

Computational Thinking Education in Korea

Hee-chan Lew

Korea National University of Education ☺

hclew@knue.ac.kr

VISION
STRATEGY
MOTIVATION



I ♥ BOYS



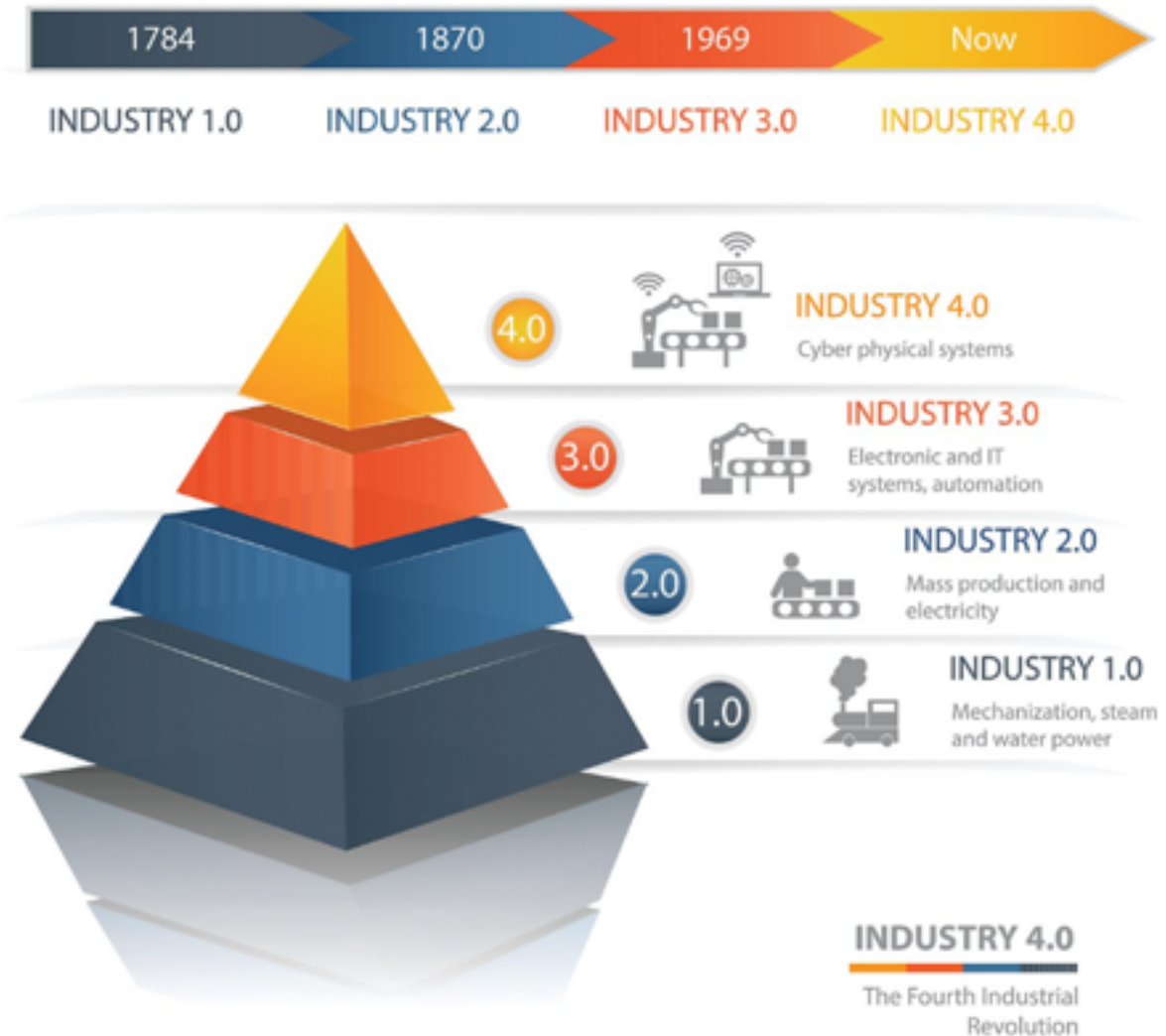
01



Why Computational Thinking?

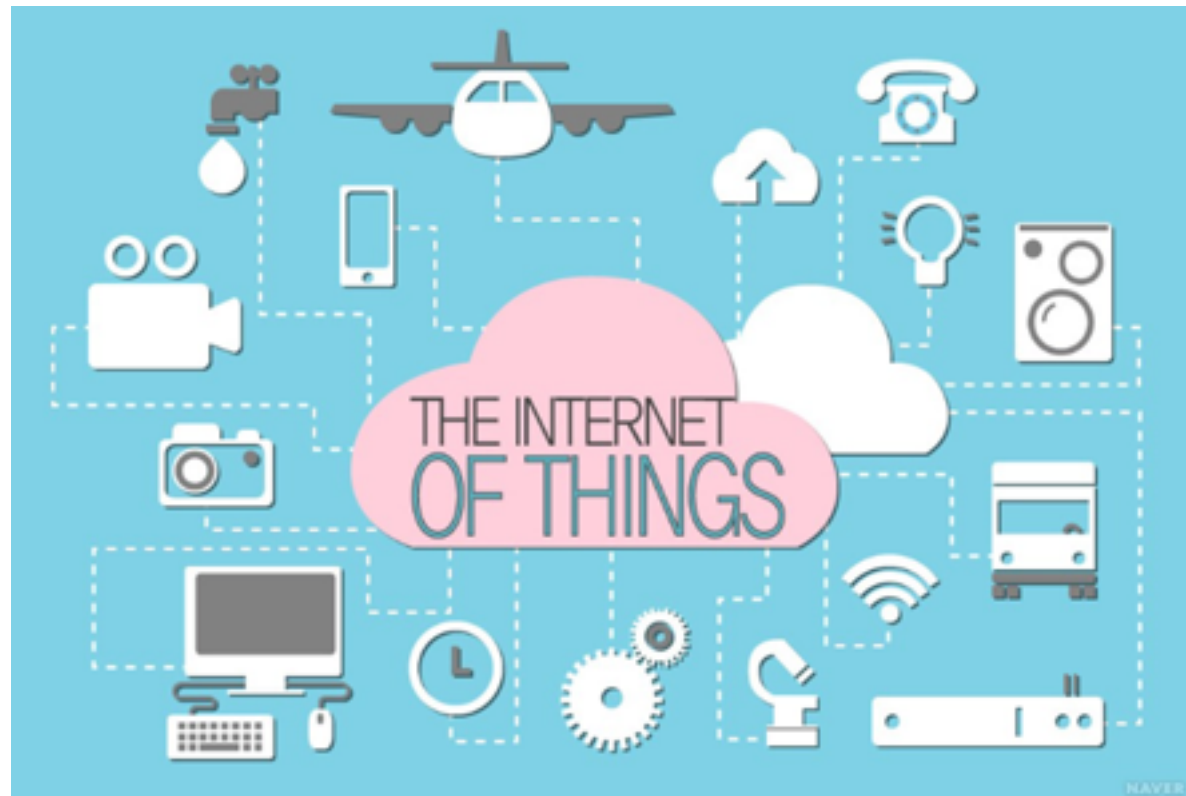
4th Industrial Revolution (Industry 4.0)

