Chapter 5: Constructivism:
From Piaget to Augmented Reality

Pierre Dillenbourg, Patrick Jermann, Stian Haklev
Learning Fractions: Comparing 3 methods

Is C closer to A or to B?

https://www.khanacademy.org/

http://nrich.maths.org/4332

http://streaming.discoveryeducation.com/braingames/iknowthat/Fractions/FractionGame.cfm?Topic=namematch
Discovery learning ≠ Cool
Serious games: beware of the ‘chocolate on brocoli’ pitfall
Lesson A

A splountz is a triangle with 3 smaller shapes placed on different sides, one in the same color as the triangle and the two others in a different color.

Is this a Splountz?

○ Yes ✓ ○ No
Lesson B

WHAT IS A SPUC?

Positive instances

Negative instances

Near-Miss instances

Near-Miss instances

Near-Miss instances
Chapter 6: **Constructivism**

How do people learn? By constructing cognitive structures from experience (trial & error)

- Experience → Reflection
- Reflection → Trial & Error
- Trial & Error → Behaviour
Jean Piaget

Stages of development

Sensori-motor (0-2 years)
- Schema created by child reinforcing that objects are permanent
- Understanding of world developed through sensory and physical experimentation

Pre-operational (2-7 years)
- Beginnings of language through understanding of symbols
- Egocentric
- Difficulty understanding conversation or more than one aspect of a situation

Concrete Operational (7-11 years)
- Ordering and classifying based on appearance
- Ability to sequence numbers
- Developing ability to empathise
- Simplistic understanding of maths, geometry and physics

Formal Operations (11+ years)
- Ability to draw conclusions based on hypotheses rather than objects
- Adolescent egocentrism
- Logical

Permanence of object

Conservation Task

Pyramid Task

https://www.papermasters.com/intellectual-growth.html
Jean Piaget

Assimilation and Accommodation

How can this girl use her “dog” schema when encountering a cat?

- She can **assimilate** the experience into her schema by referring to the cat as a “dog”
  
  or
  
- she can **accommodate** her animal schema by separating the cat, and even different types of dogs, into separate schemas.
Piaget (1952) defined a schema as 'a cohesive, repeatable action sequence possessing component actions that are tightly interconnected and governed by a core meaning'. Basically, a scheme is the building block of intelligent behavior.
(1) wool is warm

(2) wool

(3) wool is warm but the blanket is too thin

(4) wool is insulating

Mental Model

assimilation

accommodation

Conflict
Cognitive Conflict as key learning mechanism

- Learning from experience
- Learning by doing
- Discovery learning
Constructivism ≠ Teacherless
You experienced the constructivist method «Contrasting Cases»

1

2
« Contrasting Cases »

- **Treatment A**
  - Compare cases

- **Treatment B**
  - Read case summary

- **Treatment C**
  - Compare cases again

**Common Learning Experience**
- Listen to a lecture

**Target Transfer Task**
Predictions about a novel memory experiment

« Contrasting Cases »

![Bar Chart]

- Compare cases + Lecture: 40%
- Summarize + Lecture: 20%
- Compare cases twice: 10%

Percent of Possible Predictions about a Novel Experiment
Today's Orchestration Graph

- **Class**:
  - Listen refresh lecture
  - *a_1*

- **Team**:
  - Compare platforms
  - *a_3*

- **Individual**:
  - Test one platform
  - *a_2*

A time for Telling

- **Listen lecture on constructivism**
  - *a_4*

Constrasting cases

- **Produce a constructivist OG on standard deviation**
  - *a_5*

Collect knowledge
“Produtive Failure”

Who’s the most consistent striker?

<table>
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<td>Mike Arwen</td>
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<td>$\frac{280}{20}$</td>
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<td>14</td>
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<tr>
<td></td>
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<tr>
<td>Dave Backhand</td>
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<td>$\frac{280}{20}$</td>
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<tr>
<td>Mode</td>
<td>18 and 10</td>
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Frequency of years above, below, and at average

Consistency = years at the mean / years away from the mean

From question paper: Average = \( \frac{280}{20} \)

Mike has 8 years < average
4 years = average
8 years > average

Dave has 7 years < average
6 years = average
7 years > average

Ivan has 9 years < average
2 years = average
9 years > average

Sum of year-on-year deviation

Mike:
- 9 - 14 = -5
- 14 - 9 = 5
- 10 - 14 = -4
- 15 - 10 = 5

Dave:
- 7
- 4
- 2
- 1

Ivan:
- 5
- 2
- 1

Average of year-on-year absolute deviation

MIKE: $\frac{5+5+4+5+4+4+5+4+4+5+4+4+5+4}{19} = \frac{84}{19} = 4.42$ (rounded)

