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CENTRO DE INVESTIGACIÓN AVANZADA EN EDUCACIÓN

UNIVERSIDAD DE CHILE
INSTITUTO DE ESTUDIOS AVANZADOS EN EDUCACIÓN
IE

On Computational Thinking

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Computational thinking
Programming languages
Dual Cognition
Textbooks and tools
Coloring tasks

Computational thinking

Programming languages

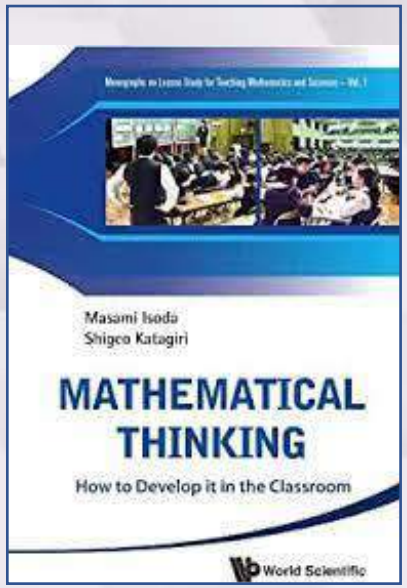
Dual Cognition

Textbooks and tools

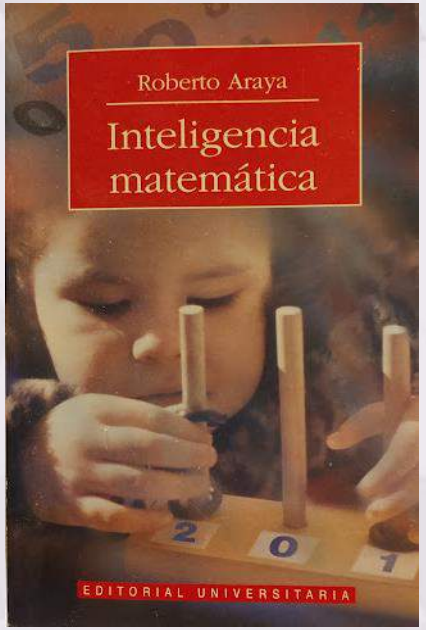
Coloring tasks

Computational thinking

What is computational thinking and how does it differ from mathematical thinking?



- Ideas, concepts, and theorems are not enough
- It is necessary to calculate and solve
- This means algorithms:
  - elementary actions that a machine can execute



Mathematical reasoning

MATH

MATH is a dataset of 12,500 challenging competition-level mathematics problems introduced by UC Berkeley researchers in 2021 (Figure 2.6.10). AI systems struggled on MATH when it was first released, managing to solve only 6.9% of the problems. Performance has significantly improved. In 2023, a GPT-4-based model posted the top result, successfully solving 84.3% of the dataset's problems (Figure 2.6.11).

A sample problem from the MATH dataset

Source: Hendrycks et al., 2023

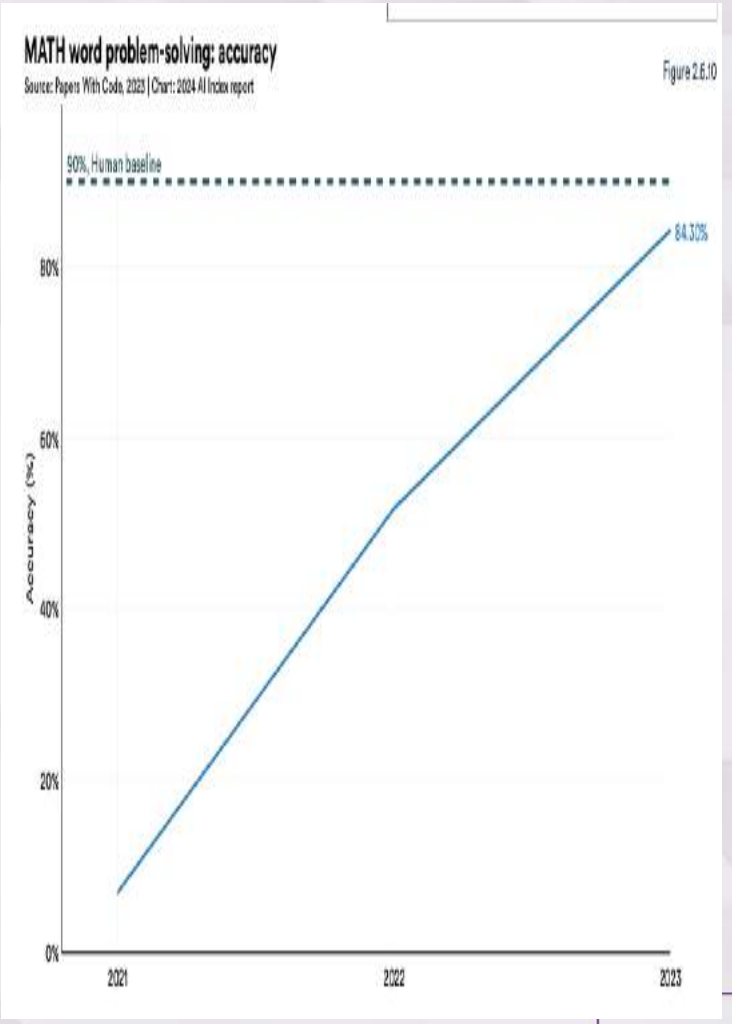
MATH Dataset (Ours)

Problem: Tom has a red marble, a green marble, a blue marble, and three identical yellow marbles. How many different groups of two marbles can Tom choose?

Solution: There are two cases here: either Tom chooses two yellow marbles (1 result), or he chooses two marbles of different colors ($\binom{4}{2} = 6$ results). The total number of distinct pairs of marbles Tom can choose is $1 + 6 = \boxed{7}$.

Problem: The equation $x^2 + 2x = i$ has two complex solutions. Determine the product of their real parts.

Solution: Complete the square by adding 1 to each side. Then $(x+1)^2 = 1 + i = e^{\frac{i\pi}{4}}\sqrt{2}$, so $x + 1 = \pm e^{\frac{i\pi}{8}}\sqrt[4]{2}$. The desired product is then $\left(-1 + \cos\left(\frac{\pi}{8}\right)\sqrt[4]{2}\right)\left(-1 - \cos\left(\frac{\pi}{8}\right)\sqrt[4]{2}\right) = 1 - \cos^2\left(\frac{\pi}{8}\right)\sqrt{2} = 1 - \frac{(1+\cos(\frac{\pi}{4}))}{2}\sqrt{2} = \boxed{\frac{1-\sqrt{2}}{2}}$.



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A Framework for Computational Thinking in Preparation for Transitioning to a Super Smart Society

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APEC
Asia-Pacific Economic Cooperation

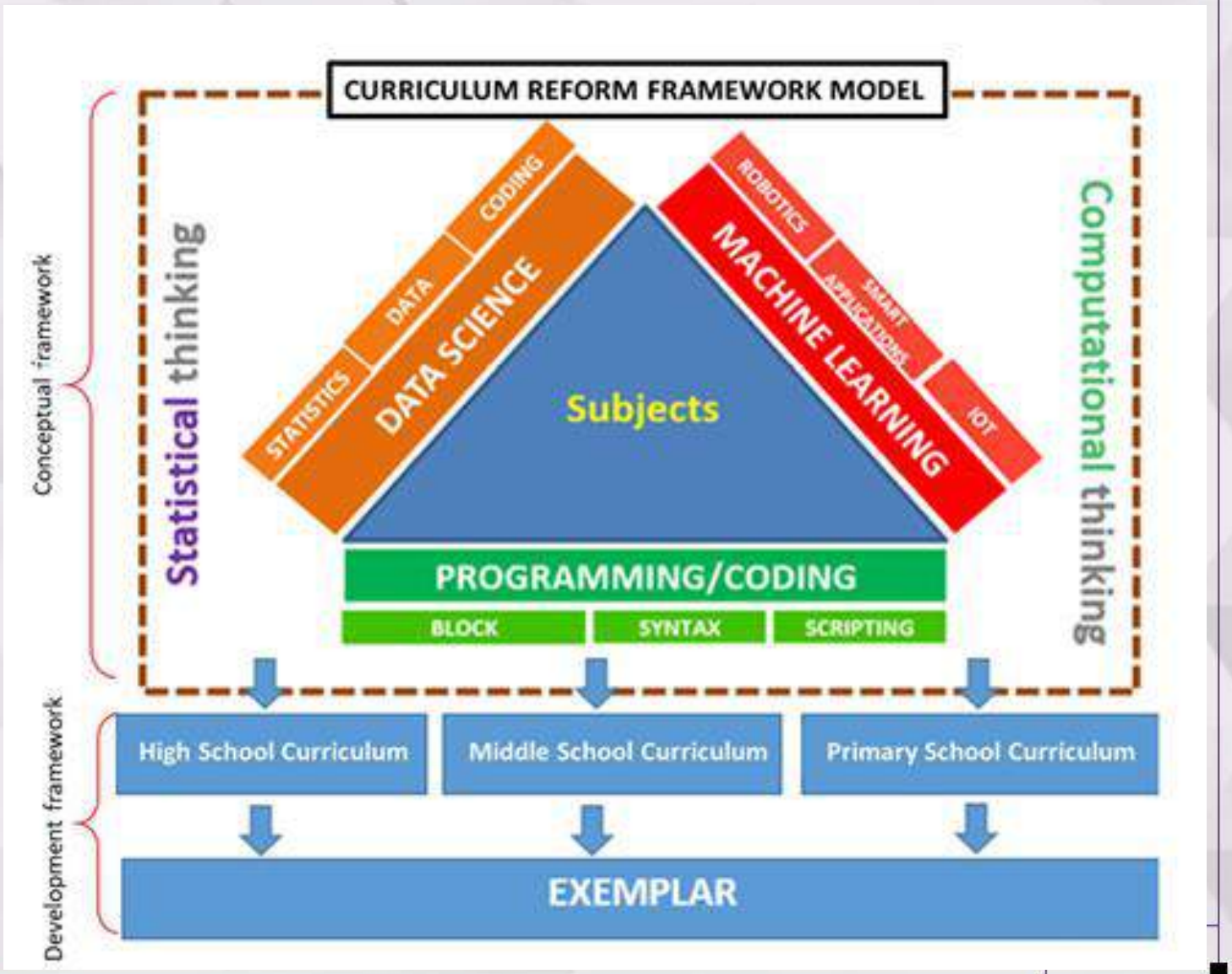
Advancing Free Trade for Asia-Pacific Prosperity

