
arm
Introducing
Physical Computing and
Project Based Learning
Theory and practice
Arm School Program

The ASP approach to PBL/PC

Hardware

Basic electronics

IPO

Making

Project-based learning (PBL)

Covering the curriculum

Engaging Learners with contexts

Solving real problems

Programming using MakeCode

Applying computational techniques confidently

Design

Creativity

6Cs

Collaboration

ASP resources

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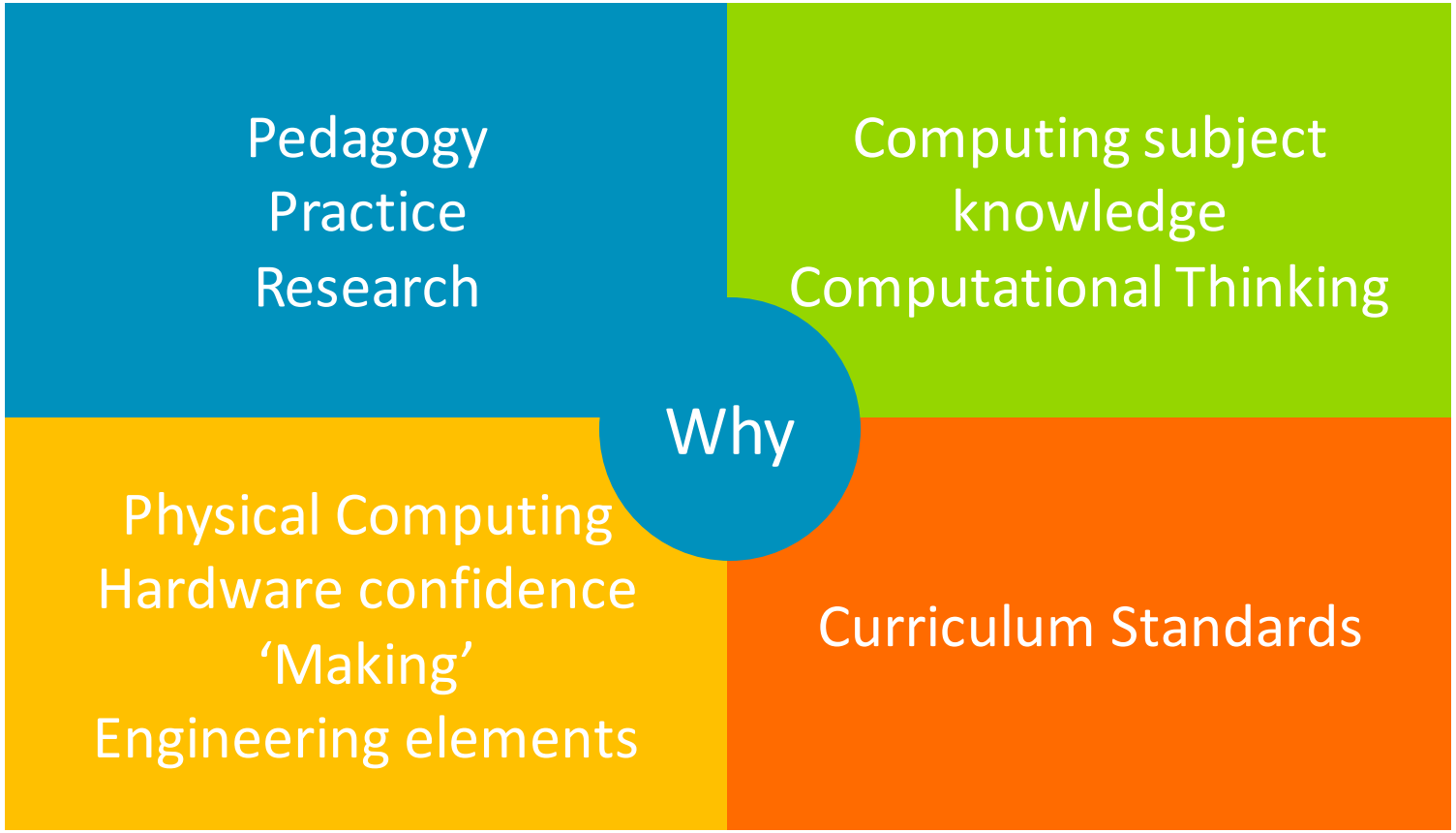
Pedagogical Content Knowledge (PCK)

How



What

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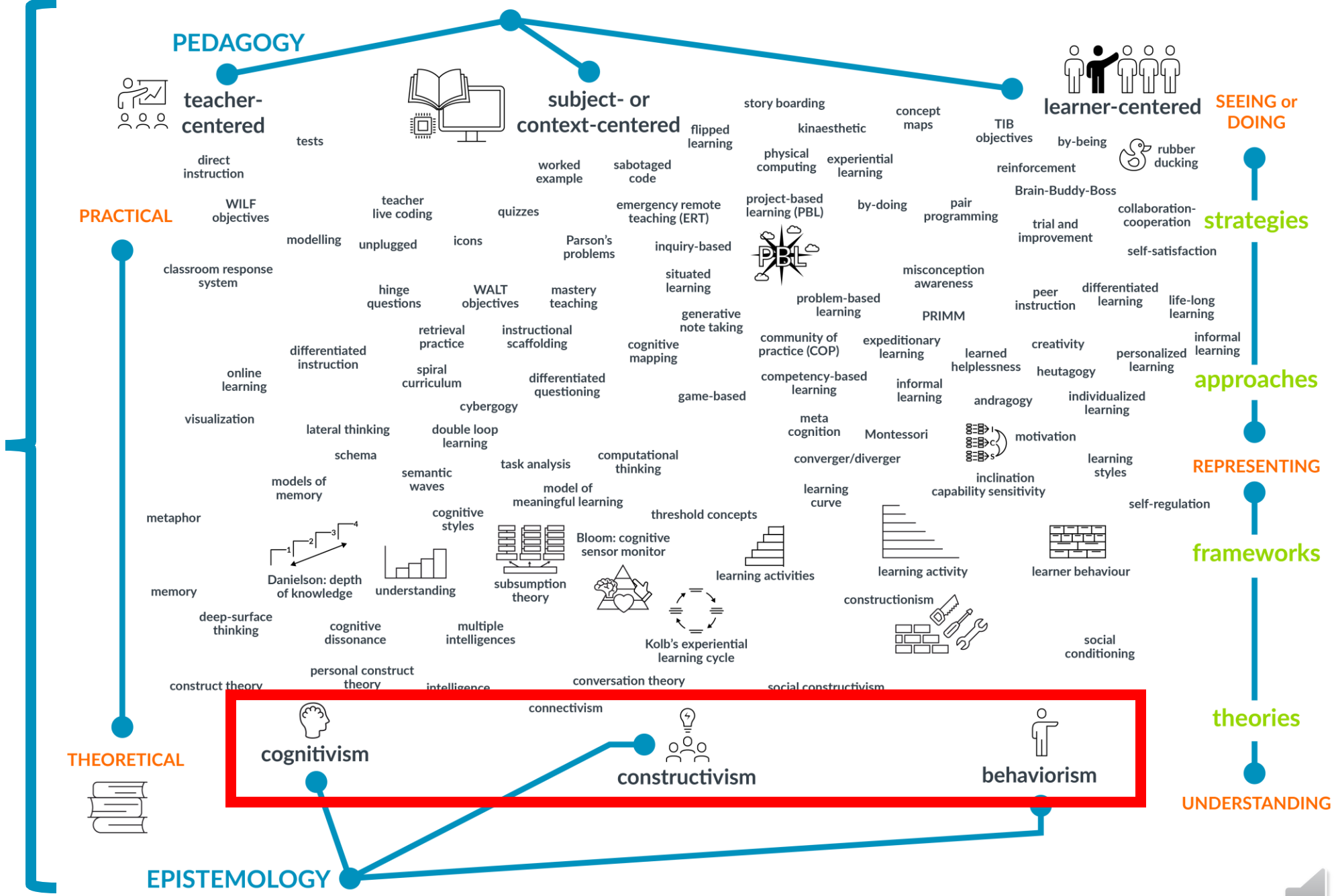
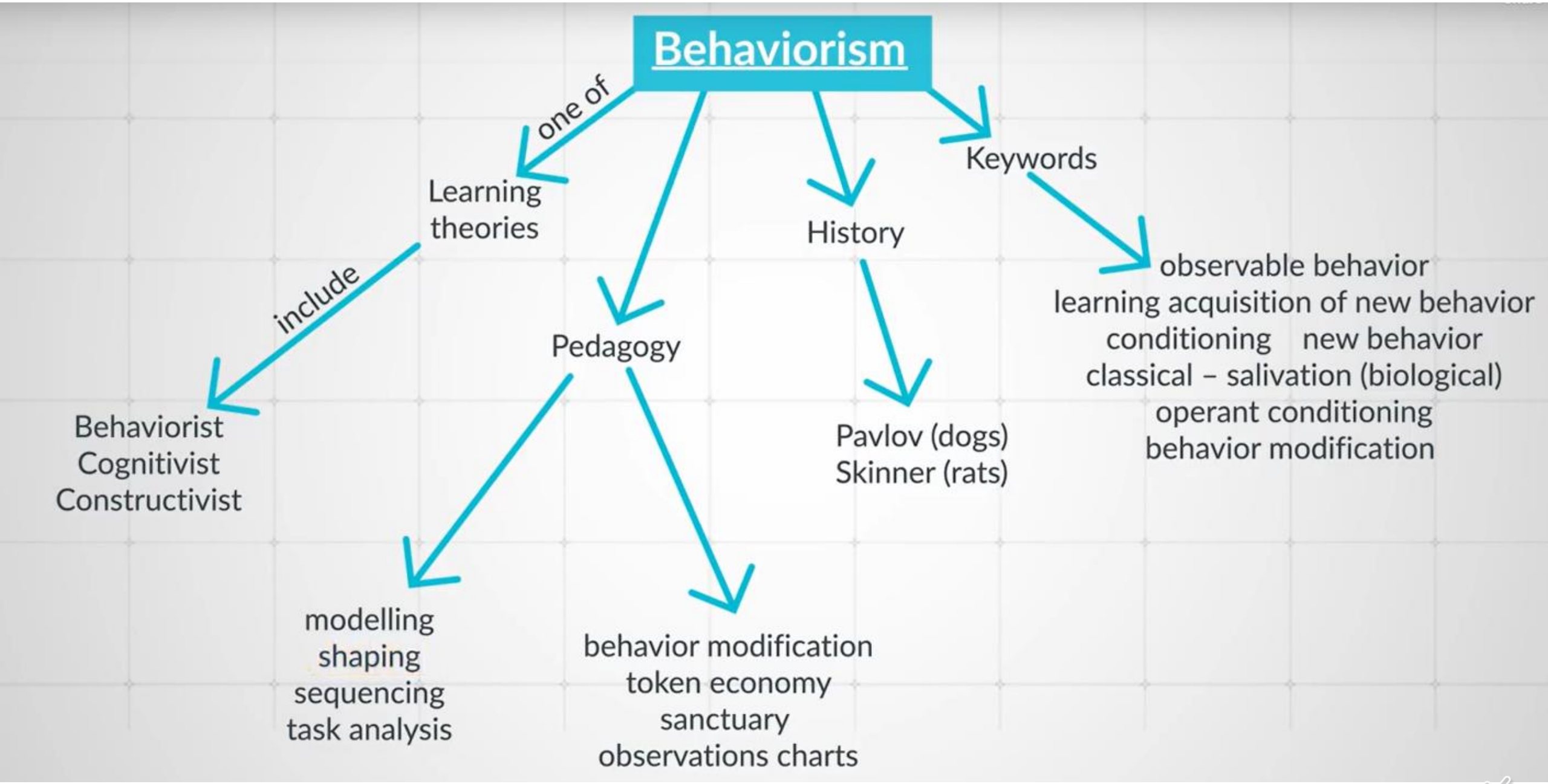
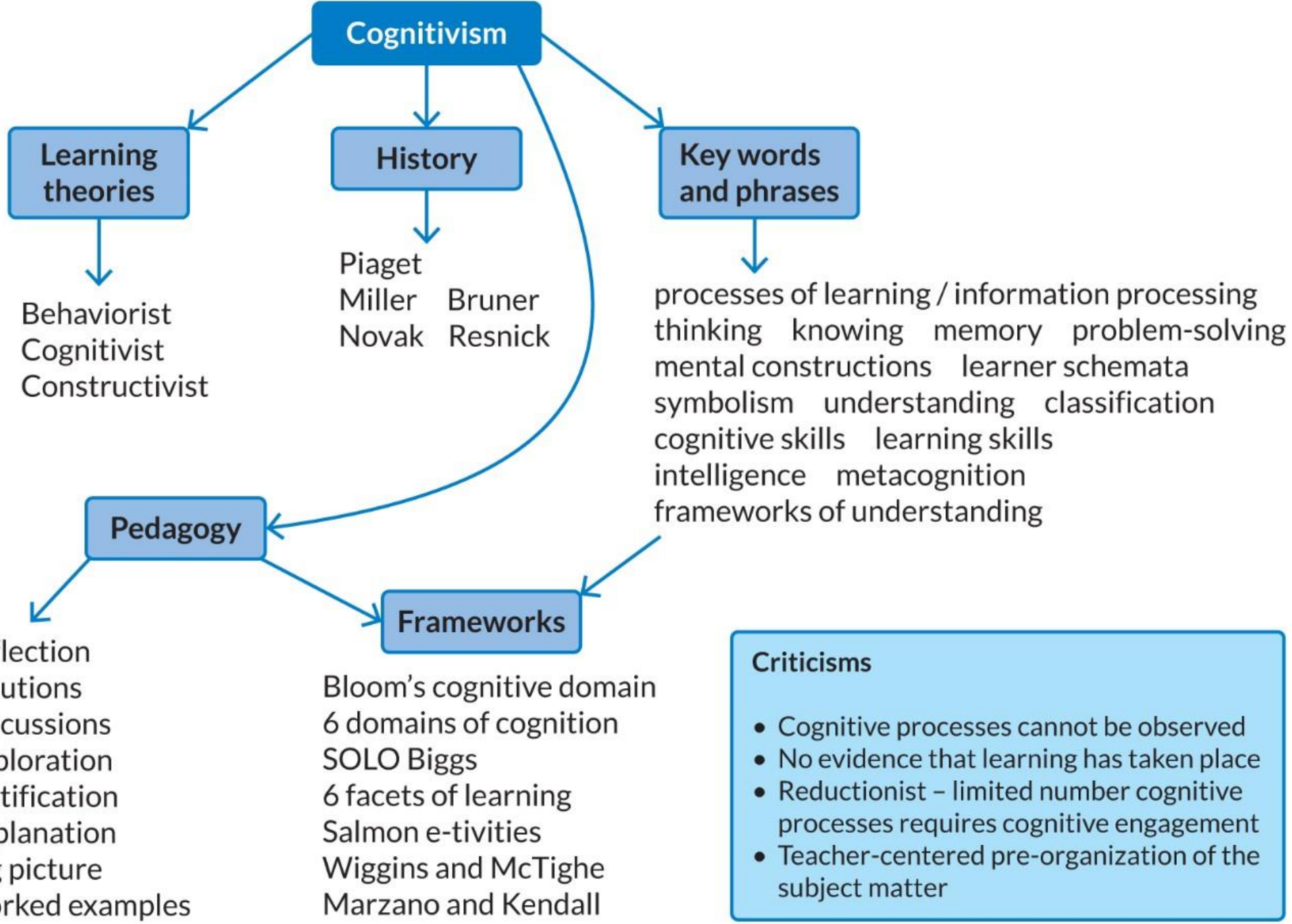
arm