DAVE: $\frac{4+7+2+4+1+2+1+1+4+5+2+3+1+3+4+1+4+4+1}{19} = \frac{54}{19} = 2.84$

Ivan: $\frac{5+3+5+1+6+7+7+2+2+5+5+4+9+1+8+7+1+8+0}{19} = \frac{47}{19} = 2.53$ (rounded)

Sum of deviations about the mean

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<th>D.E.</th>
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Goals Scored

1986 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07

- Mike Amor
- Dave Backlund
- Ivan Righ

Idea 3: Maroon Graph Length

MA \frac{1}{32} + \frac{1}{26} + \frac{1}{24} + \frac{1}{28} + \frac{1}{27} + \frac{1}{22} + \frac{1}{25} + \frac{1}{20} + \frac{1}{19} + \frac{1}{26} + \frac{1}{27} + \frac{1}{22} + \frac{1}{25} + \frac{1}{20} + \frac{1}{19} + \frac{1}{26} + \frac{1}{27} + \frac{1}{22} + \frac{1}{25} + \frac{1}{20} + \frac{1}{19} = 83.26

DB \frac{1}{26} + \frac{1}{24} + \frac{1}{25} + \frac{1}{22} + \frac{1}{20} + \frac{1}{19} + \frac{1}{26} + \frac{1}{27} + \frac{1}{22} + \frac{1}{25} + \frac{1}{20} + \frac{1}{19} + \frac{1}{26} + \frac{1}{27} + \frac{1}{22} + \frac{1}{25} + \frac{1}{20} + \frac{1}{19} = 56.54

IR \frac{1}{26} + \frac{1}{24} + \frac{1}{25} + \frac{1}{22} + \frac{1}{20} + \frac{1}{19} + \frac{1}{26} + \frac{1}{27} + \frac{1}{22} + \frac{1}{25} + \frac{1}{20} + \frac{1}{19} + \frac{1}{26} + \frac{1}{27} + \frac{1}{22} + \frac{1}{25} + \frac{1}{20} + \frac{1}{19} + \frac{1}{26} + \frac{1}{27} + \frac{1}{22} + \frac{1}{25} + \frac{1}{20} + \frac{1}{19} = 94.54

Dave Backlund is the most consistent player as he has the shortest "stretched-out" graph, showing consistency over time.
How do people learn? ➔ Which technology for learning?
If I cannot reach object A, I can take object B that connects my hand to A.

To implement a complex program, I can decompose it into sub-problems.
define "carre [[size]
[repeat 4 [forward :size wait 0.1 right 90]]]

define "fleur [[size]
[clean repeat 60 [carre :size left 6]]]

fleur 100

http://www.alancsmith.co.uk/logo/

Papert, S. & Solomon, C. (1971, Twenty things to do with a computer, AI Memo 248, MIT
define "Zum [][length divider]
  [if :length < 1
    [stop]
    [  left 45
      forward :length
      Zum :length/:divider :divider
      back :length
      right 90
      forward :length
      Zum :length/:divider :divider
      back :length
      left 45
    ]
  ]
]
Cognitive Conflict as key learning mechanism

(1) I want to get this

(2) I got that

(3) The problem is here

```
define "house1" [
    [forward 100
     right 45
     forward 60
     right 120
     forward 60
     right 45
     forward 100
     right 90
     forward 60]
]
```
Cognitive Conflict as key learning mechanism

- Learning from experience
- Learning by doing
- Learning from failure
- Discovery learning

Conditions:
1. The conflict is detected
2. The learner finds how to solve it

Role of the environment (sequence of projects / teacher / peer)
constructivism ➔ constructionnism
https://www.youtube.com/watch?v=8RiEDT8bsOs

https://aseba.wikidot.com/fr:thymiovpl

https://www.youtube.com/watch?v=8RiEDT8bsOs
constructivism ➔
constructionnism

http://guerrillamakerspace.squarespace.com/space-4/
FabLab@School
A growing network of educational digital fabrication labs that put cutting-edge technology for design and construction - such as 3D printers and laser cutters - into the hands of middle and high school students.

GoGo Boards
Students using multiple sensors and a GoGo Board for their project.