Developing Computational Thinking on AI and Big Data Era for Digital Society

Recommendations from APEC InMside I Project

APEC Human Resources Development Working Group

March 2021



Supported by MEXT

Three components of computational thinking

- **Algorithmic Thinking**
  - Abacus,
  - Logic Quantifiers
  - Steepest descent
- **Use, Selection, Adaptation and Building (USAB) Computational Models**
  - Chemotaxis
  - Forest Fire Propagation
  - Pandemia propagation
- **Machine Learning Thinking**
  - Decision Tree Induction,
  - Linear equations and Neural Networks

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Programming languages

- **Assembly languages**
  - 1842–1849, Ada Lovelace
  - 1947 Kathleen Booth
  - 1950 had largely been supplanted by higher-level languages
- **Programming languages**
  - 1954 Fortran
  - 1958 LISP
  - 1967 Logo
  - 1972 C
  - 1990 Python
- **Visual programming languages**
  - 1987 Macromedia Authorware (Adobe)
  - 1999 GameMaker
  - 2002 Scratch
- **AI and automatic code generation**
  - Welsh, Computer Science, Havard University: “The End of Programming”
  - Jensen Huang, NVIDIA

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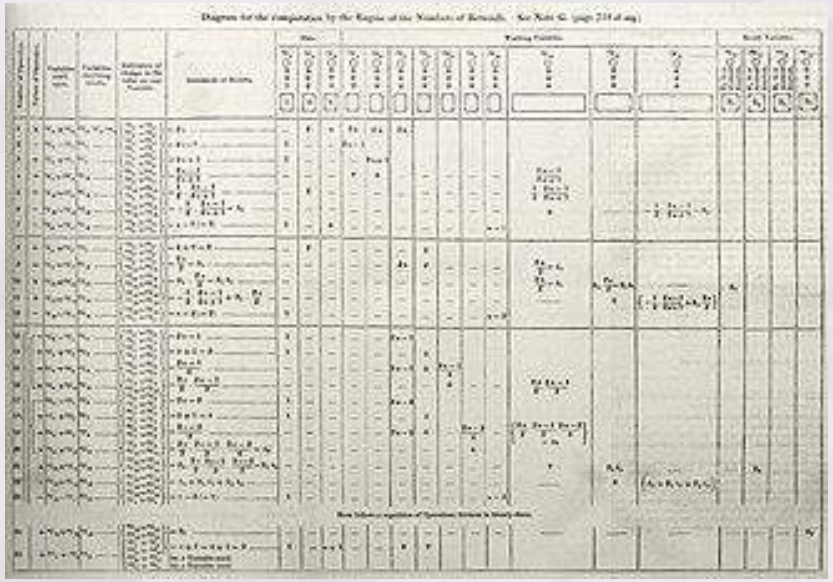
1843



Draw a star with pen

2023

CreatiCode Scratch Plugin - Enable ChatGPT for Block-Based Coding

GPT builders Plugins / Actions builders plugin-development

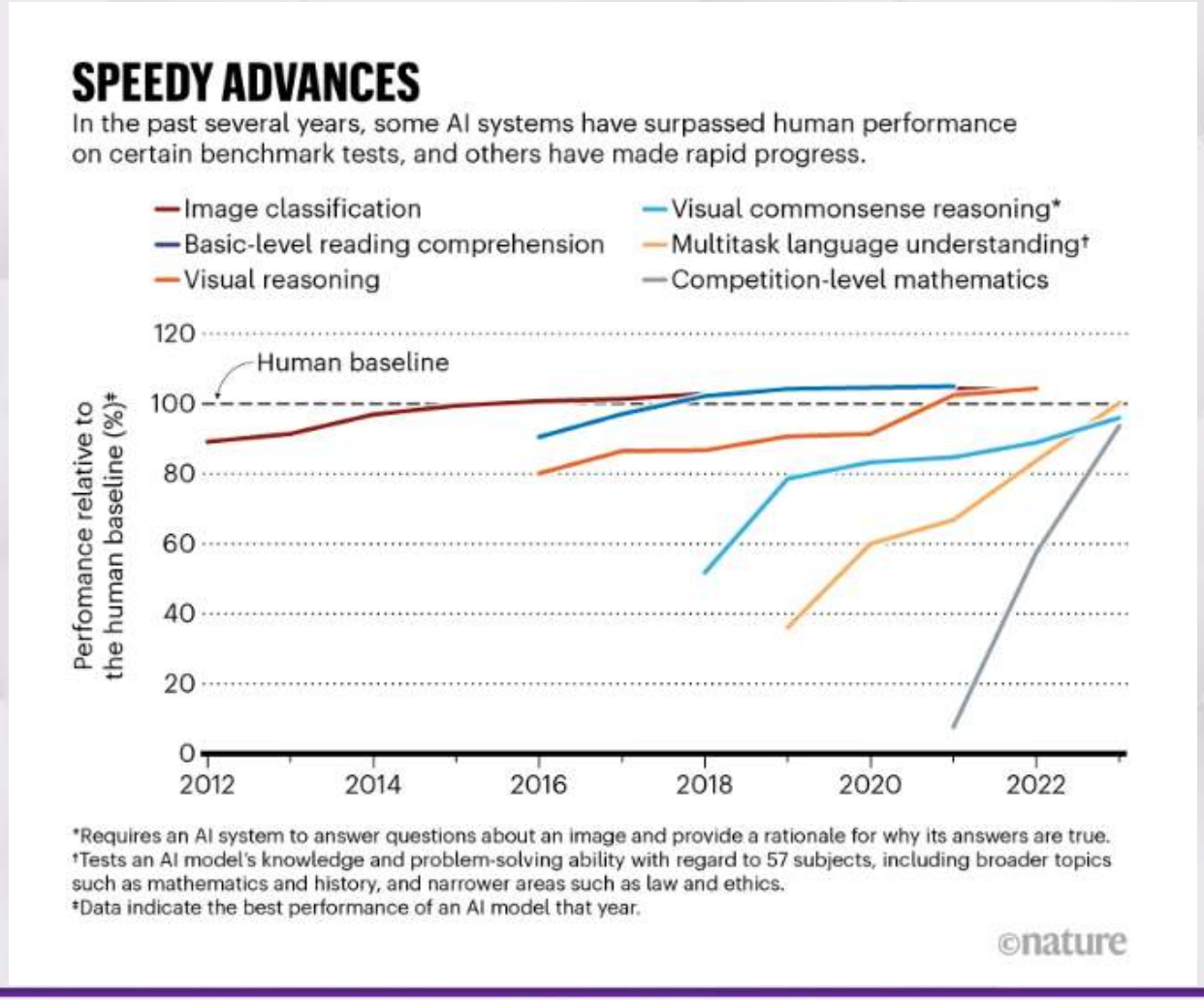
CreatiCode 4 May 2023

Hi everyone, we are proud to present our plugin "CreatiCode Scratch" to the community. This plugin helps ChagGPT to display block-based programs as images and learn to use new blocks in the CreatiCode extensions.


The End of Programming
CACM
THE END OF PROGRAMMING
By Matt Welsh
CLASSICAL CS
DELETE
January 2023
Communications of the ACM
03:44
vimeo

CEO Jensen Huang On The Future of Education with AI

Stanford´s Artificial Intelligence Index Report 2024



2.3 Coding

Generation

On many coding tasks, AI models are challenged to generate usable code or to solve computer science problems.

HumanEval

HumanEval, a benchmark for evaluating AI systems' coding ability, was introduced by OpenAI researchers in 2021. It consists of 164 challenging handwritten programming problems (Figure 2.3.1). A GPT-4 model variant (AgentCoder) currently leads in HumanEval performance, scoring 96.3%, which is a 11.2 percentage point increase from the highest score in 2022 (Figure 2.3.2). Since 2021, performance on HumanEval has increased 64.1 percentage points.