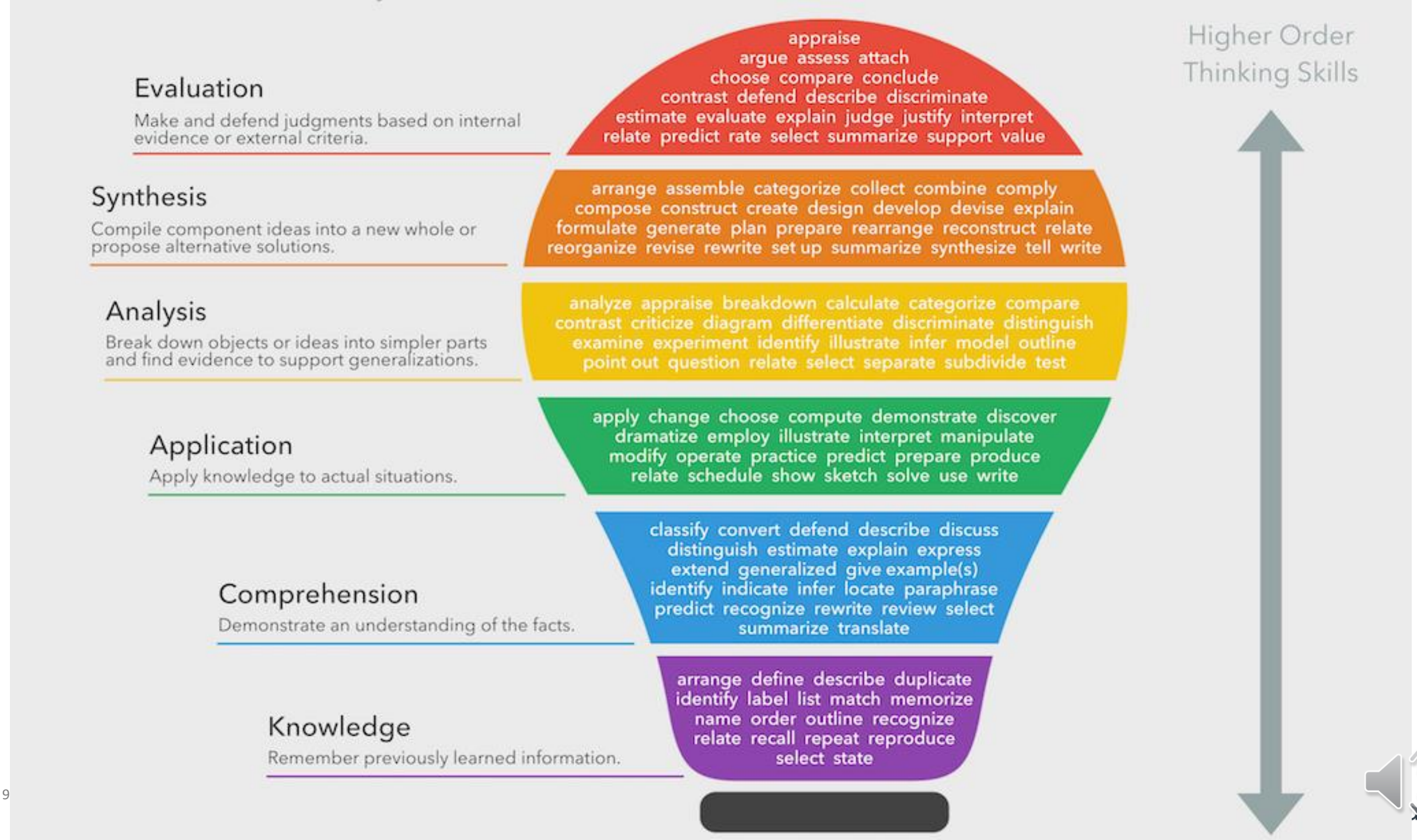
Theory and pedagogy

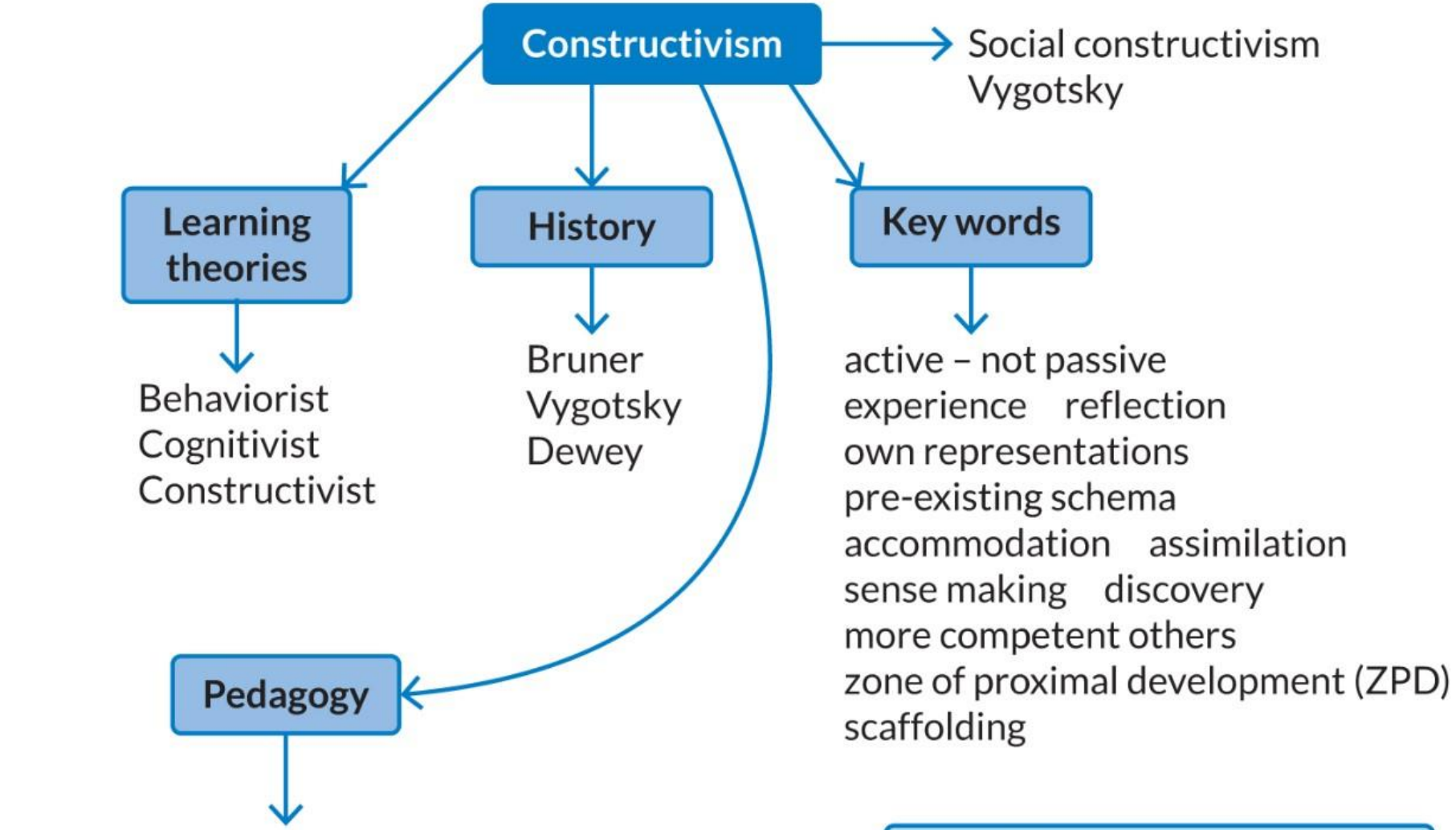

PEDAGOGY
teacher-centered
subject- or context-centered
learner-centered
SEEING or DOING
PRACTICAL
strategies
approaches
REPRESENTING
frameworks
theories
UNDERSTANDING
THEORETICAL
EPISTEMOLOGY
cognitivism
constructivism
behaviorism
tests
direct instruction
worked example
sabotaged code
flipped learning
story boarding
kinaesthetic
concept maps
TIB objectives
by-being
rubber ducking
physical computing
experiential learning
reinforcement
Brain-Buddy-Boss
WILF objectives
teacher live coding
quizzes
emergency remote teaching (ERT)
project-based learning (PBL)
by-doing
pair programming
trial and improvement
collaboration-cooperation
modelling
unplugged
icons
Parson's problems
inquiry-based
self-satisfaction
classroom response system
situated learning
misconception awareness
hinge questions
WALT objectives
mastery teaching
problem-based learning
peer instruction
differentiated learning
life-long learning
generative note taking
PRIMM
retrieval practice
instructional scaffolding
community of practice (COP)
expeditionary learning
creativity
informal learning
differentiated instruction
cognitive mapping
learned helplessness
personalized learning
online learning
spiral curriculum
differentiated questioning
competency-based learning
heutagogy
informal learning
game-based
andragogy
individualized learning
cybergogy
visualization
meta cognition
Montessori
motivation
lateral thinking
double loop learning
schema
computational thinking
converger/diverger
learning styles
task analysis
inclination
capability sensitivity
semantic waves
models of memory
model of meaningful learning
learning curve
self-regulation
metaphor
cognitive styles
threshold concepts
Bloom: cognitive sensor monitor
learning activities
learning activity
learner behaviour
Danielson: depth of knowledge
understanding
subsumption theory
memory
constructionism
deep-surface thinking
cognitive dissonance
multiple intelligences
Kolb's experiential learning cycle
social conditioning
construct theory
personal construct theory
intelligence
conversation theory
social constructivism
connectivism

How What Changes


Behaviorism
one of
Learning theories
include
Behaviorist
Cognitivist
Constructivist
Pedagogy
modelling
shaping
sequencing
task analysis
behavior modification
token economy
sanctuary
observations charts
History
Pavlov (dogs)
Skinner (rats)
Keywords
observable behavior
learning acquisition of new behavior
conditioning new behavior
classical – salivation (biological)
operant conditioning
behavior modification


Cognitivism
Learning theories
History
Key words and phrases
Behaviorist
Cognitivist
Constructivist
Piaget
Miller Bruner
Novak Resnick
processes of learning / information processing
thinking knowing memory problem-solving
mental constructions learner schemata
symbolism understanding classification
cognitive skills learning skills
intelligence metacognition
frameworks of understanding
Pedagogy
Frameworks
reflection
solutions
discussions
exploration
justification
explanation
big picture
worked examples
Bloom's cognitive domain
6 domains of cognition
SOLO Biggs
6 facets of learning
Salmon e-tivities
Wiggins and McTighe
Marzano and Kendall
Criticisms
Cognitive processes cannot be observed
No evidence that learning has taken place
Reductionist – limited number cognitive processes requires cognitive engagement
Teacher-centered pre-organization of the subject matter