Projects
Check out past student projects!

Resources
Find useful link, activities, and tutorials here!

FabLabs@School Around the World

CASTILLEJA SCHOOL
RUSSIA
STANFORD
THAILAND

How to Get a FabLab@ School

© 2014 Created by Paolo Blikstein.
From constructivism to constructionism

FabLab+ Components Toolkit

Modular ToolKit

Tool (Thymio, EPFL)
The scandal of education is that every time you teach something, you deprive a [student] of the pleasure and benefit of discovery.

I think schools generally do an effective and terribly damaging job of teaching children to be infantile, dependent, intellectually dishonest, passive and disrespectful to their own developmental capacities.

Every maker of video games knows something that the makers of curriculum don't seem to understand. You'll never see a video game being advertised as being easy. Kids who do not like school will tell you it's not because it's too hard.
Constructivism

Microworlds

Constructionism

Guided Discovery

Radical

Quest for effectiveness

• Content-rich microworlds
• Simulations
• Modelling
Quest for effectiveness: Adding Contents

https://www.geogebra.org/

Cabri Géomètre
Learning from Simulations

Acquire Skills

Discover underlying model
Learning from Simulations

More examples

An Overview paper
Inquiry learning

“Inquiry-based learning involves learners
- asking questions about the natural or material world,
- collecting data to answer those questions,
- making discoveries and
- testing those discoveries rigorously”

de Jong, 2006
Hypothetico-deductive reasoning

1. (Raise a question)
2. Generate an hypothesis
3. Design an experiment
4. Run/simulate the experiment
5. Interpret results
But…

1. Question

2. Hypothesis
   • No clear hypothesis is formulated or badly formulated (42%), i.e. no relationship between variables

3. Design
   • Design unconclusive experiments, students vary several parameters at at time
   • Confirmation bias: to design experience that confirm the hypothesis

4. Run

5. Interpret
   • 35% to 63% errors in data interpretation and graphics readings
And...

1. Question
2. Hypothesis
3. Design
   - Change several parameters
   - Keep hypothesis despite negative evidence
   - Reject hypothesis despite positive evidence
4. Run
5. Interpret
Example of **tools** to overcome these pitfalls

Tool to express hypotheses
Example of scenario to overcome these pitfalls

① Ask students to write their hypothesis
② Find student with conflicting hypothesis
③ Ask them to find out with the simulation which hypothesis is right

The effects of any learning technology depends upon the quality of classroom orchestration
Cycle of engagement and reflection
by Mike Sharples, Open University

Find my topic

Decide my inquiry question or hypothesis

Plan my methods, equipment, actions

Collect my evidence

Analyse and represent my evidence

Respond to my question or hypothesis

Share and discuss my inquiry

Reflect on my progress
Inquiry is a more open process than simulations

A lesson is not inquiry based if:

• Students know what results they are supposed to get
• The questions and steps are pre-determined for them
• The teacher is working harder than the students

http://www.stemmom.org/2012/03/what-inquiry-is-not.html

http://www.sciencescope.co.uk/Pages/SensorCategories.aspx
Constructivism

Microworlds

Radical

Constructionism

Guided Discovery

Quest for effectiveness

Inquiry-based learning

Learning by modelling
Learning from simulations

Scientific Model

Computation Model

Didactic Transformation: simplify it for didactic reasons

Hypothetic-deductive reasoning

Computation transformation: approximate it for computational reasons

Mental Model
Learning from modelling

Scientific Model

Computational Model

Matlab, Octave, …

Mental Model
Figure 2: A SCY concept map with drawers attached. Available peers are above and a SCY chat is active to the right.
Modelling Space
Manipulating real or virtual objects?

Cuisenaire Rods

iPad Version

https://itunes.apple.com/gb/app/number-rods/id536204074?mt=8
The real-virtual debate: offer both!
Manipulating real or virtual objects?
Logistics Apprentices
Summary: From Constructivism to Augmented Reality

1. People don’t learn by being taught but by adapting their knowledge structures through interaction with artefacts. Educational philosophy: from telling students what to do to letting them invent things.

2. In practice, this approach does not work very well without external support and requires talented teachers. Learning from simulation requires inquiry skills. Training these transversal skills are key goals of any education.

3. Evolution of pedagogical methods from building mental schemes to building concrete objects. Digital artefacts offer rich interactions but digital education is not limited to virtual object. Tangible interfaces and augmented reality open it to physical manipulation.