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

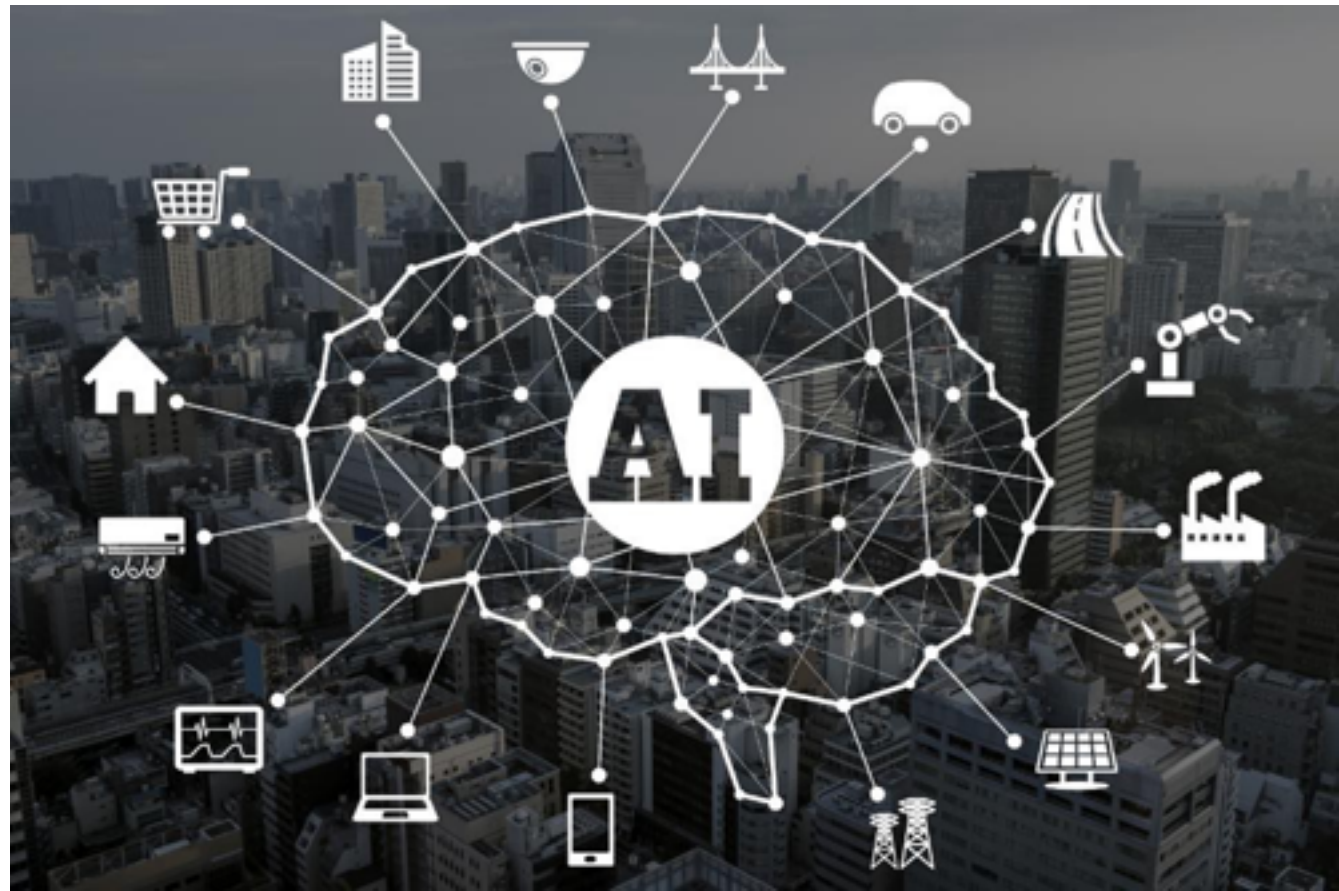
IOT(Internet of Things) refers to the connected internet system of tangible or intangible objects for providing new services that individual objects could not provide.



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.