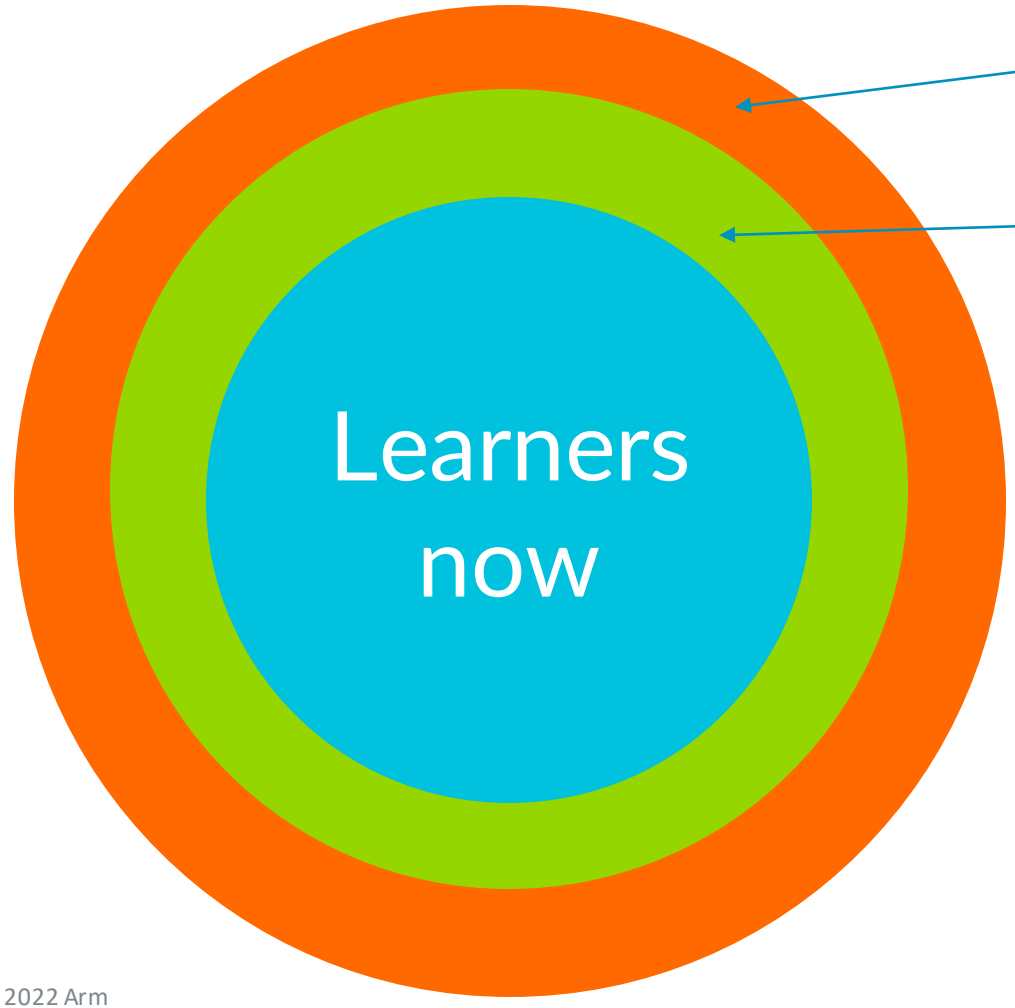

Evaluation
Make and defend judgments based on internal evidence or external criteria.
appraise
argue assess attach
choose compare conclude
contrast defend describe discriminate
estimate evaluate explain judge justify interpret
relate predict rate select summarize support value
Synthesis
Compile component ideas into a new whole or propose alternative solutions.
arrange assemble categorize collect combine comply
compose construct create design develop devise explain
formulate generate plan prepare rearrange reconstruct relate
reorganize revise rewrite set up summarize synthesize tell write
Analysis
Break down objects or ideas into simpler parts and find evidence to support generalizations.
analyze appraise breakdown calculate categorize compare
contrast criticize diagram differentiate discriminate distinguish
examine experiment identify illustrate infer model outline
point out question relate select separate subdivide test
Application
Apply knowledge to actual situations.
apply change choose compute demonstrate discover
dramatize employ illustrate interpret manipulate
modify operate practice predict prepare produce
relate schedule show sketch solve use write
Comprehension
Demonstrate an understanding of the facts.
classify convert defend describe discuss
distinguish estimate explain express
extend generalized give example(s)
identify indicate infer locate paraphrase
predict recognize rewrite review select
summarize translate
Knowledge
Remember previously learned information.
arrange define describe duplicate
identify label list match memorize
name order outline recognize
relate recall repeat reproduce
select state
Higher Order Thinking Skills



Criticisms

- Rejects the efficacy of didactic approaches
- Learners reinventing the wheel

Zones of proximal development (ZPD)

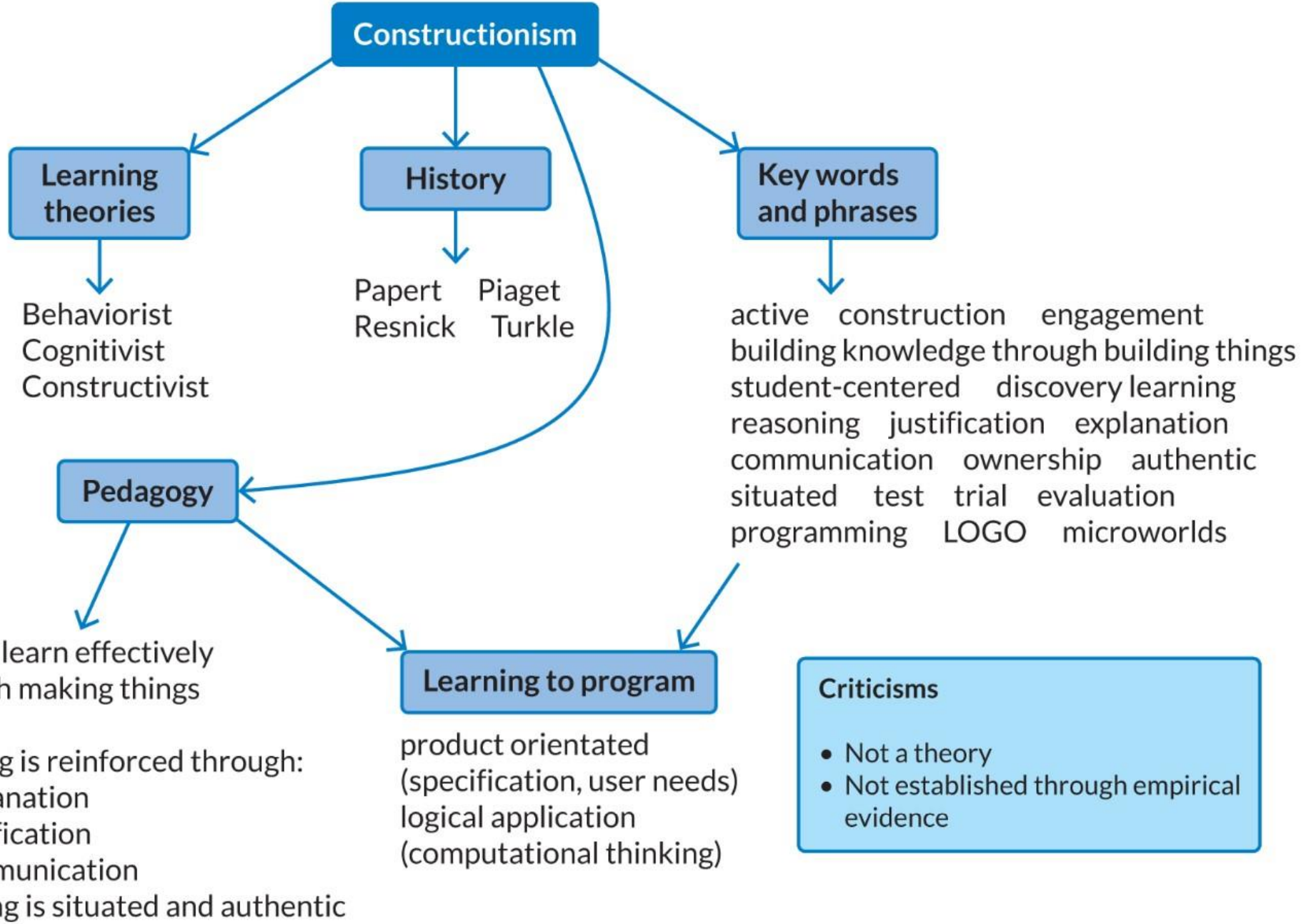


Your goal (what I can't do)

Zone of proximal development (what I can do with help)

ZPD:

What a learner can do without help and what they can't do



PBL is not just Constructionism!

Key concepts:

- A reaction to didactic teaching approaches
- Learning as contextualised action (practical in nature)
- “Learning by doing” (historically referred to as kinaesthetic)

Limitations:

- Assumption that only exploration yields learning
- Not all learners will discover the intended learning
- Assumes a deep desire for learning and unlimited engagement

Why making matters – thinking in systems

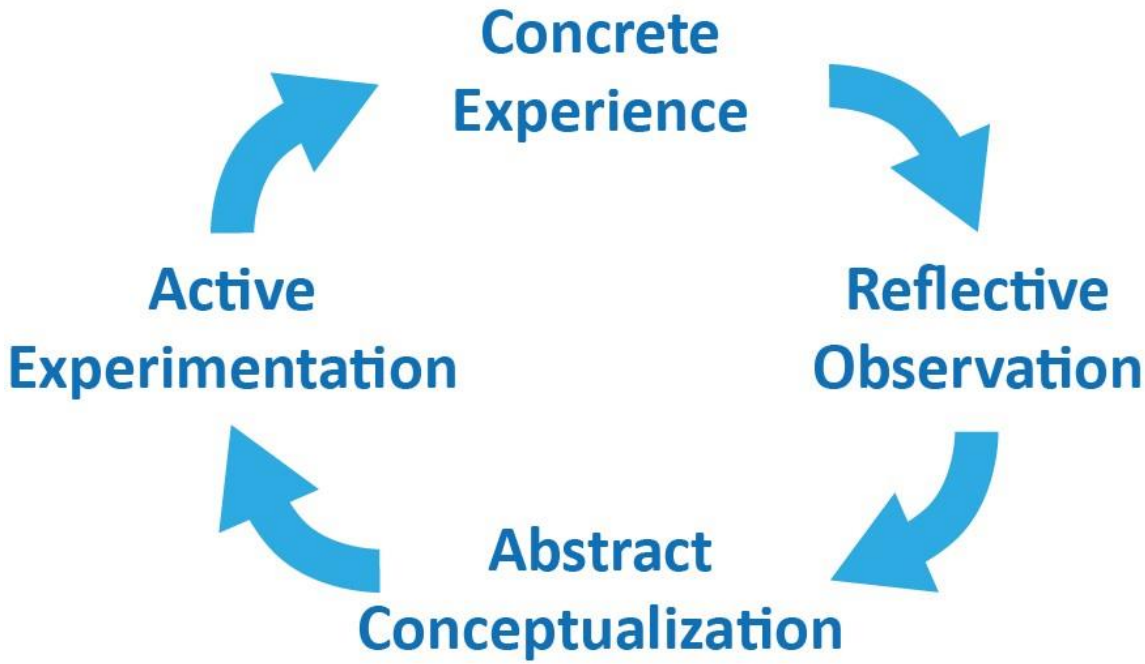
'Engineers use a unique mode of thinking based on seeing everything as a system. They see structures that aren't apparent to the layperson, they know how to design under constraints, and they understand trade-offs. Adopting an engineering mindset can help you in any field.'