Sample HumanEval problem

Source: Chen et al., 2023

```
def incr_list(l: list):
    """Return list with elements incremented by 1.
    >>> incr_list([1, 2, 3])
    [2, 3, 4]
    >>> incr_list([5, 3, 5, 2, 3, 3, 9, 0, 123])
    [6, 4, 6, 3, 4, 4, 10, 1, 124]
    """
    return [i + 1 for i in l]
```

Figure 2.3.1

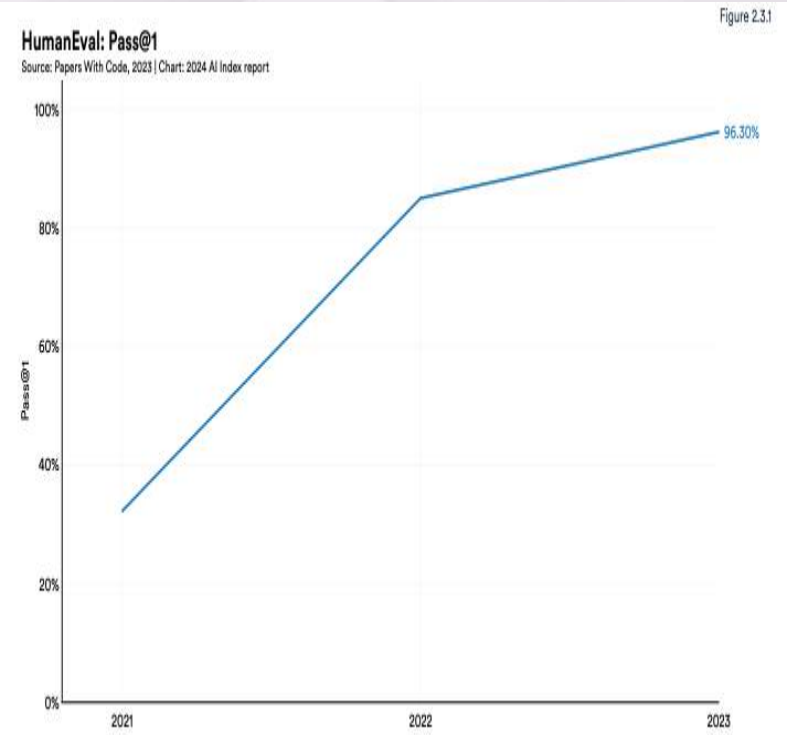


Figure 2.3.2

According to Geoffrey Hinton, Turing Award winner, LLMs understand and do not just reproduce memorization

- They do this because the first layers learn low-level characteristics, the following layers mix them, and so on.
- In the case of images, they learn edges, then interactions between edges, etc.
- In language they learn characteristics of language, so many words that specifically go together as hierarchical dependency structures.
- That generates true understanding.

Lecture at the Sheldonian Theatre, Oxford University, 19 February 2024

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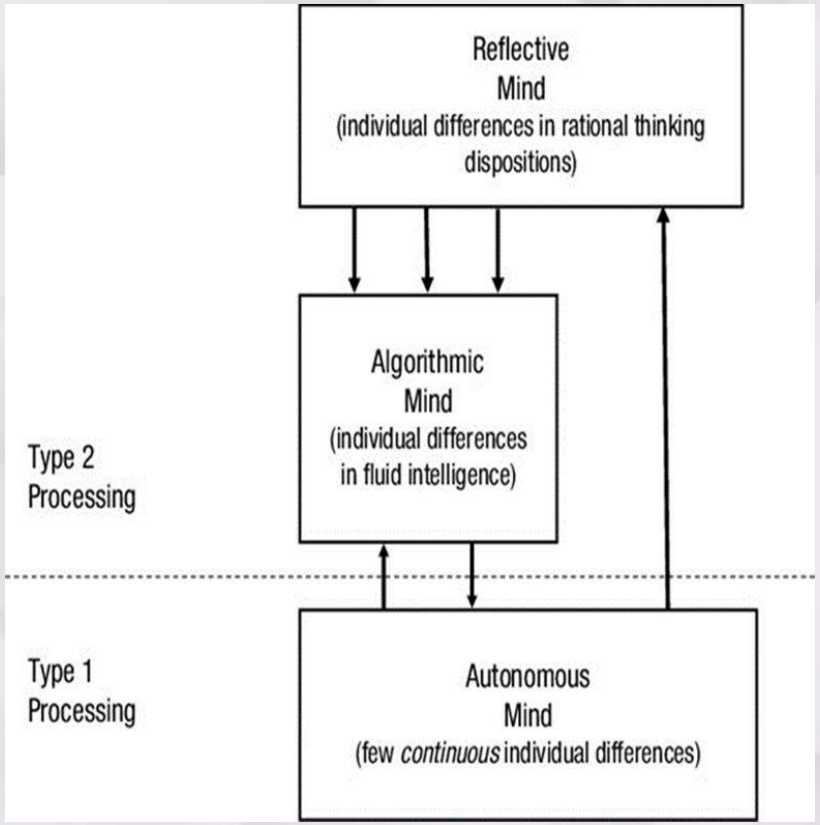
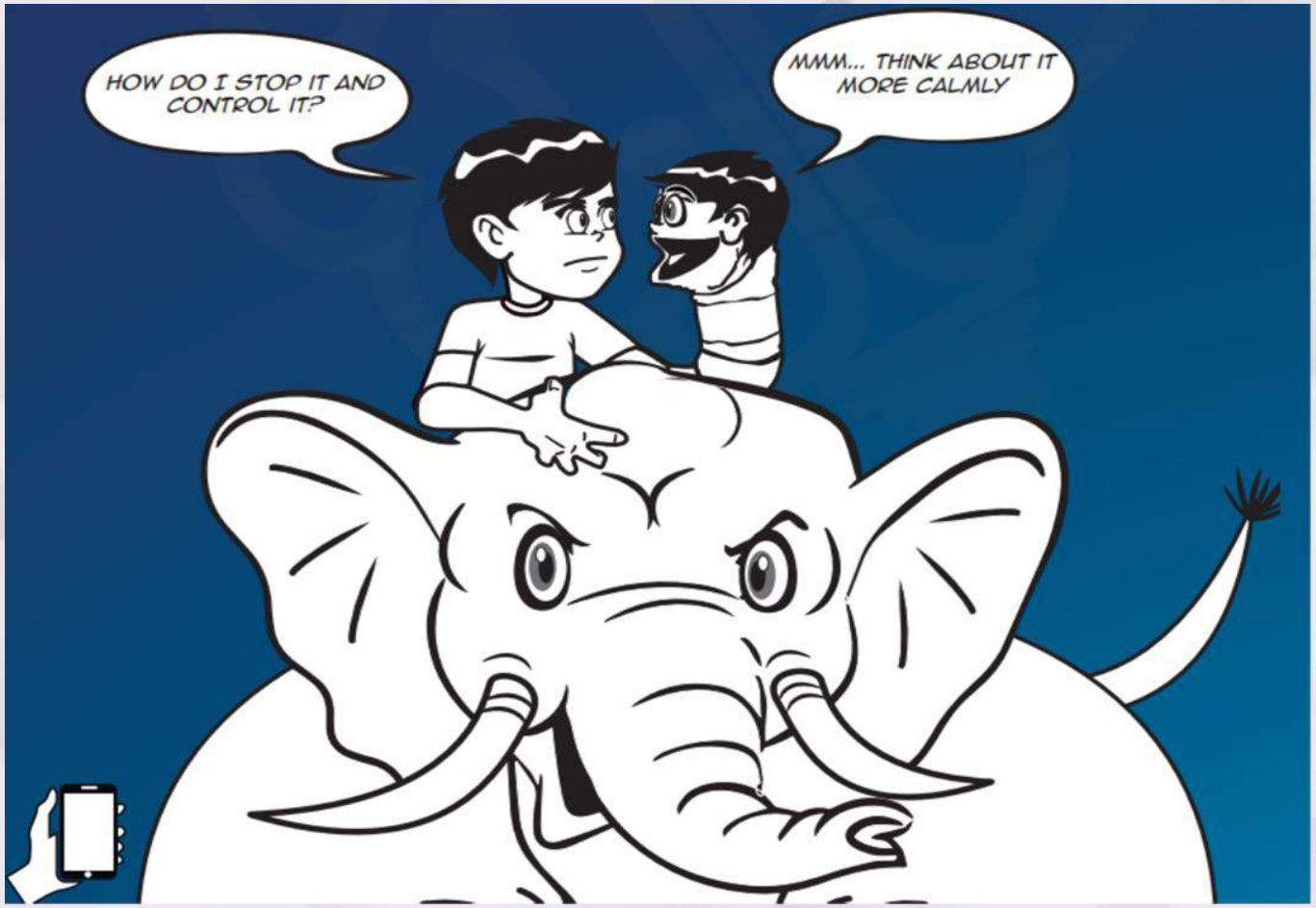
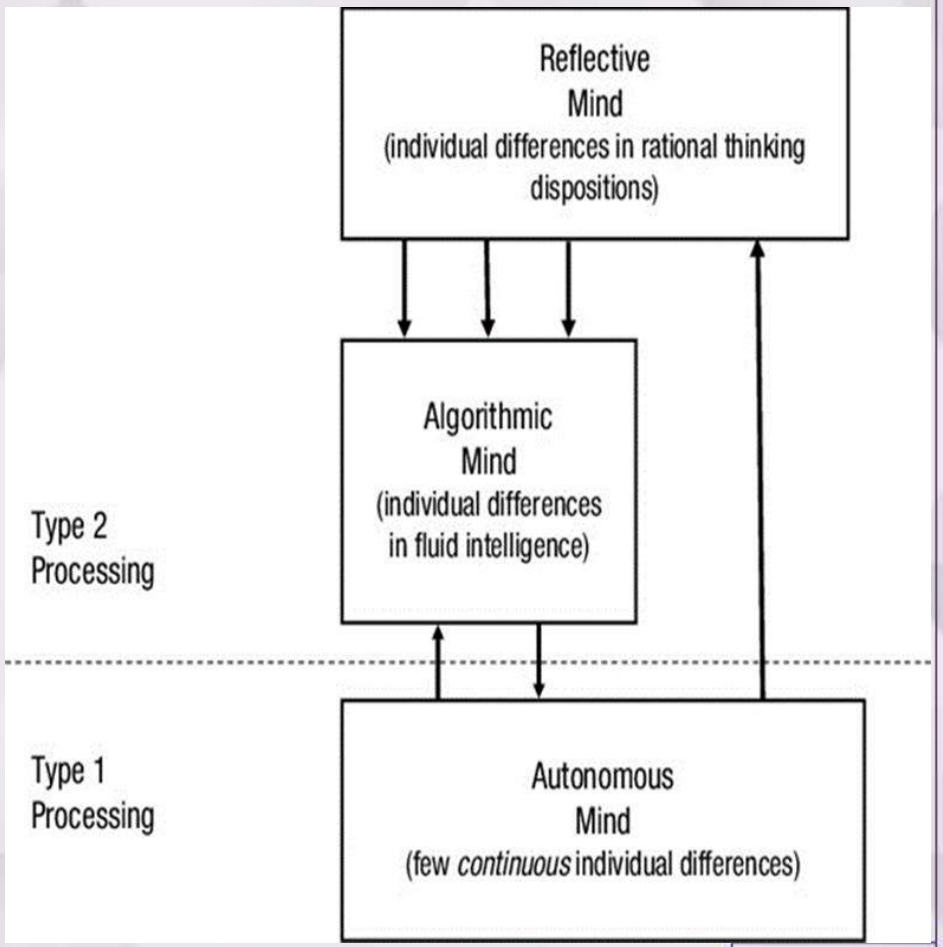
Dual cognition