1.0

- ◆ **1780 - Mechanisation**
Industrial production based on machines powered by water and steam

2.0

- ◆ **1870 - Electrification**
Mass-production using assembly lines

3.0

- ◆ **1970 - Automation**
Automation using electronics and computers

3.5

- ◆ **1980 - Globalisation**
Offshoring of production to low-cost economies

4.0

- ◆ **Today - Digitalisation**
Introduction of connected devices, data analytics and artificial intelligence technologies to automate processes further

5.0

- ◆ **Future - Personalisation**
The fifth industrial revolution, or Industry 5.0, will be focused on the co-operation between man and machine, as human intelligence works in harmony with cognitive computing. By putting humans back into industrial production with collaborative robots, workers will be upskilled to provide value-added tasks in production, leading to mass customisation and personalisation for customers

Faster fish rather than big fish!!

Smart thinking rather than lots of knowledge



In the new world,
it is not the big fish
which eats the
small fish, it's the
fast fish which
eats the **slow fish**

Klaus Schwab
Founder and Executive Chairman
World Economic Forum

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.

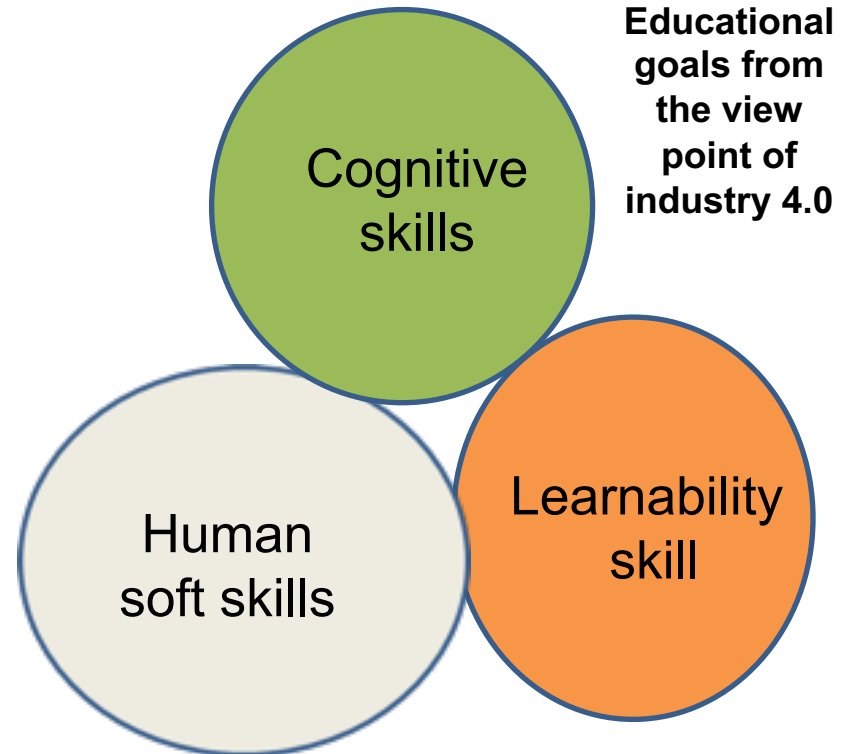
 edcast



Educational goal from the view point of Industry 4.0

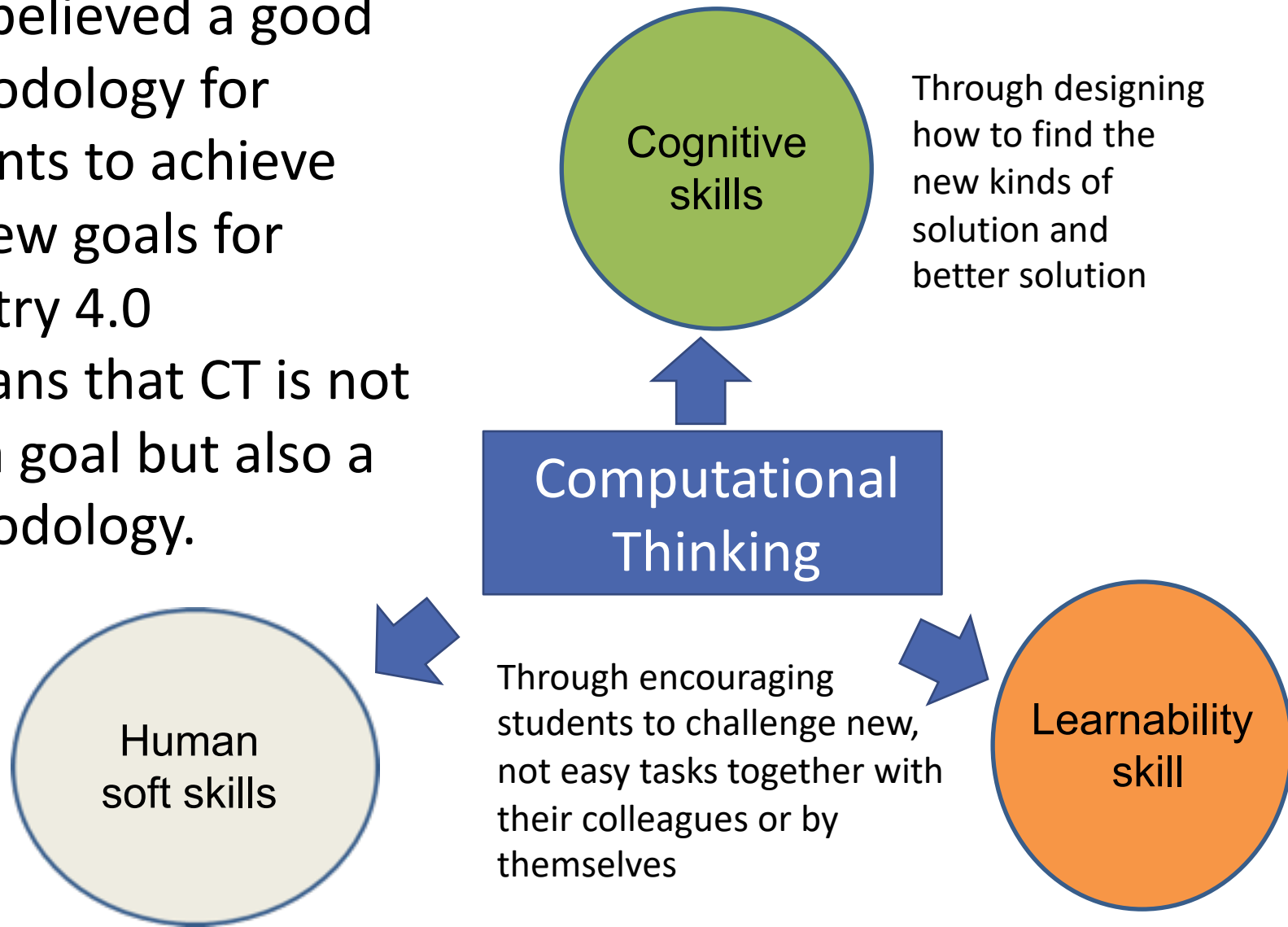
- For sustainable development of the 4th industrial revolution, the most important factor is to train students with new kinds of skills:

- 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.

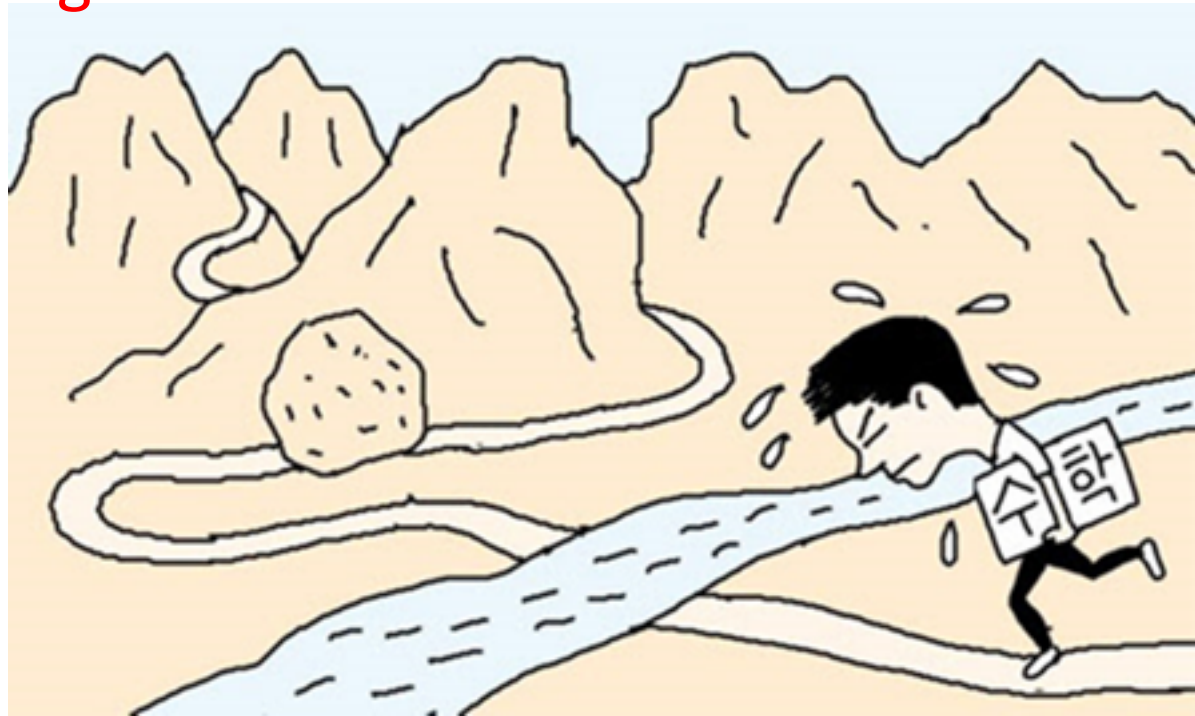
“The scandal of education is that every time you teach something, you deprive a student of the pleasure and benefit of discovery.”

Seymour Papert
born February 29, 1928
died July 31, 2016

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!!