Engineering mindset:

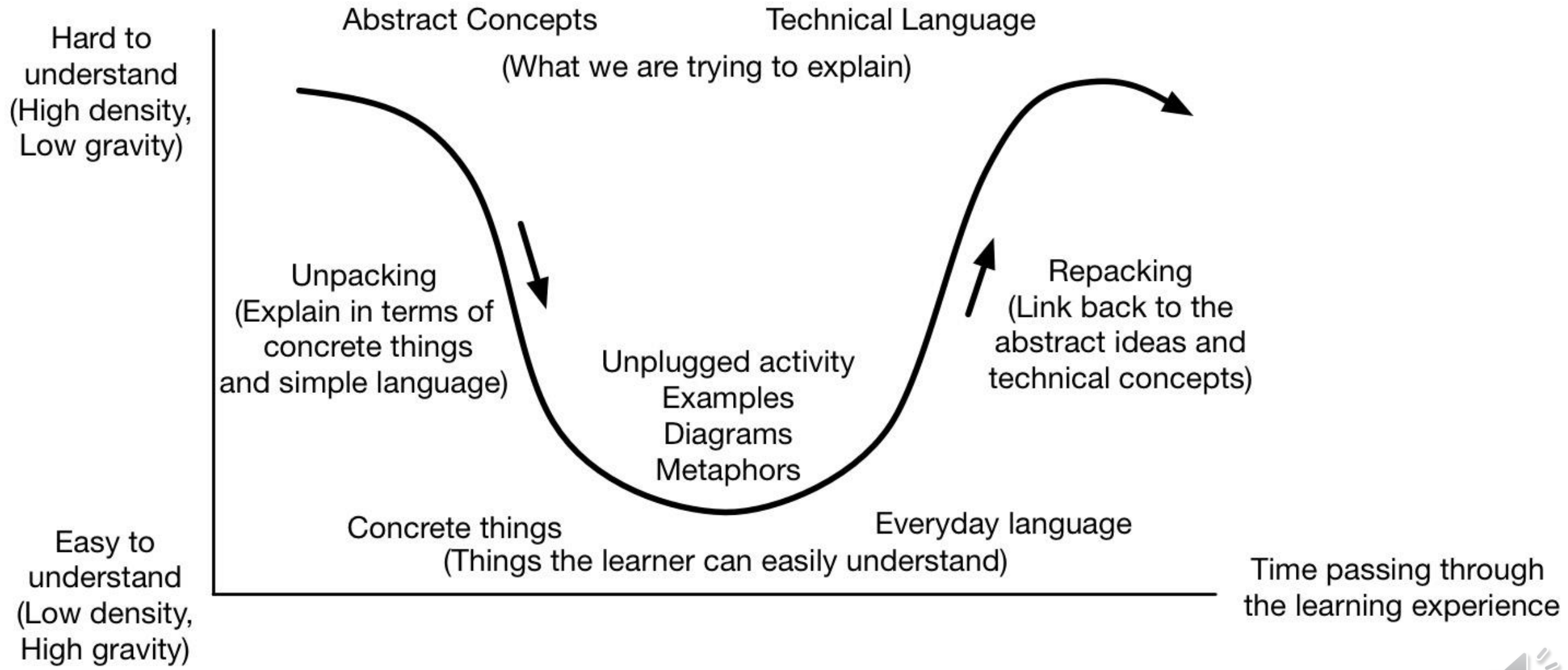
- The ability to see a structure where there's nothing apparent
- Designing under constraints
- Understanding trade-offs

Kolb's learning theory (1984)

- **Concrete Experience -** a new experience or situation is encountered, or a reinterpretation of existing experience.
- **Reflective Observation of the New Experience -** of particular importance are any inconsistencies between experience and understanding.
- **Abstract Conceptualization -** reflection gives rise to a new idea, or a modification of an existing abstract concept (the person has learned from their experience).
- **Active Experimentation** - the learner applies their idea(s) to the world around them to see what happens.



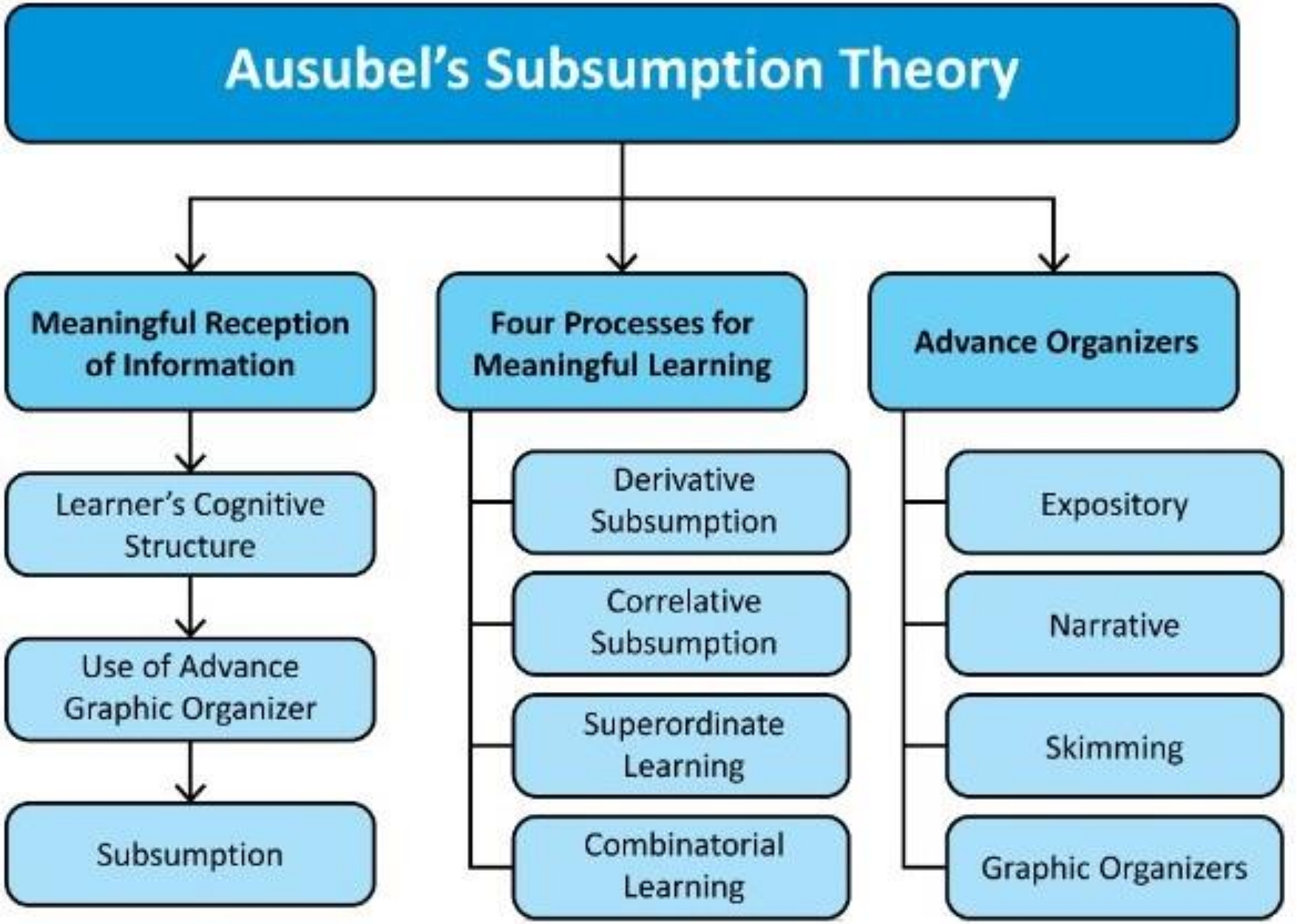
Semantic waves

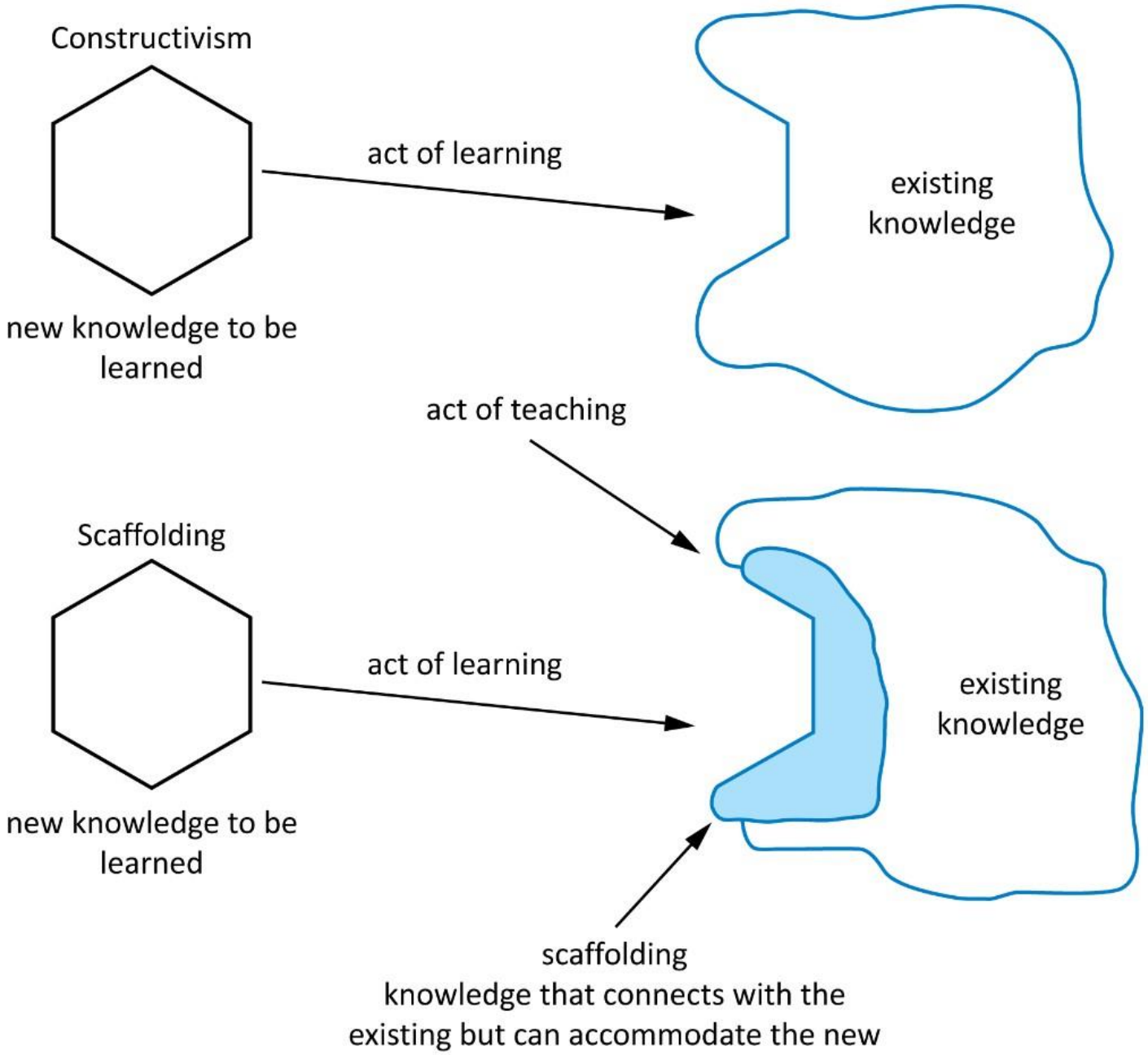


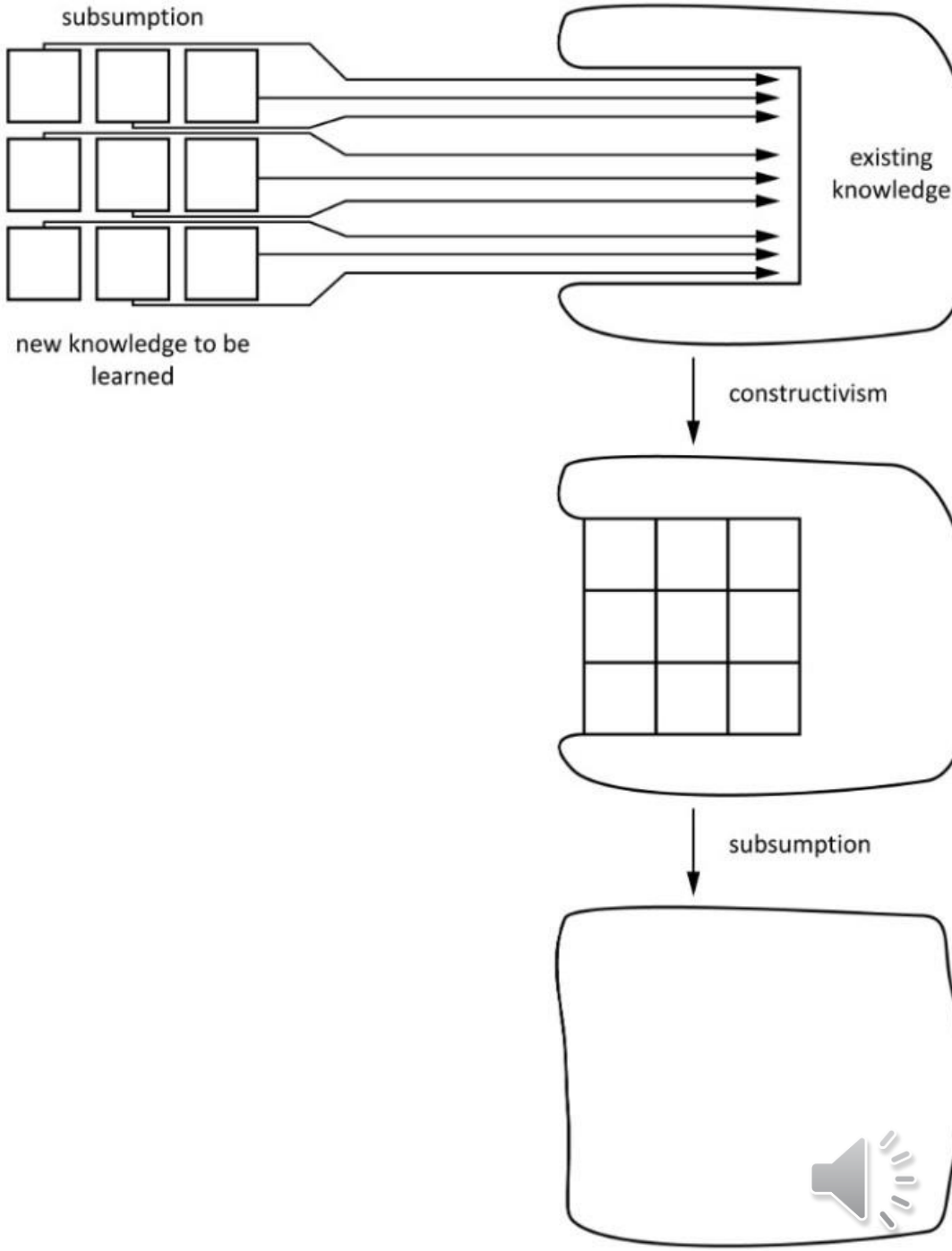
PRIMM for programming

- **Predict**
- **Run**
- **Investigate**
- **Modify**
- **Make**

- What will the code do? CT tasks
- Low bar to entry – fundamentals
- Scaffolded tasks on code/blocks
- ‘Partly mine’ meeting a criteria
- Applying it in anger