Argumentation





Argumentation

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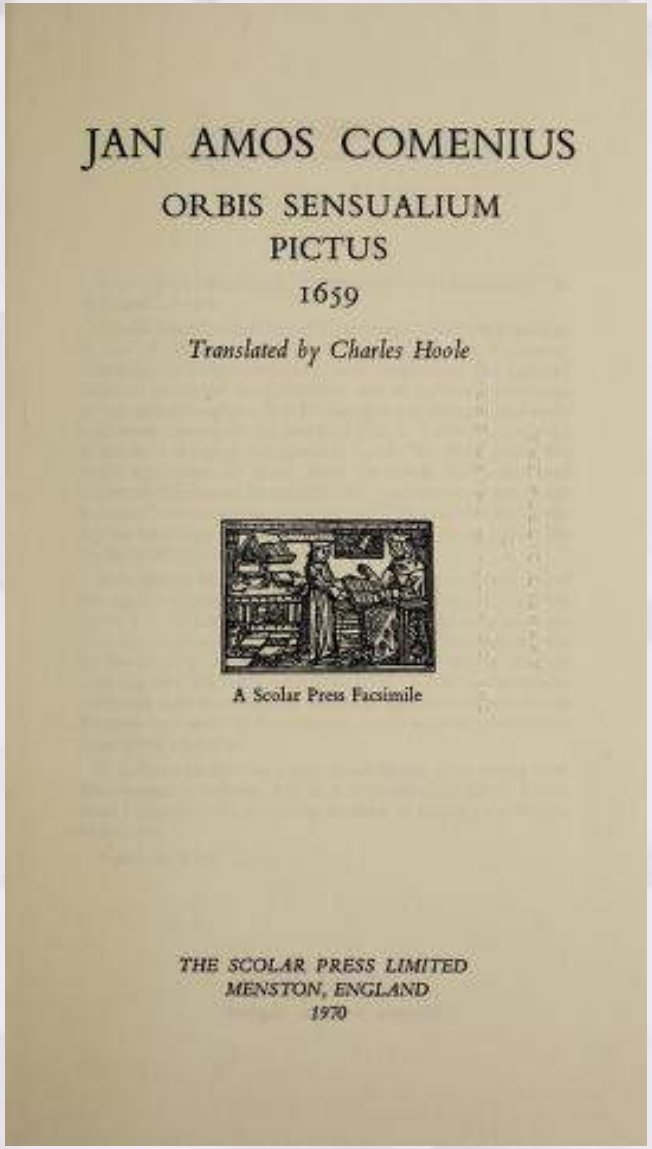
Textbooks and Tools

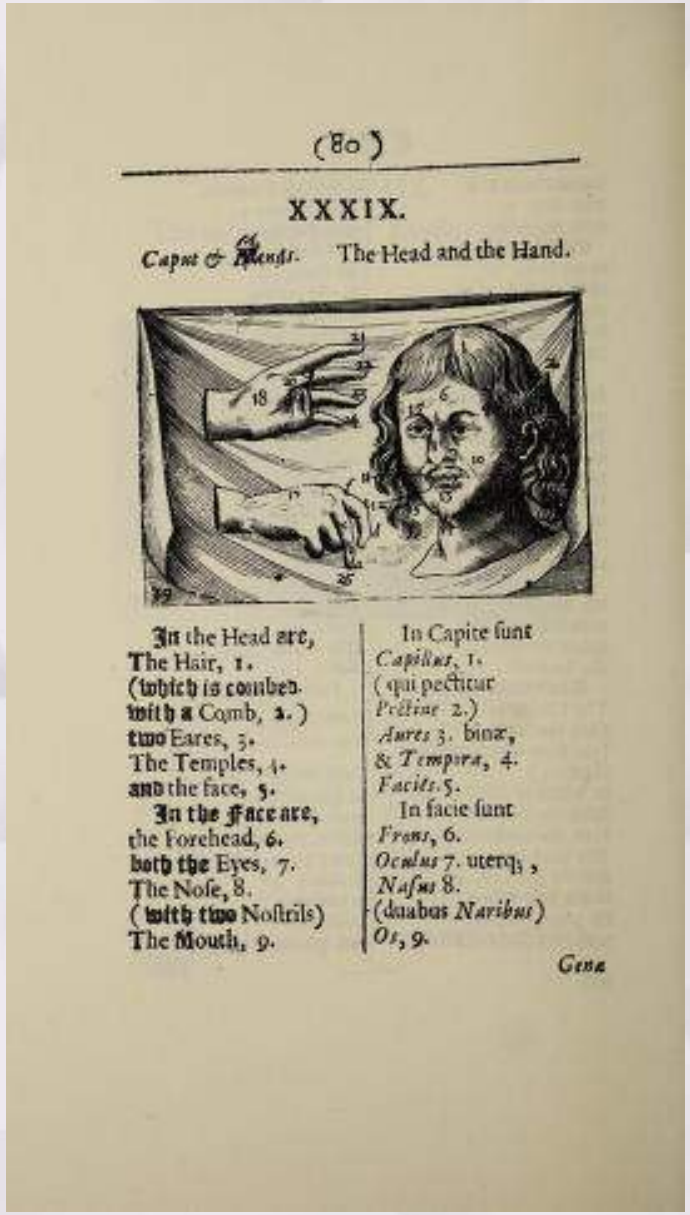
- Sumerian tables (2000 BCE)
- Ibn Khaldun (1377)
  - children should first be taught calculation,
  - divides sciences into two categories,
  - The perfect way of conveying ideas is eloquence
- The Treviso Arithmetic: Arte dell Abbaco (1478)
  - is the earliest known printed mathematics book in the West,
  - one of the first printed European textbooks dealing with a science.
  - It is a practical book intended for self-study.
- Comenius Orbis Sensalium Pictus (1658)



Comenius' extraordinary and revolutionary textbook, Orbis Sensalium Pictus (**1658**), enables us to see a cornucopia of meaning.

His method is iconic -- a method rarely used by historians of education -- and the result is uniquely illuminating.

