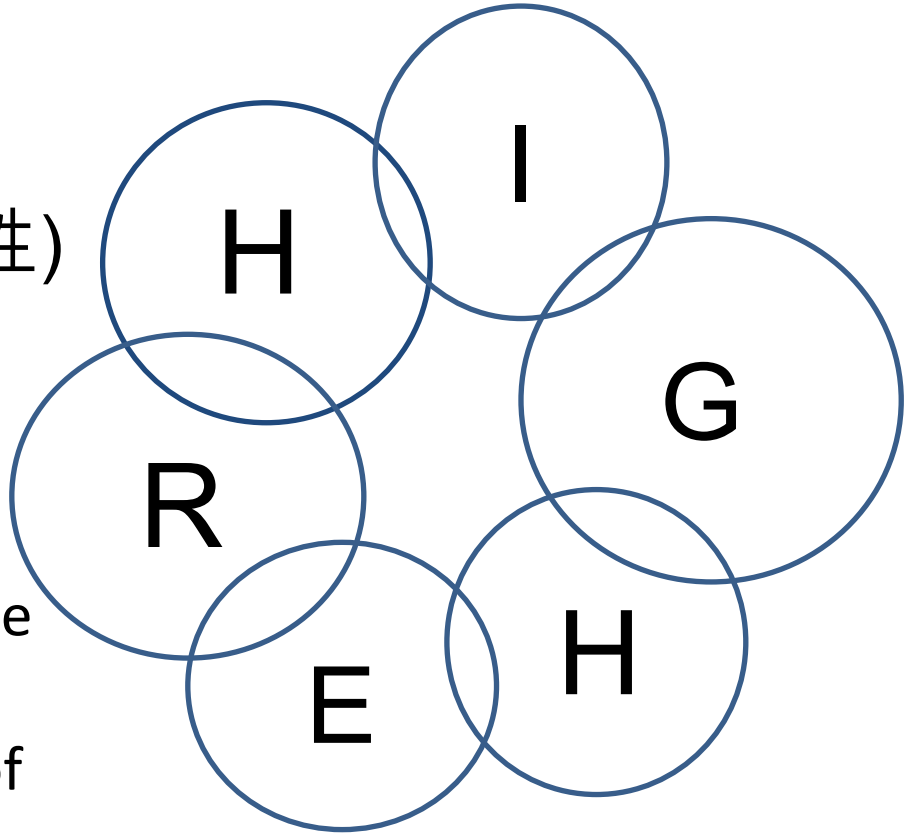
KNUE model for training interdisciplinary Teachers

Setting up Executive Organization: Institute of Interdisciplinary Teacher Education

Goal: To provide a new paradigm of the interdisciplinary teacher education for nurturing human resources with converging perspective required in the 4th revolution era.

VISION of KNUE

- **H**umanity(人性)
- **I**ntegrated Intelligence(統合知性)
- **G**lobalization(國際化)
- **H**armony(調和)
- **E**xperience(實踐力)
- **R**enovation Mind(革新性)



HIGHER^{+} !!

It takes a time to train a good teacher. I do not know how to cope with the fast industrial revolution from the coding education point of view

International Cooperation

- There are always two sides in the age of revolution. As Charles Dickens, the best and the worst, wisdom and foolishness, faith and doubt, light and dark coexist when revolution rises.
- It is the only way for scholars and teachers in various fields to open their minds and have serious and keen discussions not to move in the wrong direction.
- I sincerely hope that this special workshop will make a chance for such public debate in education, particularly in mathematics education.


Thank you for
your Attention !