Constructivism
act of learning
existing knowledge
new knowledge to be learned
act of teaching
Scaffolding
act of learning
existing knowledge
new knowledge to be learned
scaffolding
knowledge that connects with the existing but can accommodate the new


subsumption
existing knowledge
new knowledge to be learned
constructivism
subsumption

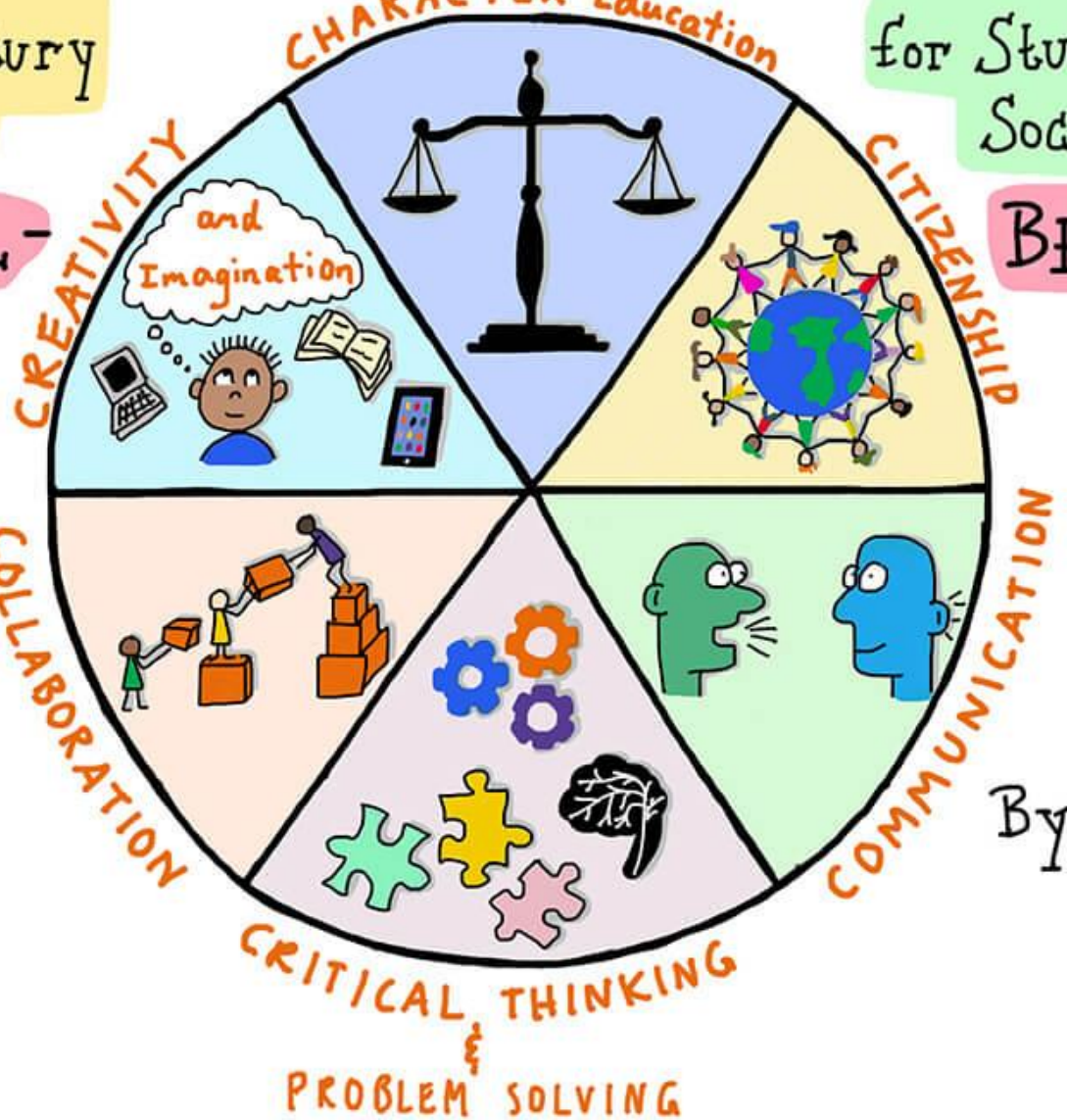
THE 6 C's of Education

21st Century skills

WELL-

for Student and Society

BEING



@sylvia duckworth

By Michael Fullan

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Practice and pedagogy

The ASP Schema

Engaging context

CT problem

Making elements

PBL

Flipped resources

Getting started

Success criteria

Pro-tips

Stretch tasks

Final thoughts

Lesson plan

Slide deck

Worksheets

Cheat sheets

Teacher Solutions

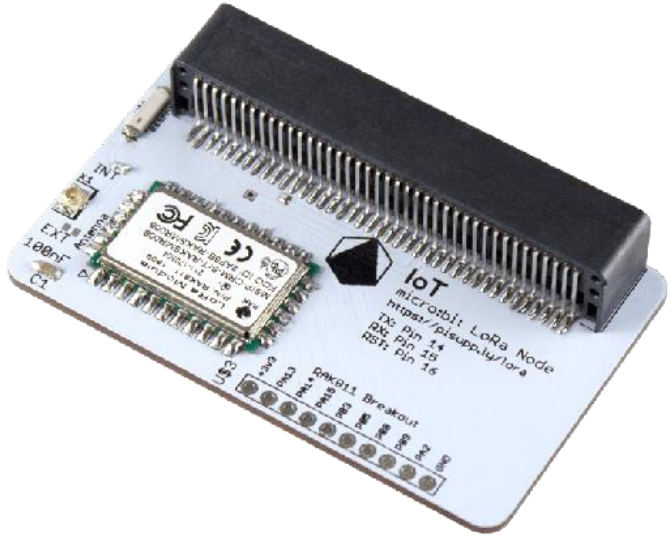
Formal lessons

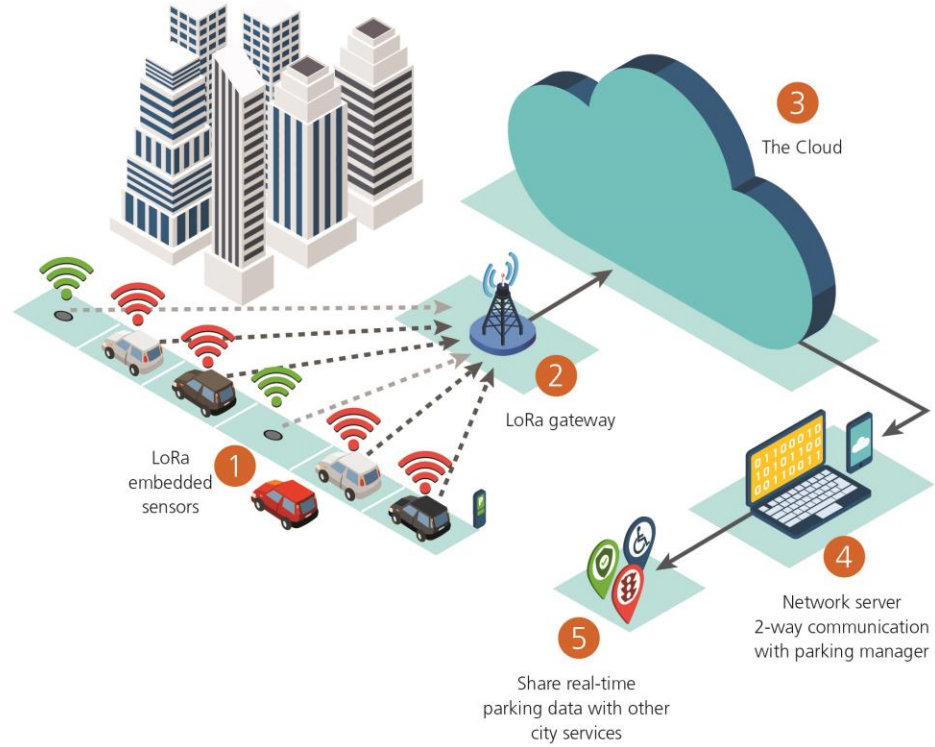
Collapsed days

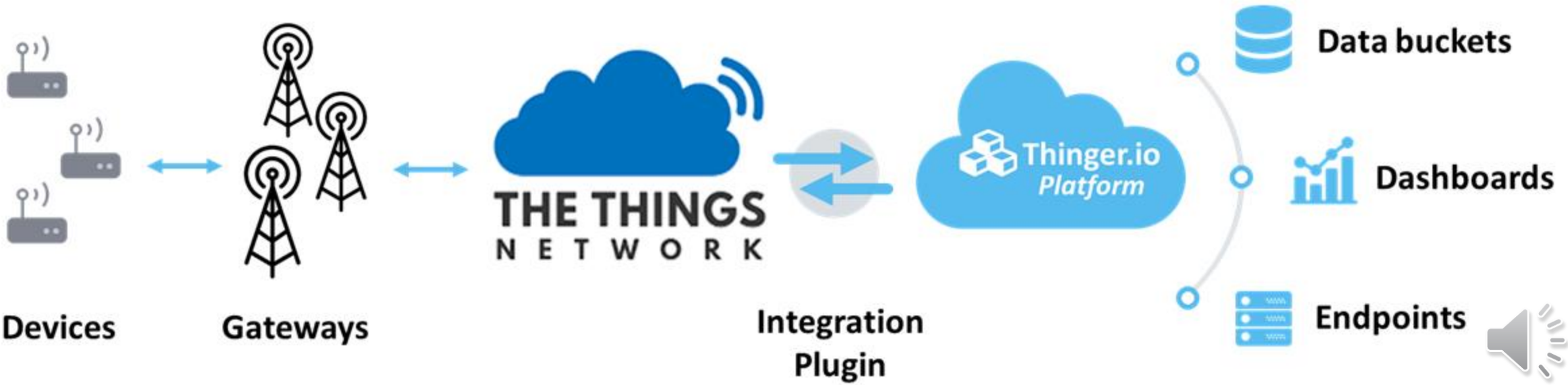
Flipped

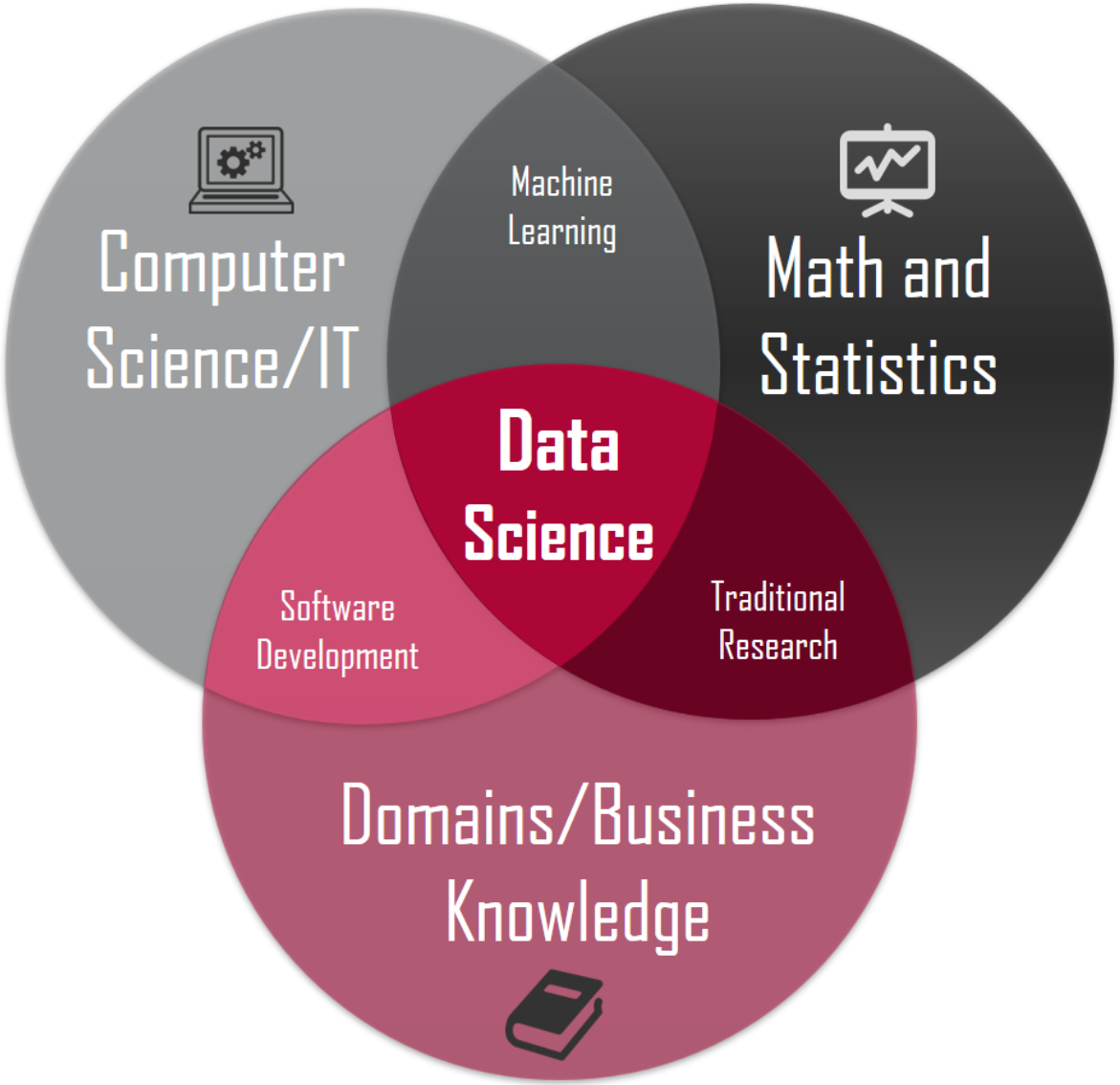
Extra curricula

LoRaWAN®


IoT
mCrobit: LoRa Node
https://pisupply/lora
TX: Pin 14
RX: Pin 15
RST: Pin 16
RAK811 Breakout