The revolutionary book spread quickly across Europe and became the defining children's textbook for centuries



(80)

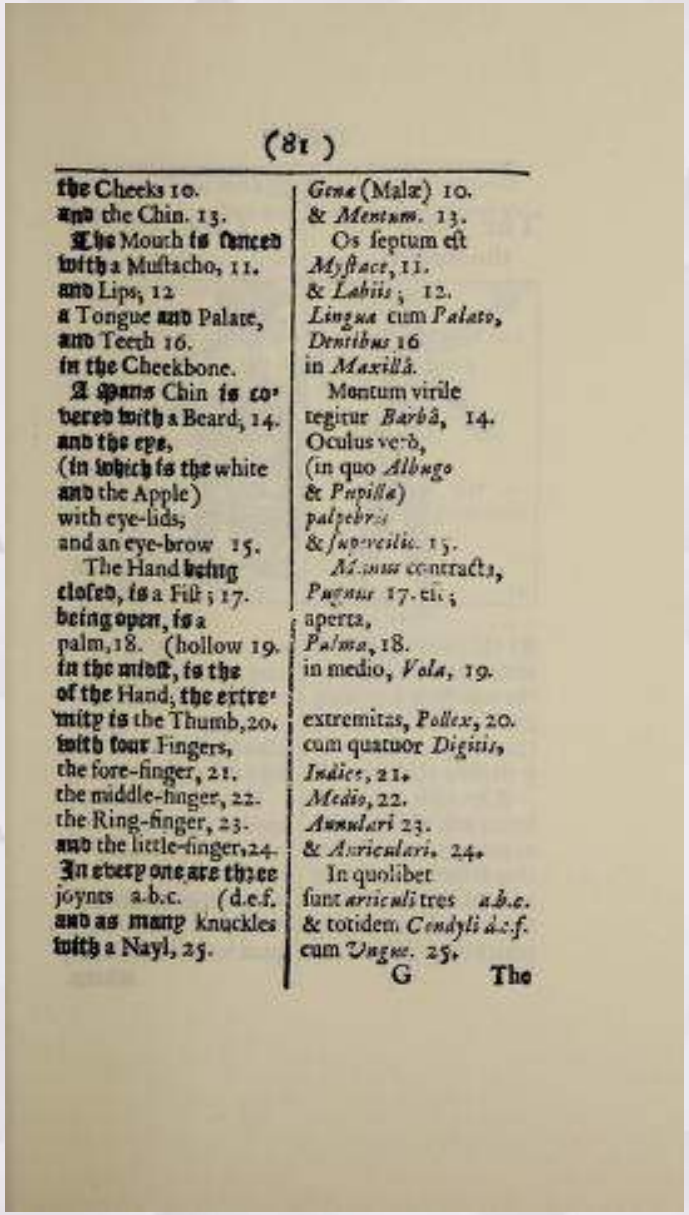
XXXIX.

Caput & Manus. The Head and the Hand.

In the Head are,
The Hair, 1.
(which is combed
with a Comb, 2.)
two Eares, 3.
The Temples, 4.
and the face, 5.
In the Face are,
the Forehead, 6.
both the Eyes, 7.
The Nose, 8.
(with two Noſtrils)
The Mouth, 9.

In Capite ſunt
Capillus, 1.
(qui pectitur
Pecten 2.)
Aures 3. binæ,
& *Tempora*, 4.
Facies. 5.
In facie ſunt
Frons, 6.
Oculus 7. utercq;
Naſus 8.
(duabus *Naribus*)
Os, 9.

Gena



(81)

the Cheeks 10.
and the Chin. 13.
The Mouth is fenced
with a Muſtacho, 11.
and Lips, 12
a Tongue and Palate,
and Teeth 16.
in the Cheekbone.
A mans Chin is co-
vered with a Beard, 14.
and the eye,
(in which is the white
and the Apple)
with eye-lids,
and an eye-brow 15.
The Hand being
cloſed, is a Fiſt; 17.
being open, is a
palm, 18. (hollow 19.
in the midſt, is the
of the Hand; the extre-
mity is the Thumb, 20.
with four Fingers,
the fore-finger, 21.
the middle-finger, 22.
the Ring-finger, 23.
and the little-finger, 24.
In every one are three
joynts a.b.c. (d.e.f.
and as many knuckles
with a Nayl, 25.

Gena (Malæ) 10.
& *Mentum*. 13.
Os ſeptum eſt
Myſtace, 11.
& *Labiis*; 12.
Lingua cum *Palato*,
Dentibus 16
in *Maxillâ*.
Mentum virile
tegitur *Barbâ*, 14.
Oculus verò,
(in quo *Albugo*
& *Pupilla*)
palpebris
& *ſupercilio*. 15.
Manus contracta,
Pugnus 17. eſt;
aperta,
Palma, 18.
in medio, *Vola*, 19.

extremitas, *Pollex*, 20.
cum quatuor *Digitis*,
Indice, 21.
Medio, 22.
Annulari 23.
& *Auriculari*. 24.
In quolibet
ſunt *articuli* tres *a.b.c.*
& totidem *Condyli d.e.f.*
cum *Ungue*. 25.

G The

According to Thompson's preface, Orbis' fame and lasting usefulness is due to its ingenious integration of 3 characteristics:

- **encyclopedism**
- **bilingualism**
- **visual imagery**

Now, there is nothing in our understanding that has not passed through our senses.

Exercising our senses in correct perception of differences between things means laying the foundations for all wisdom, all wise discourse and all wise acts in life.

- Comenius

Orbis Sensualium Pictus was revolutionary However, it focused in

(82)

XL.

The Flesh and the Bowels. *Caro & Viscera.*

The Body are ꝑ Skin with the Membranes, the flesh with ꝑ muscles, the Chanels, the Grissles, ꝑ bones & the bowels

The Skin 1. being pull'd off ꝑ flesh appeareth, not in a continued lump, but being distributed, as it were into stuft puddings which they call muscles

In *Corpore* sunt *Cutis* cum *Membranis*, *Caro* cum *Musculis*, *Canales*, *Cartilagines*, *Ossa* & *Viscera*.

Detracta *Cute* 1. apparet *Caro* 2. non continua massa, sed distributa, tanquam in farcimina, quod vocant *Musculos*, where-