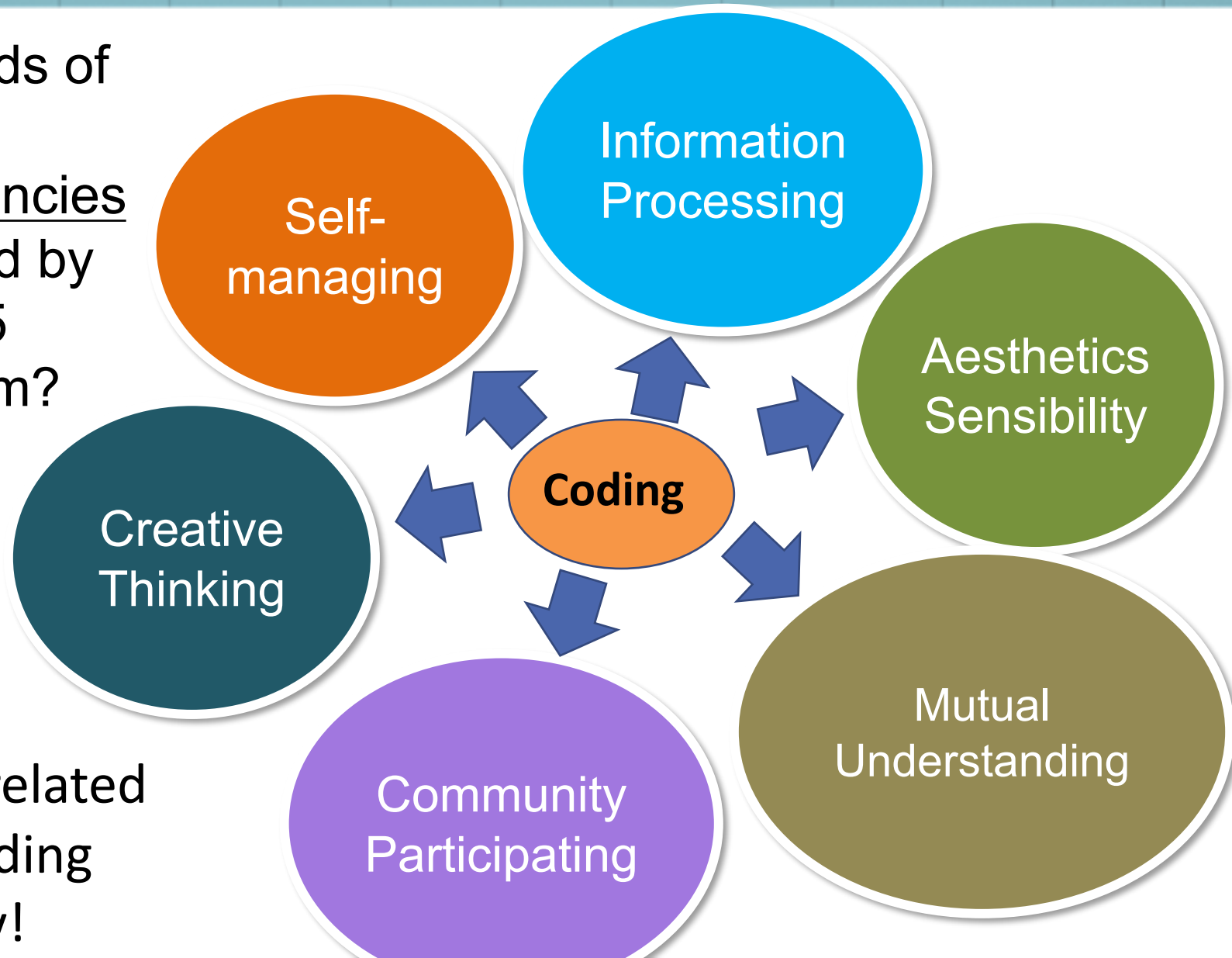
Computational Thinking in STEAM

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!

02



Computational Thinking Education in Korea

4 R in the Digital Era

- **R**eading, **w**riting, **A**rithmetic and **P**rogramming 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?



읽고
Reading



쓰고
wRiting



셈하고
aRithmetic



프로그래밍하고
pRogramming

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.”



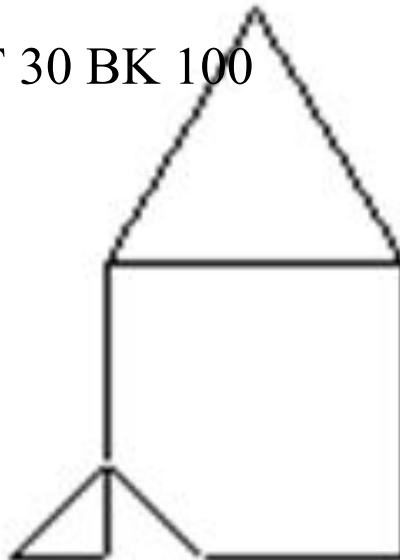
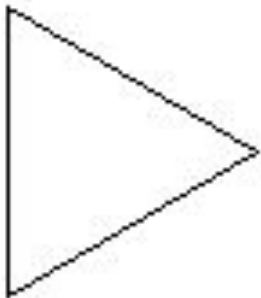
Seymour Papert (1928-2016)