3
The Cloud
2
LoRa gateway
LoRa
embedded
sensors
1
4
Network server
2-way communication
with parking manager
5
Share real-time
parking data with other
city services


THE THINGS
NETWORK
Thinger.io
Platform
Data buckets
Dashboards
Endpoints
Devices
Gateways
Integration
Plugin



Data Science

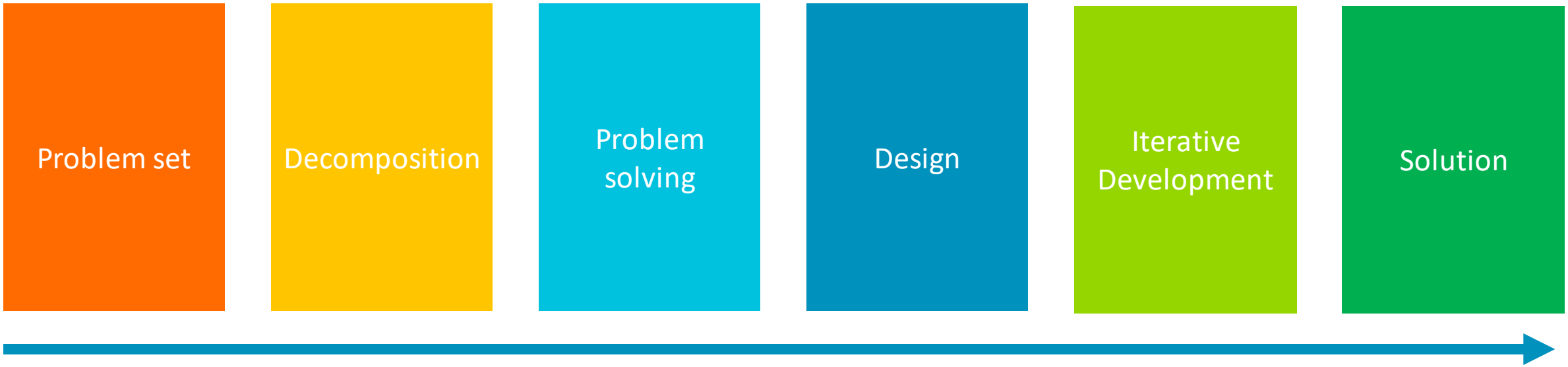
- The next tech wave
- A new subject?
- Where would it live in the curriculum?

The Input Process Output (IPO) Model

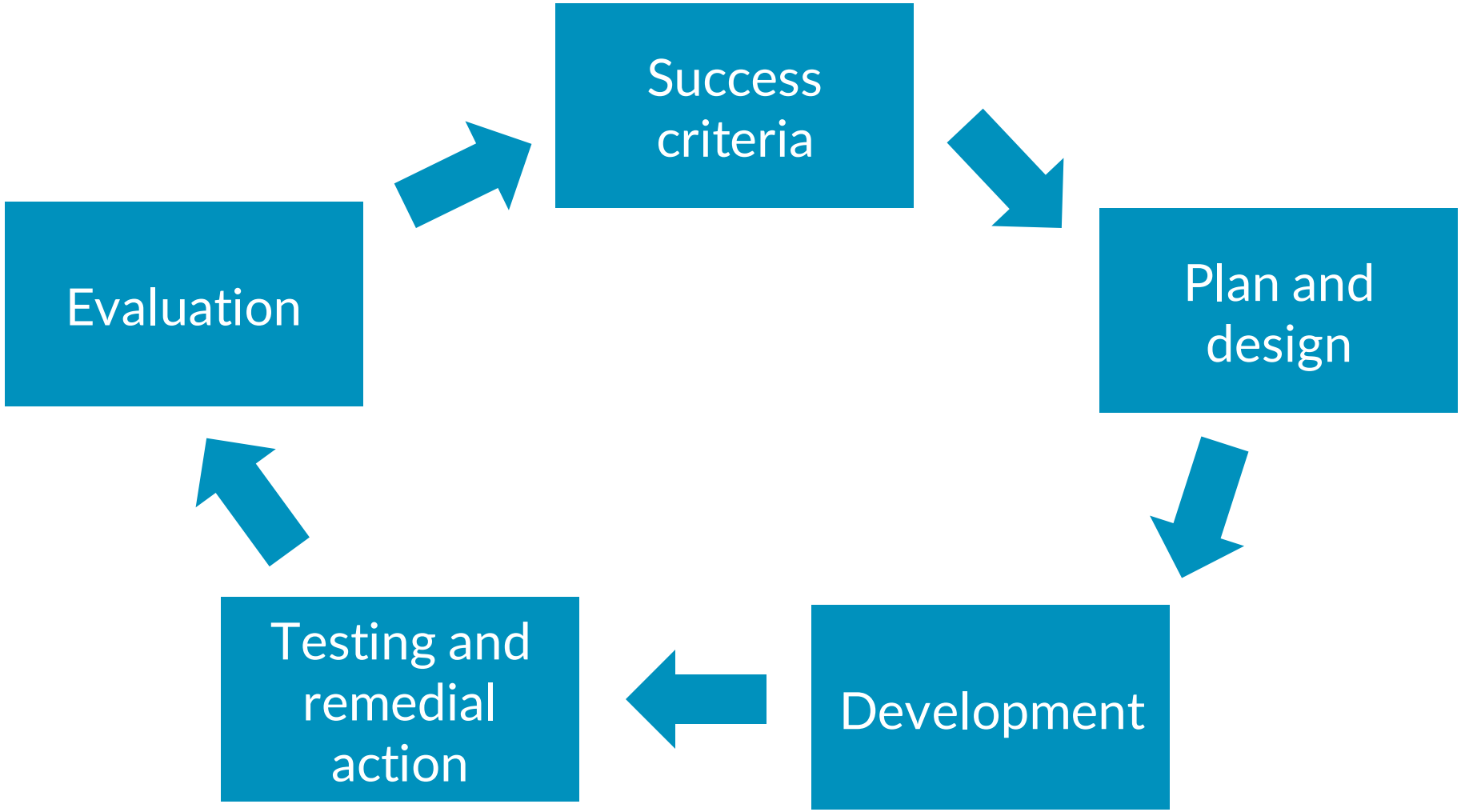
- All computer systems take data into a system using ‘Inputs’, carry out processes on the inputs and then display the result of that processing using ‘Outputs’
- Using the **Input, Process, Output** worksheet try to identify what the outputs will be

Decomposition

- Decomposition involves breaking down the overall task into a series of smaller problems



Iterative development cycle



Hardware as an intermediary relational step

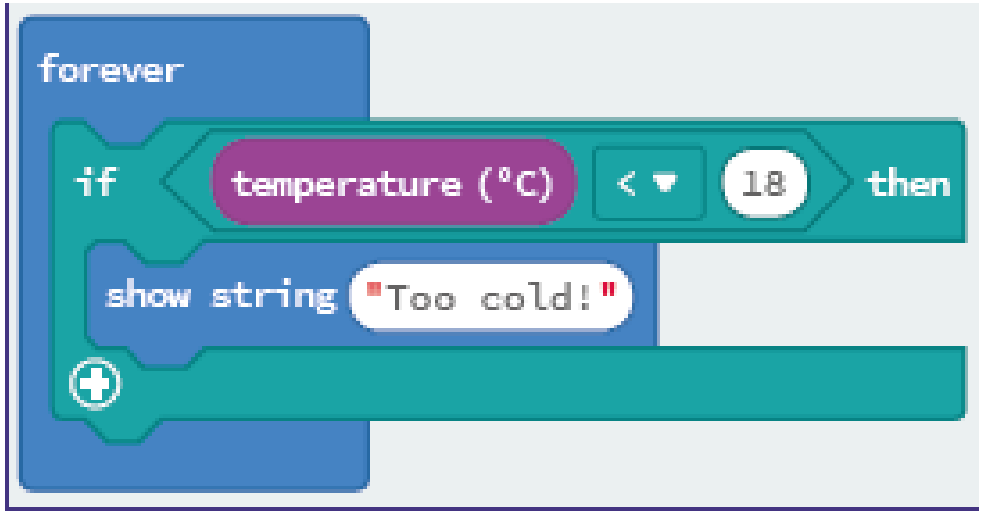
Selection as an abstract concept

```
a = [1,2,3]
b = [1,2,3]

if a == b:
    print("These lists have the same value.")

if a is b:
    print("These lists are the same list.")
```

PBL



- Real world context
- Instantly familiar
- Recognisable application of abstract concept
- Less cognitive demand

THE GLOBAL GOALS
For Sustainable Development

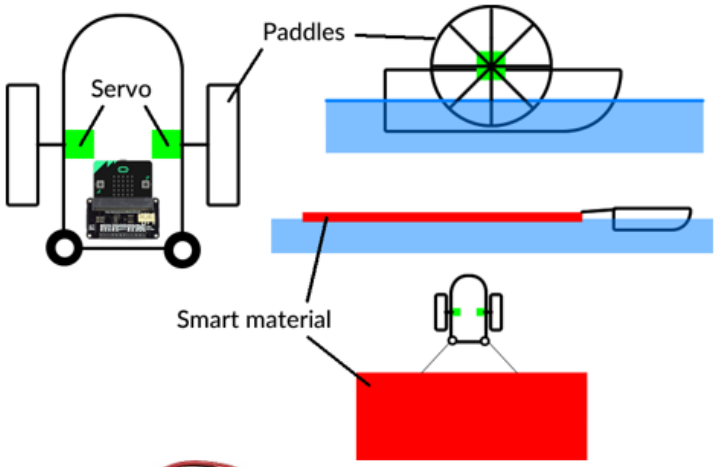
arm School Program

micro:bit

Oil spill cleaner-upper

Building the product

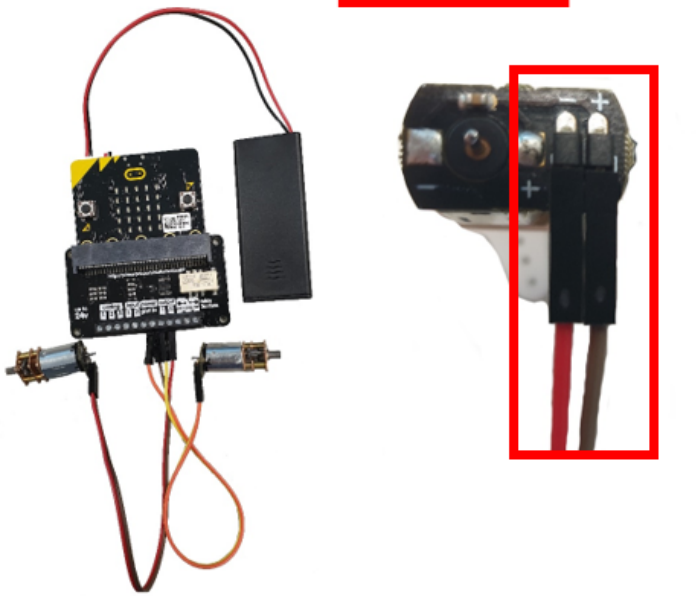
For this project we need to build a simple boat. You can use anything that is waterproof.



Kit required:

- A micro:bit
- Header wires
- Battery pack
- Boat building materials
- A foam sponge
- A mini screwdriver
- A servo driver board

There are many types of servo controller boards for micro:bit, in this example an 'automation bit' was used.