Encyclopedic facts

No connecting ideas, algorithms, or computational thinking

Several natural (vernacular) languages in parallel

No logical or mathematical languages

Passive reading

No active actions, no coloring, writing explanations, posing problems

Isolated reader

No explicit social learning

Hierarchical teaching

No dialogic pedagogy

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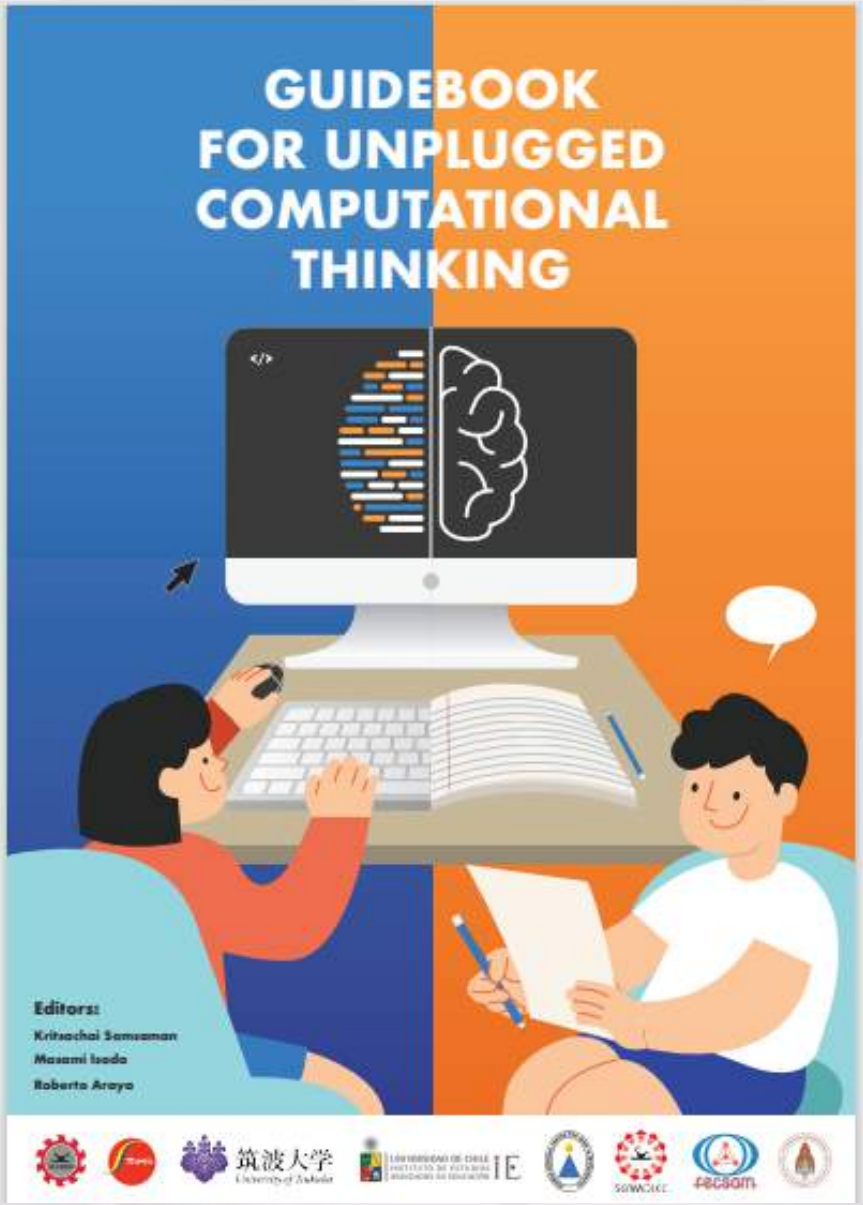
GUIDEBOOK
FOR UNPLUGGED
COMPUTATIONAL
THINKING
Editors:
Kritsadhai Sumsaman
Masami Isoda
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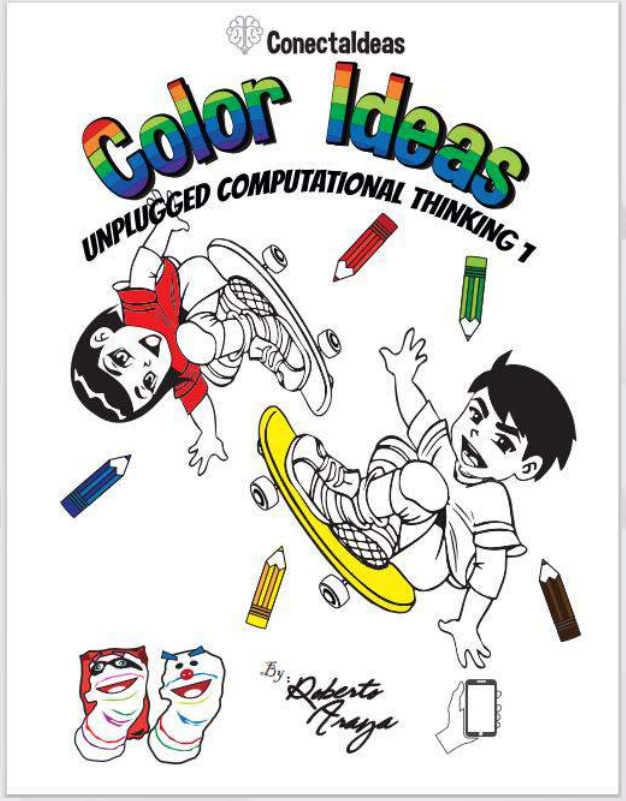
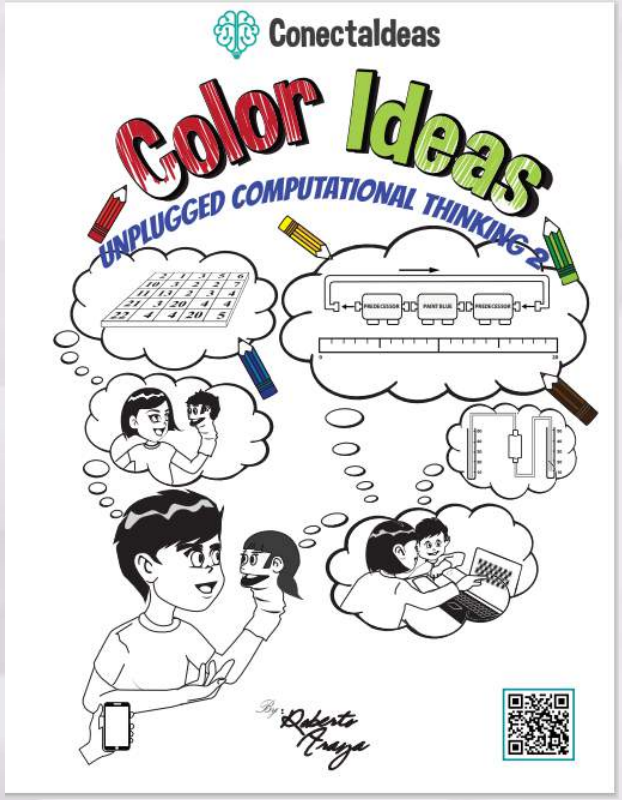
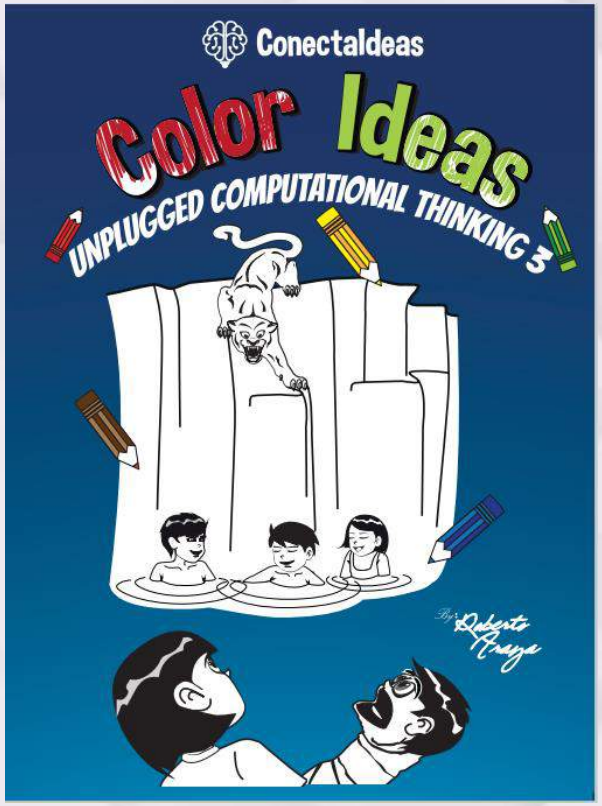

Conectaldeas
Color Ideas
UNPLUGGED COMPUTATIONAL THINKING 1
By: Roberto Araya


Conectaldeas
Color Ideas
UNPLUGGED COMPUTATIONAL THINKING 2
By: Roberto Araya


Conectaldeas
Color Ideas
UNPLUGGED COMPUTATIONAL THINKING 3
By: Roberto Araya

First-order logic

WRITE AND PAINT

PAINT WHERE THE CARD IS MOST LIKELY TO BE

EXPLAIN IN YOUR OWN WORDS HOW YOU FOUND THE CARD

9A

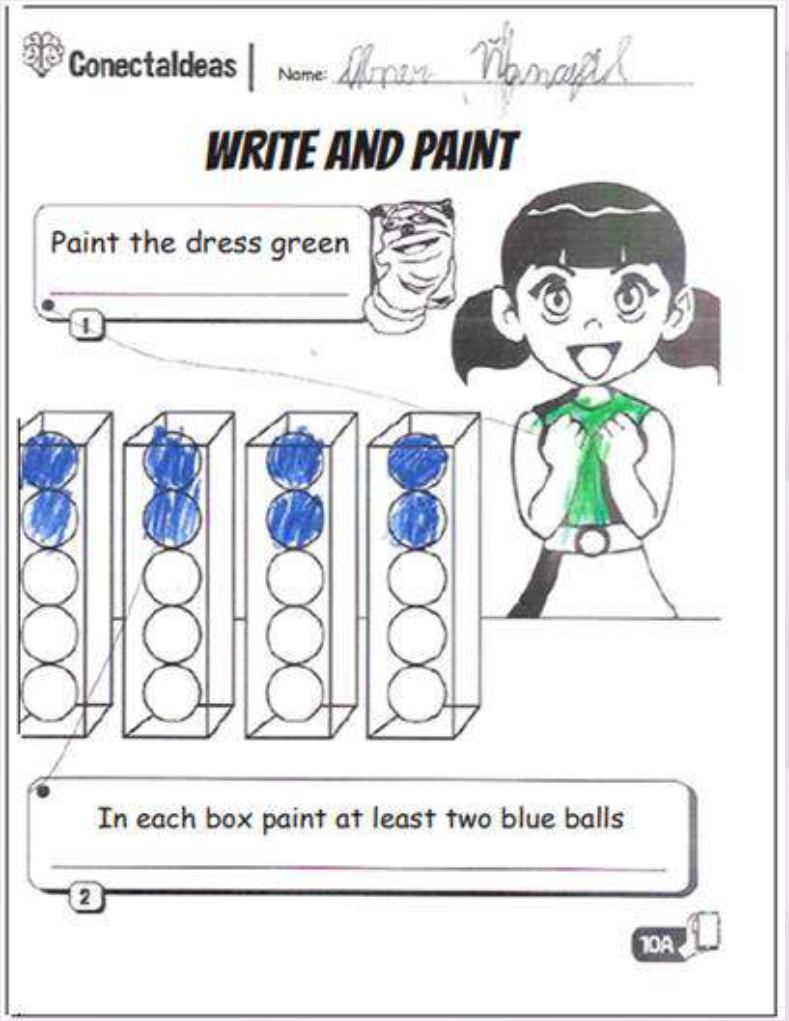
Conectaldeas | From: _____ To: _____

WRITE AND PAINT

1

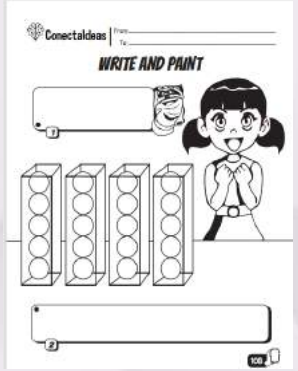
13B

Universal and existential quantifiers



https://youtu.be/XvhuUz-j9EY

Are these 6 instructions really different?