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



**Practical Arts
(mandatory)**

Grades 5~6
17 hours

From 2019



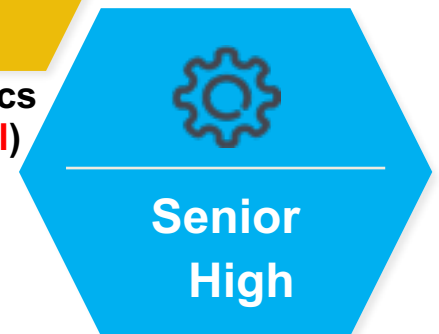
**Informatics
(mandatory)**

Grades 7~9
34-68 hours



**Informatics
(optional)**

Grades 10~12
68-136 hours




**Information science
(optional)**

From 2018



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

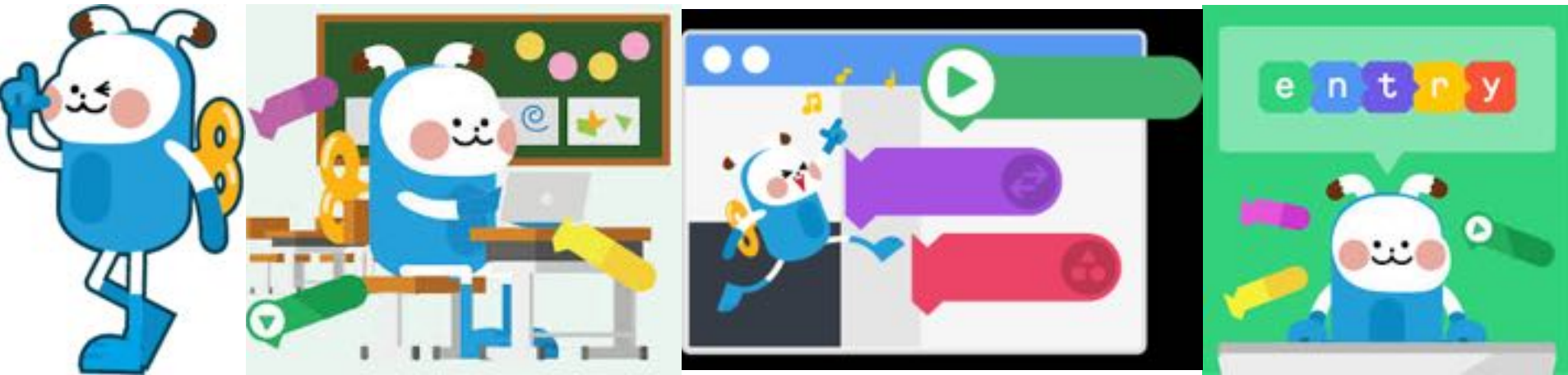


Senior
High

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

03



Some Examples of Computational Thinking Education

Example 1 with Entry

The screenshot displays the '엔트리 v2.0.5' (Entry v2.0.5) software interface. The top menu bar includes 'File', 'Edit', and 'Help'. The main workspace shows a scene titled '대단한 작품' (Great Work) with a stage labeled '장면 1'. The stage contains two objects: a brown puppy and a white cat. The puppy's position is indicated as X: 175.5, Y: 4.4. Below the stage, there are controls for the objects, including a list with 'Kitty' and 'Puppy', and a properties panel for the selected object showing X: -75.3, Y: 4.7, Size: 96.2, Rotation: 0.0, and Direction: 90.0.

The right side of the interface features a 'Block' palette with categories: Start, Flow, Moving, Looks, Brush, Sound, Decision, Calculate, Variable, and Function. The script area contains the following blocks:

- When run
- Say **Hi!** for **2** secs Speak
- Wait **2** seconds
- Say **Let's go picnic** for **2** secs Speak
- Wait **2** seconds
- Repeat **50** times
- Move **10** forward

A trash can icon is visible in the bottom right corner of the script area.

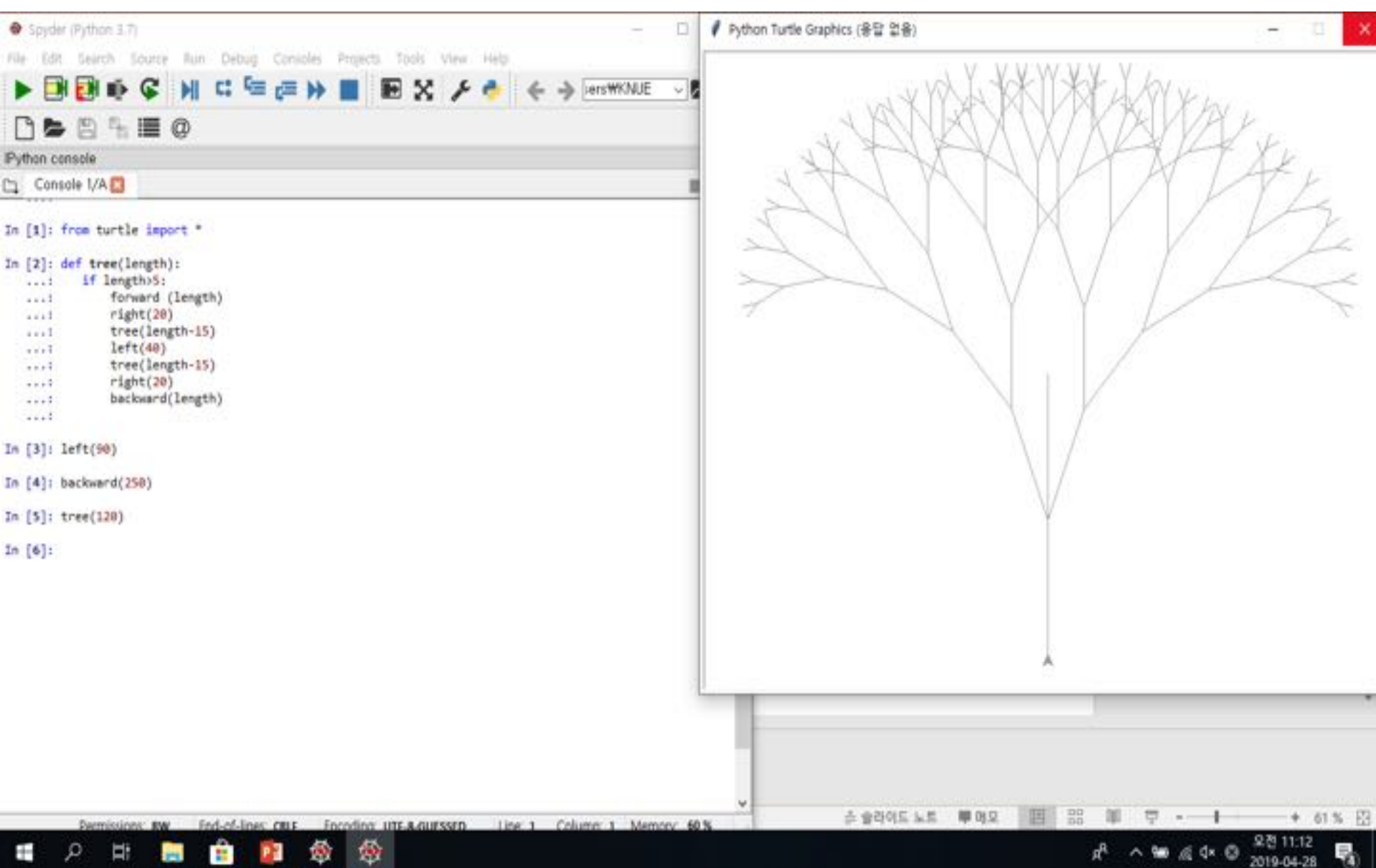
Example 2 with Entry

LED-bright-change_e

Example 3 with Entry

three-color-LED

Examples with Python(Spyder)