Here you can see how the servo motors are wired to the servo controller and micro:bit.

The + cable from **both** the servos need to go into the 3v opening on the servo control board.

The – cable needs to go into output 1 and 2 respectively.

Pay attention to which side you put them on. In this image:

Output 1 = Right
Output 2 = Left

You may have a third cable for the servo which is the ground (GND), attach this to the GND terminal on the board if you have this.

Success criteria:

- Build a floating oil spill cleaner upper boat drone that starts with a button press
- The product should be able to autonomously navigate over an area
- The product should be made to clean up an oil spill by dragging a 'smart material'

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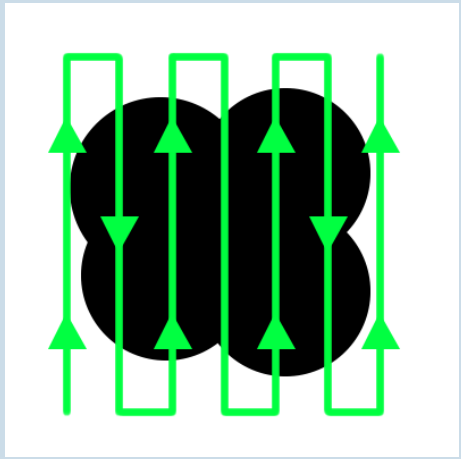
Setting the scene

A group of marine scientists have asked you to develop an algorithm that could be used on a boat drone to drag around a sheet of this smart material to clean up an oil spill.

Success criteria:

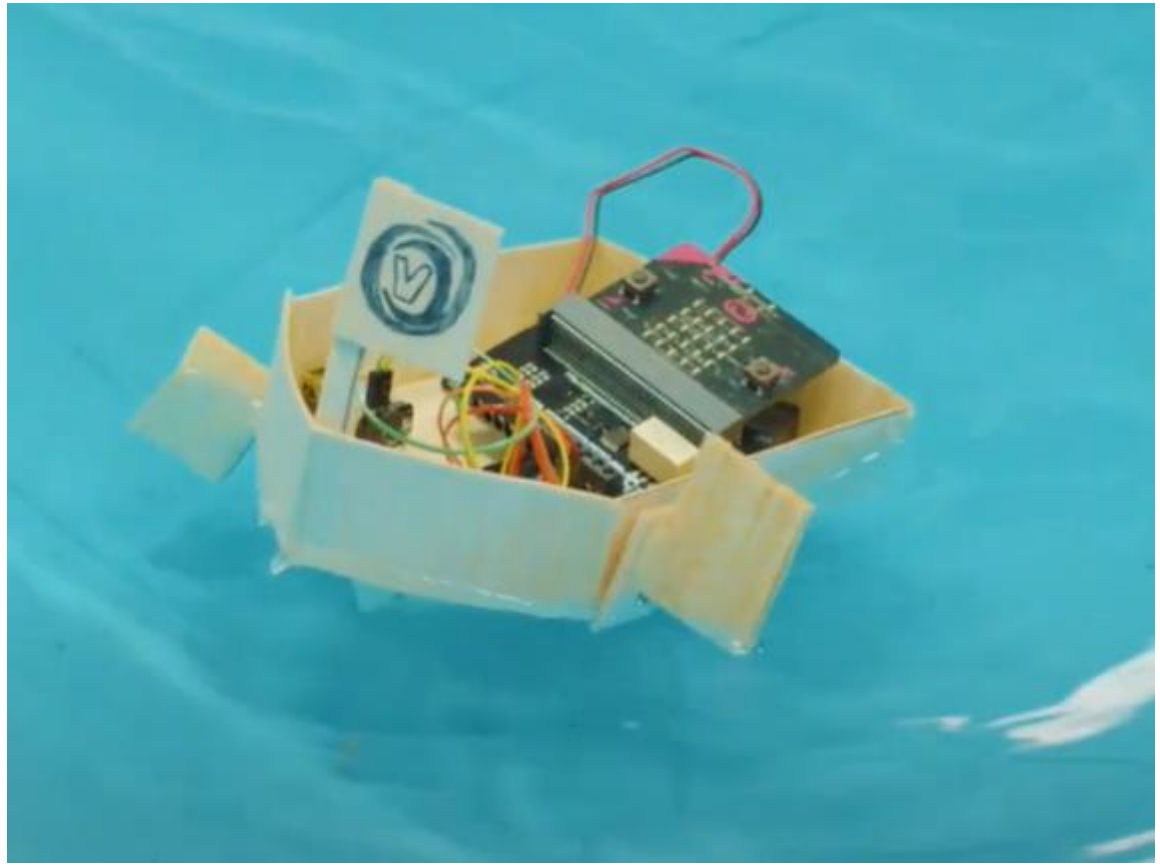
- Build a floating oil spill cleaner-upper boat drone that starts with a button press
- The product should be able to autonomously navigate over an area
- The product should be made to clean up an oil spill by dragging a ‘smart material’

Input process output

Input	Process	Output
Button press	Algorithm to control the movement of the boat drone in a path to clean up oil: 	Servo motor control

Making – rapid prototyping

- Key part of Physical Computing
- Ensures the projects are tangible, visceral and most importantly, engaging
- Typical making tools:
  - Cardboard
  - Scissors
  - Glue guns
  - Tape
  - Velcro tape
  - Colouring pens/pencils



Group task:

- Get into pairs/groups
- Use the Oil Spill Cleaner Upper worksheet to help you design and create your product
- The product must meet the success criteria
- Use the IPO worksheet to design further features
- Make a model tree to test your product

do your :bit | THE GLOBAL GOALS For Sustainable Development | arm School Program

Goal 14 - Life under water – oil spill cleaner upper

Getting started

Oil spills do untold damage to eco-systems.

A new material can absorb up to 90 times its own weight in spilled oil and then be squeezed out like a sponge and reused, raising hopes for easier clean-up of oil spill sites.

https://www.newscientist.com/article/2123391-sponge-can-soak-up-and-release-spilled-oil-hundreds-of-times/

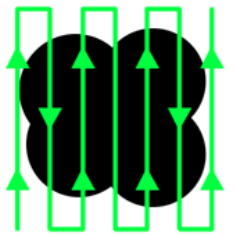
Success criteria

- Build a floating oil spill cleaner upper boat drone that starts with a button press
- The product should be able to autonomously navigate over an area
- The product should be made to clean up an oil spill by dragging a 'smart material'

Breaking down the problem

The input and output for this problem are simple as the drone boat should start with a button press and should follow a pre-programmed path. Creating the algorithm for the movement is the tricky part and will require some thought.

Input process output (IPO)

Input	Process	Output
Button press	Algorithm to control the movement of the boat drone in a path to clean up oil: 	Servo motor control

Pro-tip

Don't worry about distances at this point. Oil spills can be small or large, and the product just needs to be able autonomously clean an area. Think about how the size of the area can be changed.

We won't have access to any smart material but we can simulate it using a normal sponge.

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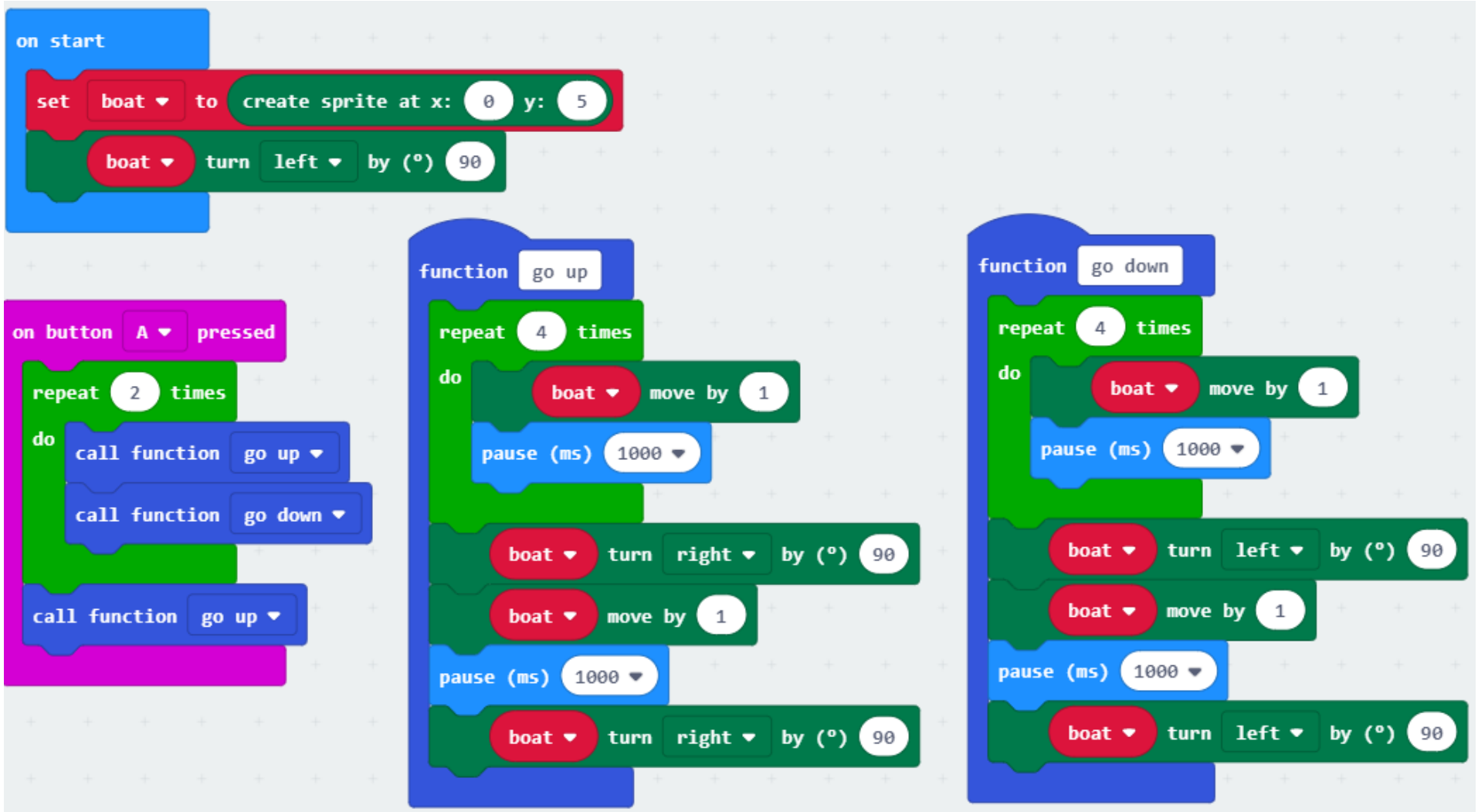
micro:bit

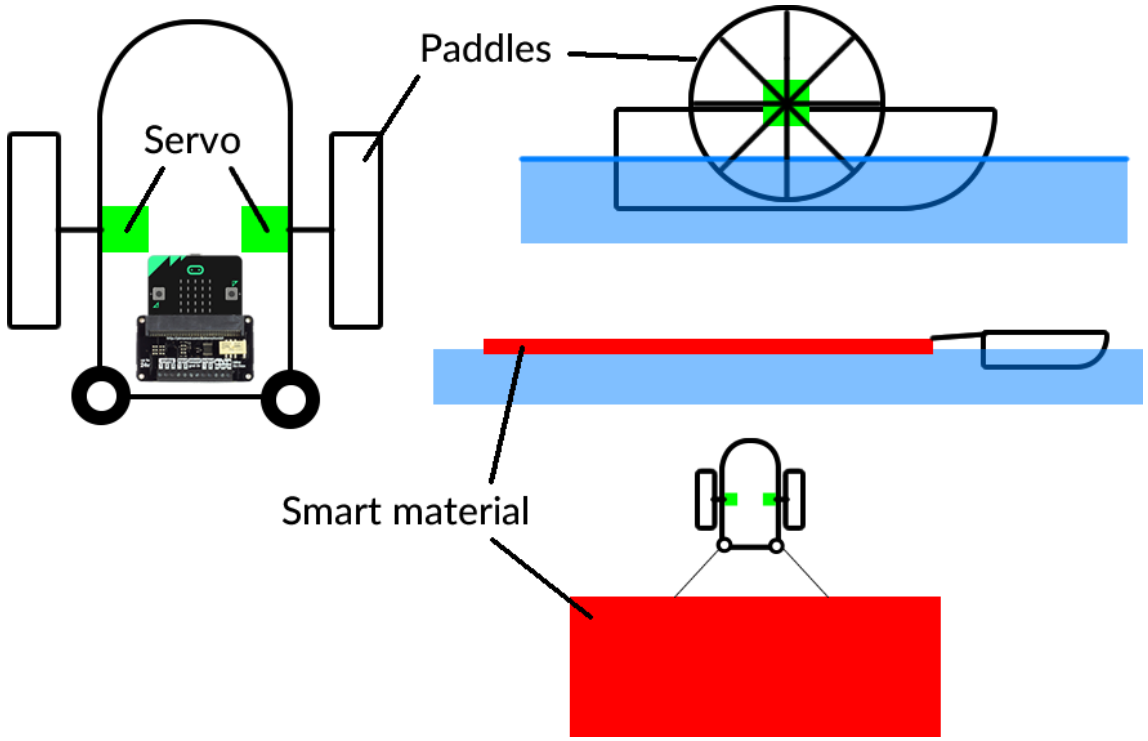
Creating a model



These blocks create an on-screen mock-up using a sprite.