Which ones are the same?

a) Choose a color and in each box paint at least 2 balls of that color

b) In each box choose a color and paint at least 2 balls of that color

c) In each box for at least 2 balls choose a color to paint them

d) Choose a color and in at least 2 boxes paint each ball of that color

e) In at least 2 boxes choose a color and paint each ball of that color

f) In at least 2 boxes for each ball choose a color to paint them

Steepest descent algorithm

Conectaldeas | Name: _____

WRITE AND PAINT

EACH TIME PERRIN TAKES A STEP TO THE NEIGHBORING CELL WITH THE HIGHEST NUMBER, BUT IF THERE IS NO CELL HIGHER THAN THE ONE HE'S IN, THEN HE STAYS THERE

PAINT IN RED THE PATH THAT PERRIN FOLLOWS, STARTING FROM THE TOP WHERE NUMBER 2 IS LOCATED

2	1	3	5	6	3	3	4	3	0
10	3	2	2	7	4	5	5	4	2
11	13	2	3	4	9	10	3	14	13
21	3	20	4	4	19	5	15	4	3
22	4	4	20	5	25	6	16	25	5
30	24	5	18	6	25	6	6	19	4
32	4	6	16	6	17	6	6	4	4
2	4	26	15	12	19	27	35	25	15
32	34	36	37	38	10	47	41	35	14
38	44	35	8	39	28	29	38	18	13
11	4	4	6	40	38	9	10	11	12
0	0	3	4	41	8	8	5	4	2

HOW DO YOU TALK TO YOUR INNER VOICE?

EXPLAIN IN YOUR OWN WORDS IF PERRIN MEETS PERRON WHO STARTS FROM THE BOTTOM 2

10A

Conectaldeas | From: _____ To: _____

WRITE AND PAINT

2	1	3	5	6	3	3	4	3	0
10	3	2	2	7	4	5	5	4	2
11	13	2	3	4	9	10	3	14	13
21	3	20	4	4	19	5	15	4	3
22	4	4	20	5	25	6	16	25	5
30	24	5	18	6	25	6	6	19	4
32	4	6	16	6	17	6	6	4	4
2	4	26	15	12	19	27	35	25	15
32	34	36	37	38	10	47	41	35	14
38	44	35	8	39	28	29	38	18	13
11	4	4	6	40	38	9	10	11	12
0	0	3	4	41	8	8	5	4	2

WHAT DOES YOUR INNER VOICE SUGGEST TO YOU?

10B

Journal of Steroid Biochemistry and Molecular Biology 241 (2024) 106499

Contents lists available at ScienceDirect

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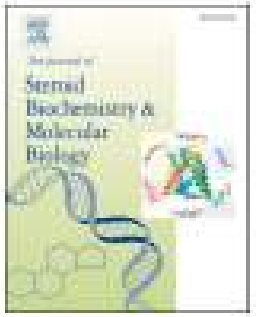
journal homepage: www.elsevier.com/locate/jsbmb



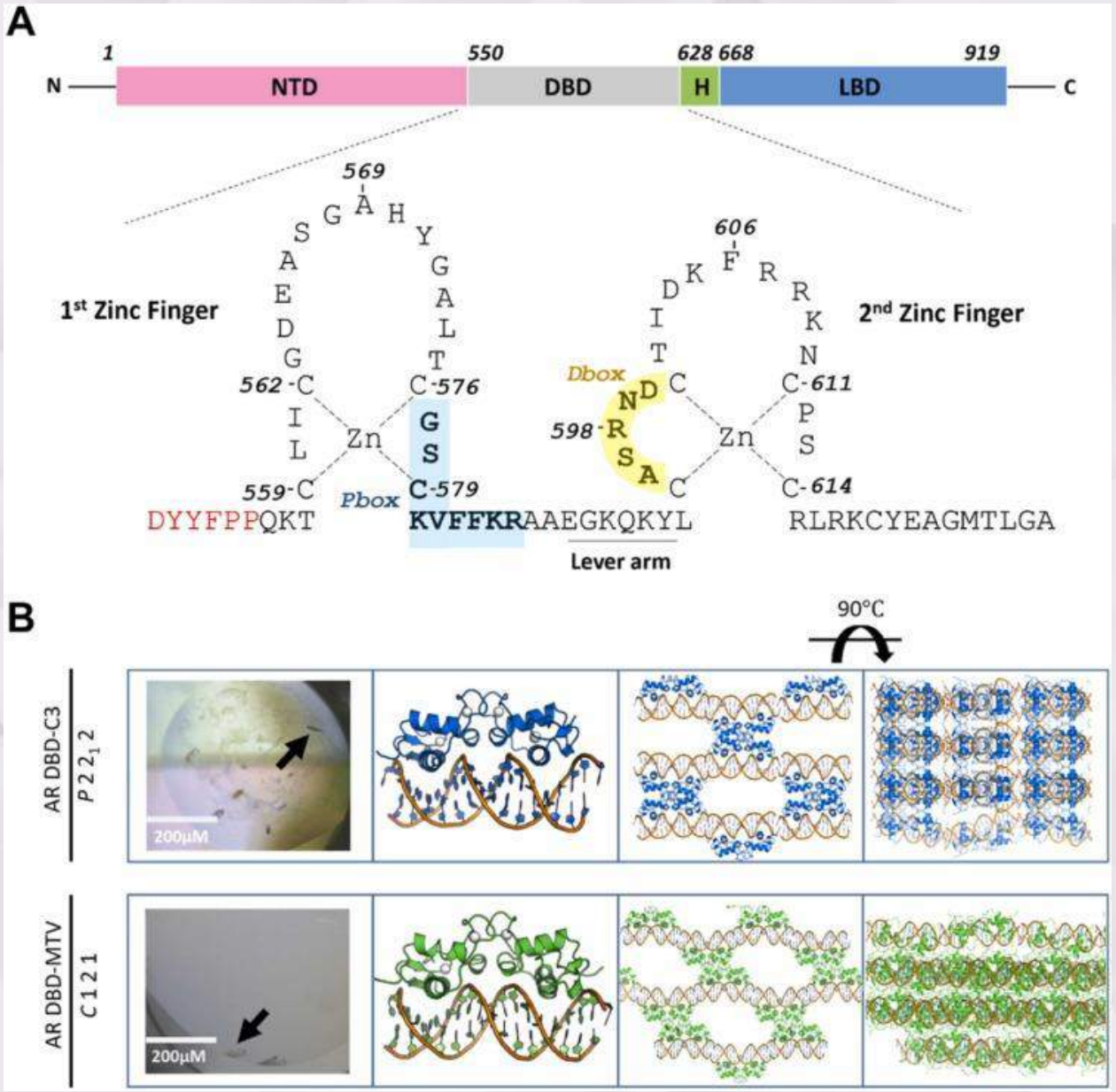
Structural mechanism underlying variations in DNA binding by the androgen receptor

Xiao Yin Lee [a,1], Wout Van Eynde [b,1], Christine Helsen [a], Hanne Willems [a], Kaat Peperstraete [a], Sofie De Block [a], Arnout Voet [b], Frank Claessens [a,*]

[a] Molecular Endocrinology Laboratory, Department of Cellular and Molecular Medicine, Campus Gasthuisberg ON1 Herestraat 49 - box 901, Leuven 3000, Belgium
[b] Department of Chemistry, Laboratory of Biomolecular Modelling and Design, Heverlee 3001, Belgium

Androgens are hormones such as testosterone. They play an essential role in the development and maintenance of male characteristics by affecting tissues of the male reproductive system as well as organs like kidneys, the musculoskeletal system, and the brain.

Androgen receptors allow the body to respond appropriately to these hormones



Protein construct of the Androgen Receptor DNA-binding domain (DBD) co-crystallization and the resulting crystal structures.

A) Schematic representation of the human AR-DBD.

B) The crystal packing of AR DBD.

mathematics

MDPI

Article

Enriching Elementary School Mathematical Learning with the Steepest Descent Algorithm

Roberto Araya

Centro de Investigación Avanzada en Educación, Instituto de Educación, Universidad de Chile, Santiago 8320000, Chile; roberto.araya.schulz@gmail.com

Abstract: The steepest descent (or ascent) algorithm is one of the most widely used algorithms in Science, Technology, Engineering, and Mathematics (STEM). However, this powerful mathematical tool is neither taught nor even mentioned in K12 education. We study whether it is feasible for elementary school students to learn this algorithm, while also aligning with the standard school curriculum. We also look at whether it can be used to create enriching activities connected to children's real-life experiences, thus enhancing the integration of STEM and fostering Computational Thinking. To address these questions, we conducted an empirical study in two phases. In the first phase, we tested the feasibility with teachers. In a face-to-face professional development workshop with 457 mathematics teachers actively participating using an online platform, we found that after a 10-min introduction they could successfully apply the algorithm and use it in a couple of models. They were also able to complete two complex and novel tasks: selecting models and adjusting the parameters of a model that uses the steepest descent algorithm. In a second phase, we tested the feasibility with 90 fourth graders from 3 low Socioeconomic Status (SES) schools. Using the same introduction and posing the same questions, we found that they were able to understand the algorithm and successfully complete the tasks on the online platform. Additionally, we found that close to 75% of the students completed the two complex modeling tasks and performed similarly to the teachers.