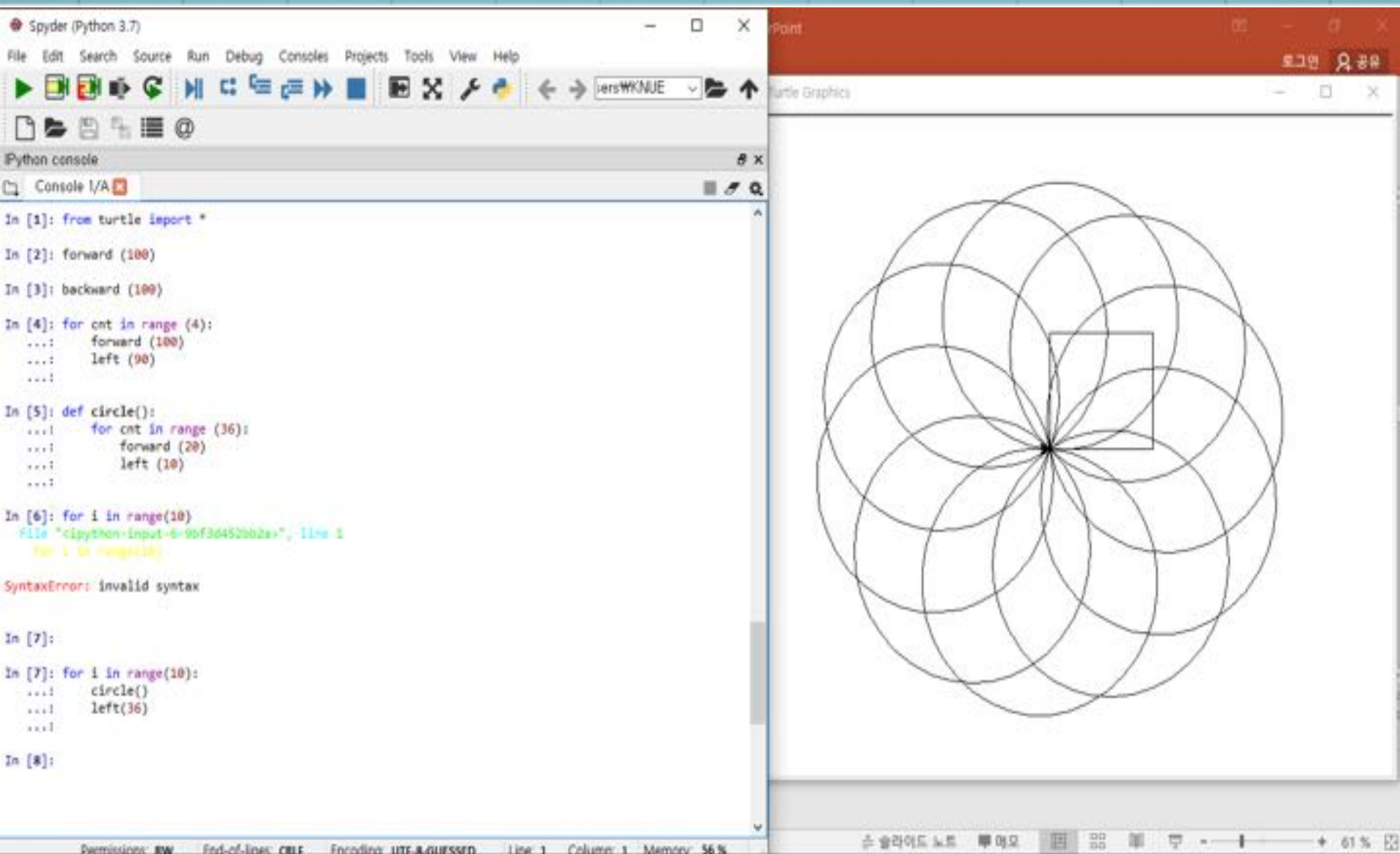
The image shows a screenshot of the Spyder Python IDE interface. The left pane displays the Python console with the following code and execution steps:

```
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]:
```

The right pane, titled "Python Turtle Graphics (응답 없음)", displays the resulting fractal tree drawing. The tree is a symmetric, branching structure with a central vertical trunk and numerous smaller branches extending outwards, resembling a fan or a stylized tree. The drawing is rendered in black lines on a white background.

At the bottom of the screen, the Windows taskbar is visible, showing the system tray with the date and time: "2019-04-28 오전 11:12".

Example with Python(Spyder)



The image shows a screenshot of the Spyder Python IDE interface. The left pane displays the Python console with the following code and output:

```
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 "c:\python-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]:
```

The right pane shows the Turtle Graphics window, which displays a complex fractal drawing consisting of overlapping circles and a central square. The drawing is rendered in black lines on a white background. The status bar at the bottom of the IDE shows "Permissions: RW", "End-of-lines: CRLF", "Encoding: UTF-8 GUESSED", "Line 1", "Column 1", and "Memory: 56%". The system tray at the bottom right shows the date and time: "오전 10:37 2019-04-28".