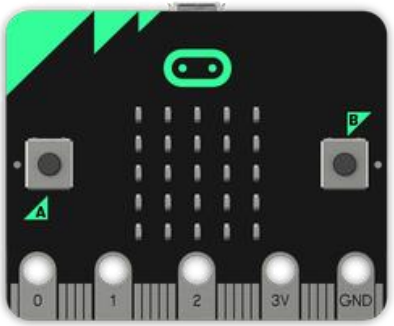
We can use this to test our algorithm on the micro:bit or in MakeCode.

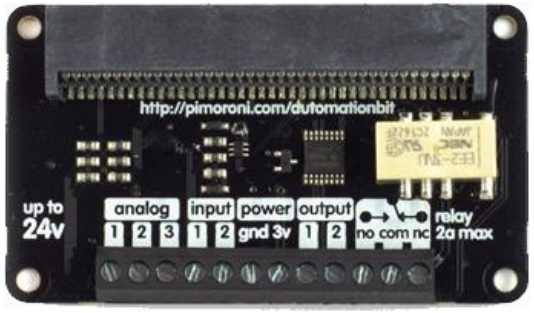
The paddle wheel:



Hardware needed:

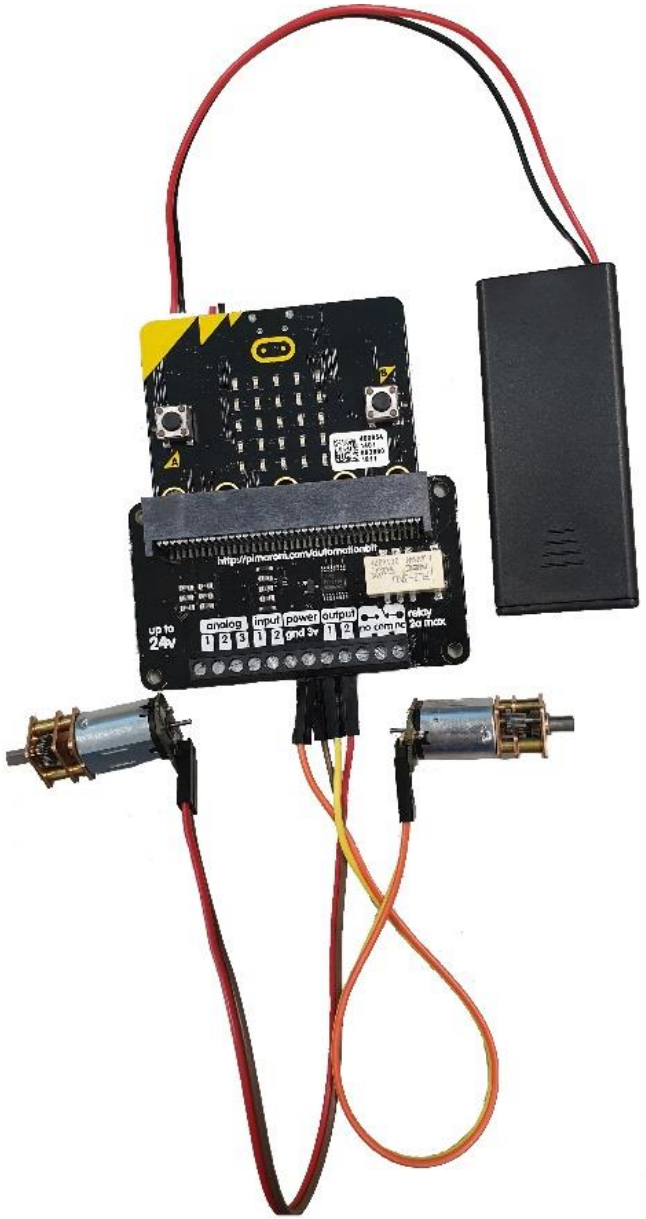
- micro:bit(s)
- battery peripheral and batteries
- materials to make the floating body and paddles
- servo control board
- servo motors
- a sponge to simulate the smart material

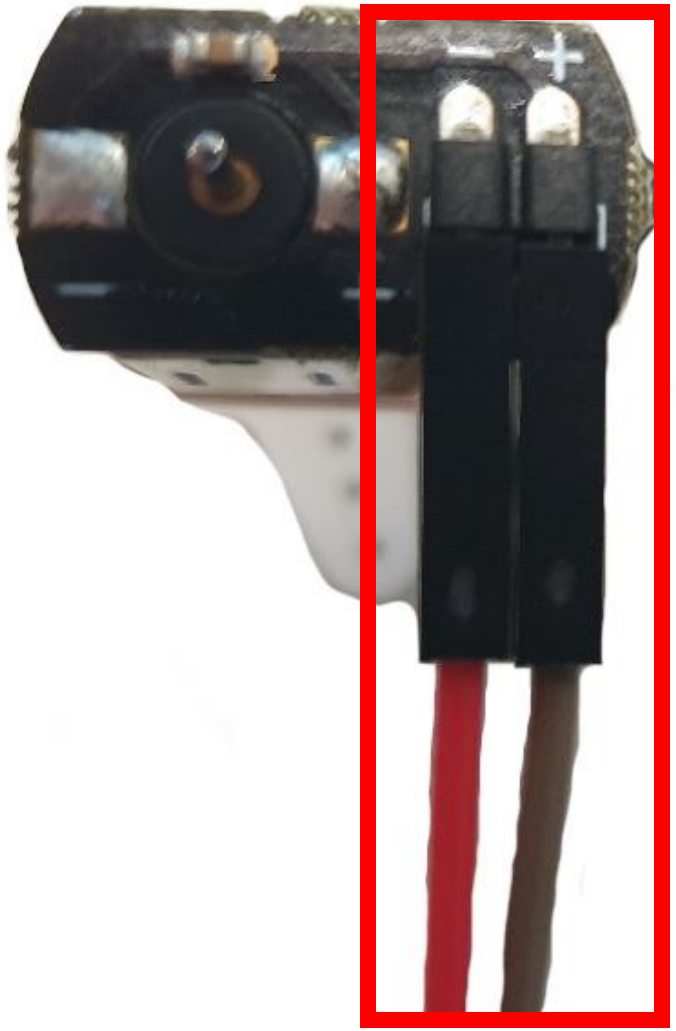




arm School Program

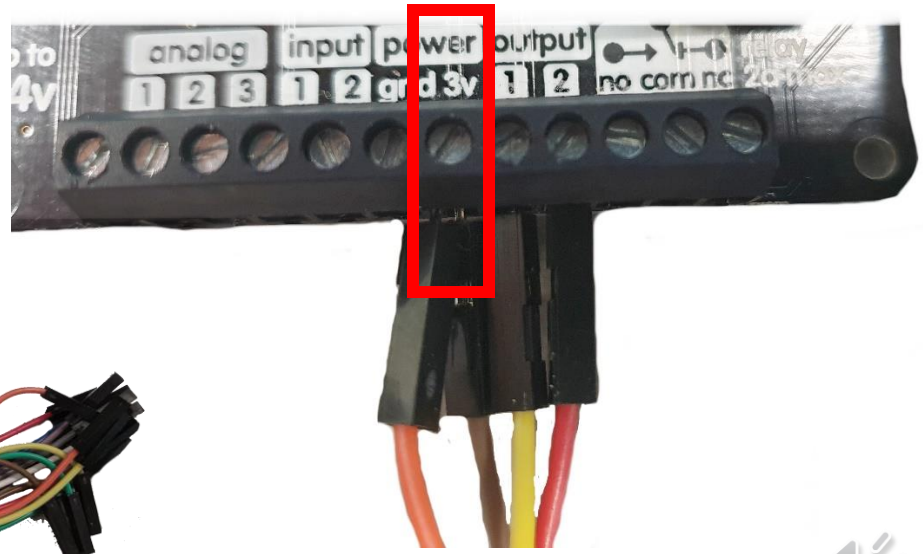
micro:bit





Note:

- The motors need power from the batteries
- The + wires from both servos go into the 3v terminal
- Output one is right
- Output two is left
- Ground (GND) wires got to the GND terminal



arm School Program

micro:bit

Research driven

- EEF meta analysis of EdTech shows “consistent benefits”
- The technology in isolation is irrelevant, technology enthuses learners, what matter is that the pedagogy, activity and technology are aligned
- Enhances teaching rather than replacing it

- Collaborative use of technology (in pairs or small groups) is usually more effective than individual use, though some pupils, especially younger children, may need guidance in how to collaborate effectively and responsibly.
- Technology can be as powerful as a short but focused intervention to improve learning, particularly when there is regular and frequent use (about three times a week) over the course of about a term (5 - 10 weeks). Sustained use over a longer period is usually less effective at improving this kind of boost to attainment.
- Remedial and tutorial use of technology can be particularly practical for lower attaining pupils, those with special educational needs or those from disadvantaged backgrounds in providing intensive support to enable them to catch up with their peers.
- In researched interventions, technology is best used as a supplement to normal teaching rather than as a replacement for it. This suggests some caution in the way in which technology is adopted or embedded in schools.
- Tested gains in attainment tend to be greater in mathematics and science (compared with literacy for example) though this is also a more general finding in meta-analysis and may be at least partly an artefact of the measurement process. In literacy the impact tends to be greater in writing interventions compared with reading or spelling.
- At least a full day’s training or on-going professional inquiry-based approaches to support the introduction of new technology appear the most successful. The implication is that such support should go beyond the teaching of skills in technology and focus on the successful pedagogical use of technology to support teaching and learning aims.

The Impact of Digital Technology on Learning: A Summary for the Education Endowment Foundation

Implications

Pedagogical:

- Authentic contexts required
- Achievable success criteria
- Appropriate scaffolding of resources and differentiation
- Resource heavy approach
- Group work commonly employed but no necessary
- Assessment (formative/summative)

Practical:

- Hardware accessibility
- Hardware availability
- Cost
- Time constraints on projects (multi lesson)

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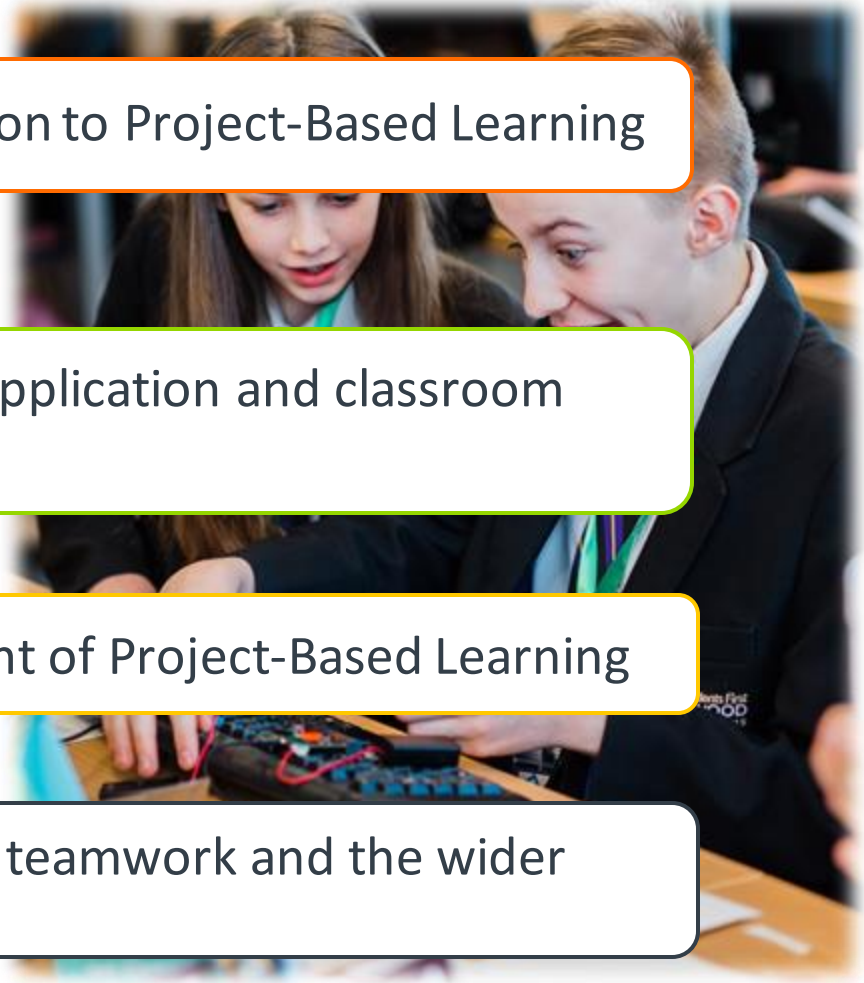

https://www.edx.org/professional-certificate/armeducationx-teaching-with-physical-computing

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Thank You
Danke
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Grazie
谢谢
ありがとう
Asante
Merci
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