[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

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



Steve Jobs

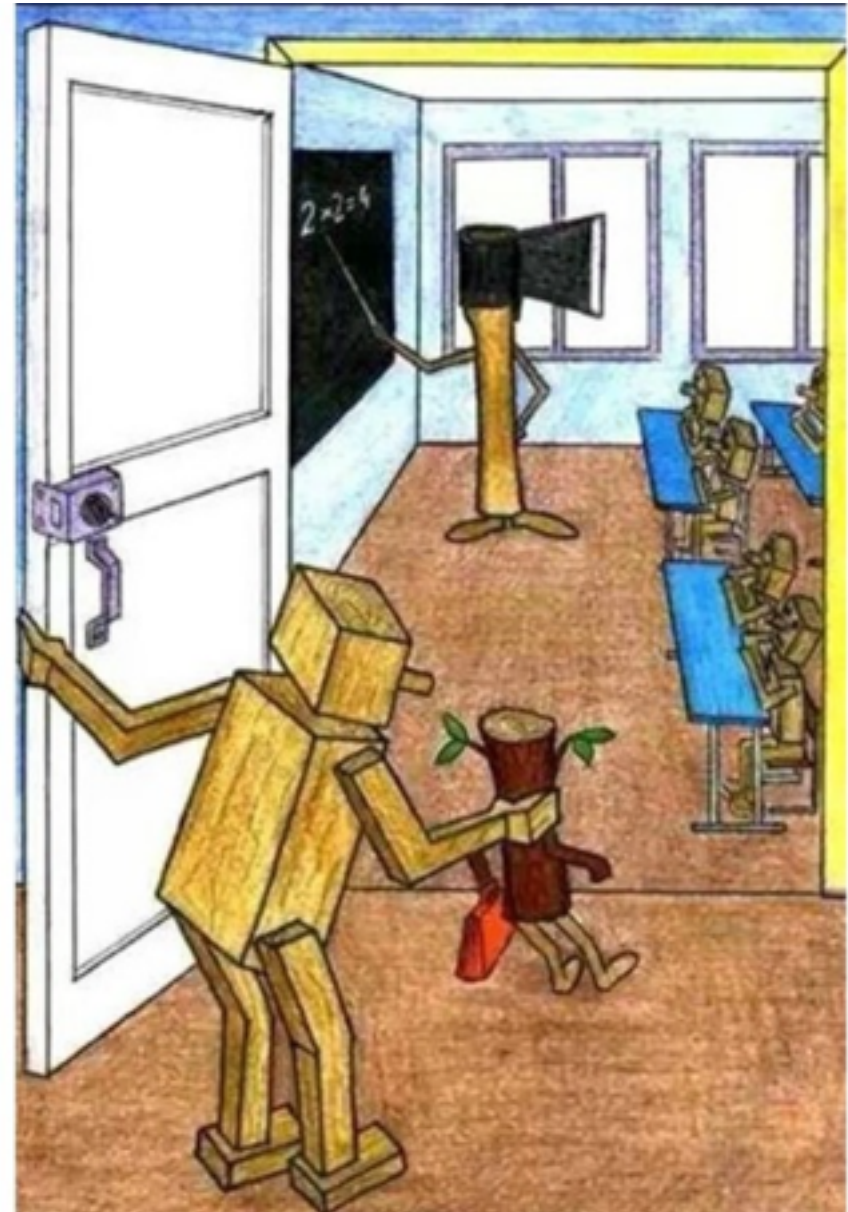
Everyone living in this country must learn computer programming. This is because it teaches you how to think.

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?



Steve Jobs

1955-2011



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.

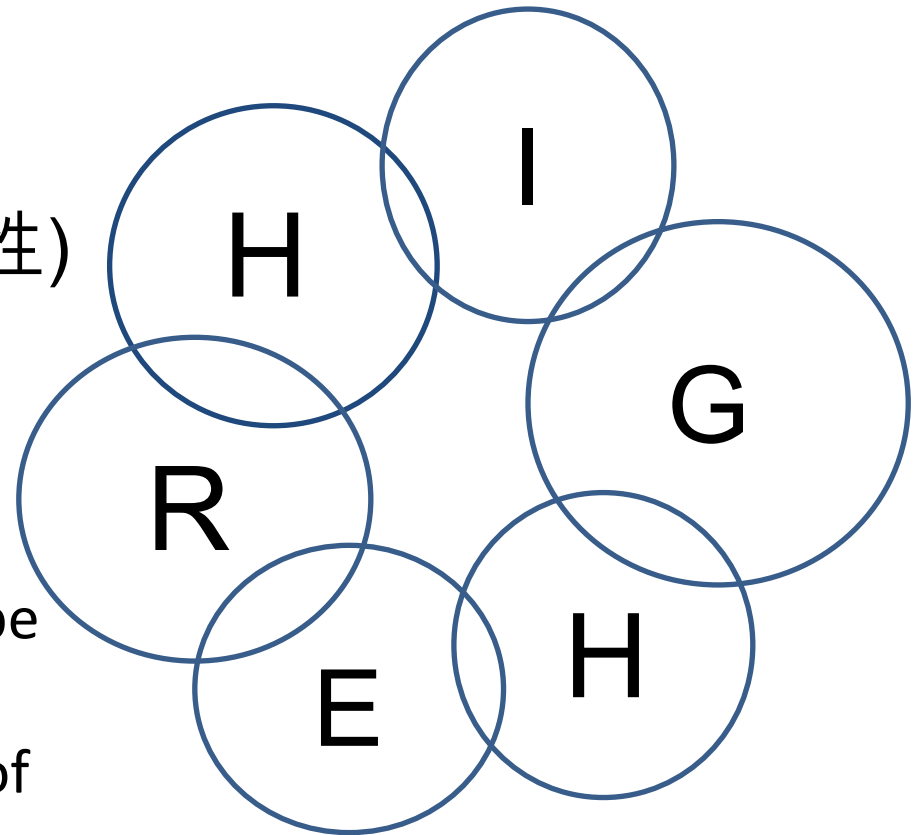


VISION of KNUE

- **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 !**