Citation: Araya, R. Enriching

Р. АРАЙЯ,
Чили

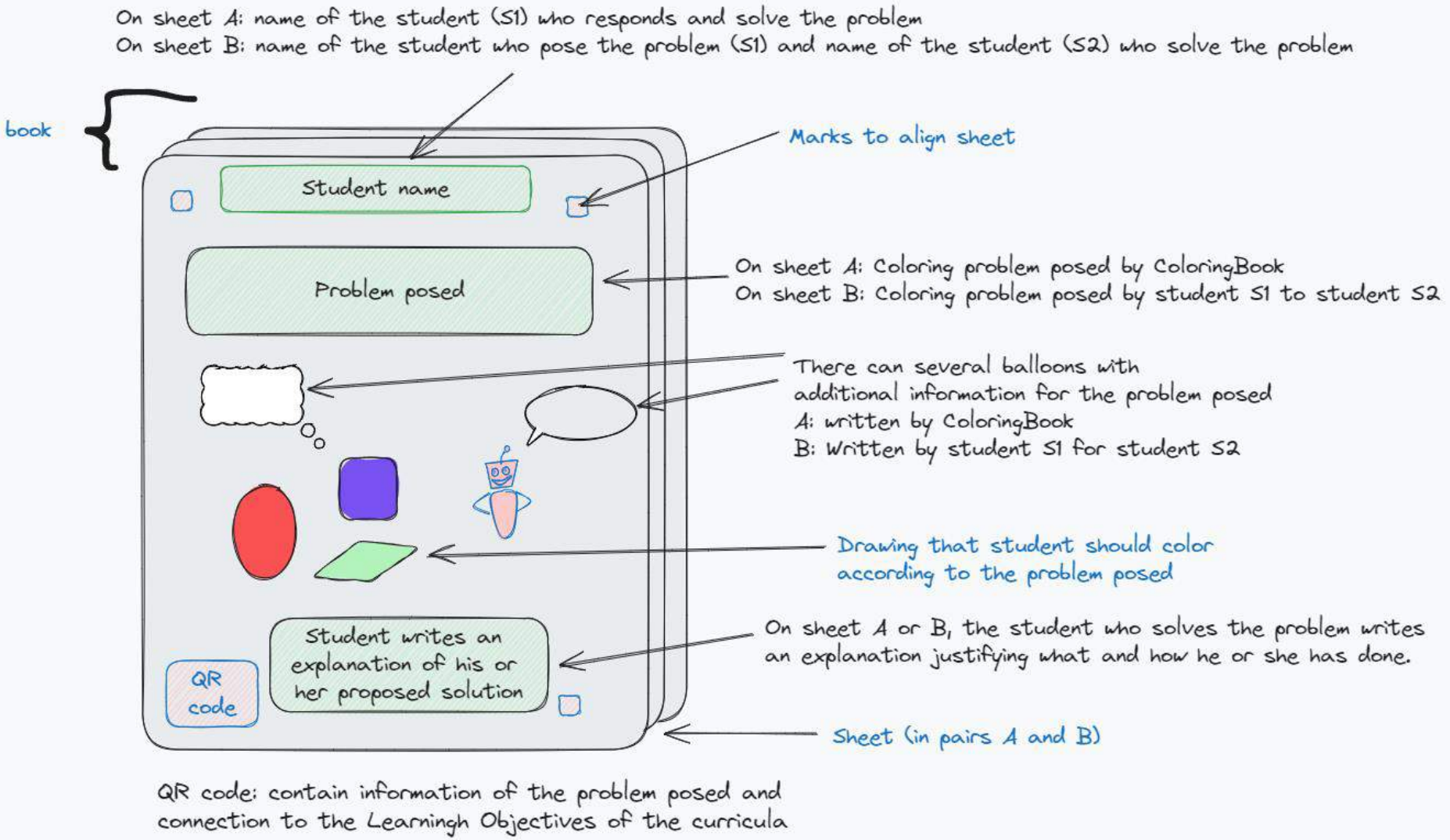
(Roberto Araya Shulz, профессор. Centro de Investigación Avanzada en Educación, Instituto de Educación, Universidad de Chile)

Перевод и обзор Ю. Тюриной
под редакцией И. Высоцкого

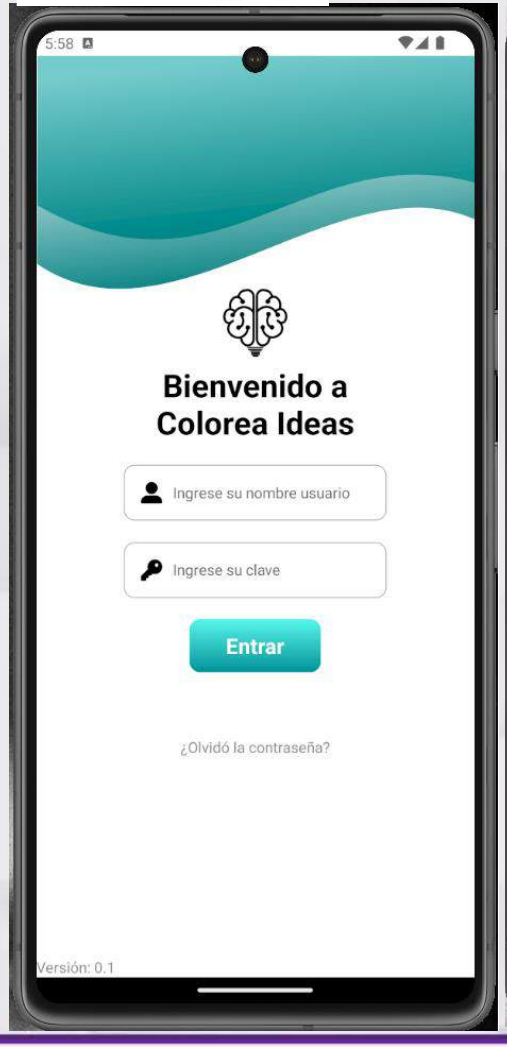
АЛГОРИТМ НАИСКОРЕЙШЕГО СПУСКА ДЛЯ НАЧАЛЬНОЙ ШКОЛЫ

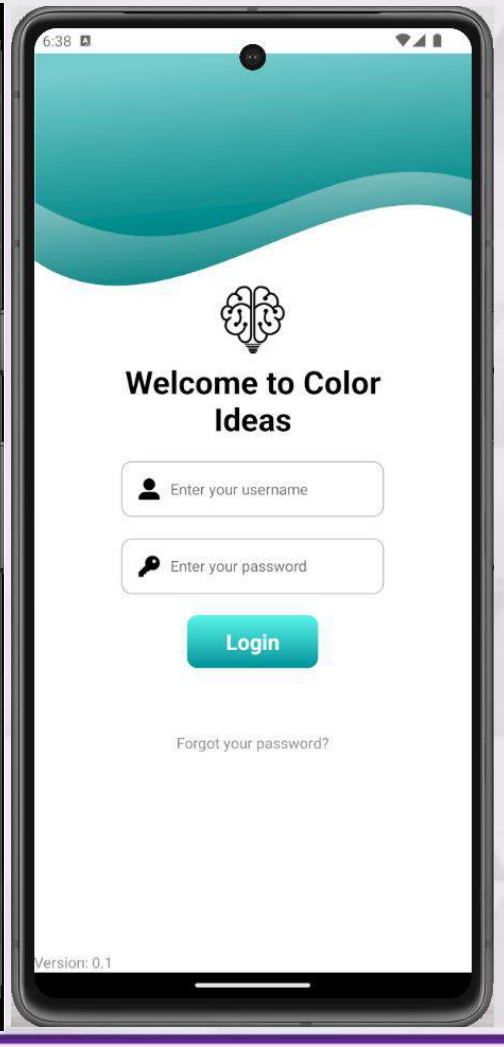
Введение и мотивация

2	1	3	5	6	3	3	4	3	0
10	2	2	2	7	4	5	5	4	2
11	13	2	3	4	9	10	3	14	13
21	3	19	4	4	19	5	14	4	3
22	4	4	40	5	25	6	16	25	5
30	24	5	18	6	25	6	6	19	4
32	4	6	16	6	17	6	6	4	4
2	4	26	15	12	19	27	35	25	15
32	34	36	37	38	10	47	41	35	14
38	44	35	8	39	28	29	38	18	13
11	4	4	6	40	38	9	10	11	12
0	5	3	4	41	8	8	5	4	2


On sheet A: name of the student (S1) who responds and solve the problem
On sheet B: name of the student who pose the problem (S1) and name of the student (S2) who solve the problem
book
Student name
Marks to align sheet
Problem posed
On sheet A: Coloring problem posed by ColoringBook
On sheet B: Coloring problem posed by student S1 to student S2
There can several balloons with additional information for the problem posed
A: written by ColoringBook
B: Written by student S1 for student S2
Drawing that student should color according to the problem posed
Student writes an explanation of his or her proposed solution
On sheet A or B, the student who solves the problem writes an explanation justifying what and how he or she has done.
QR code
Sheet (in pairs A and B)
QR code: contain information of the problem posed and connection to the Learningh Objectives of the curricula

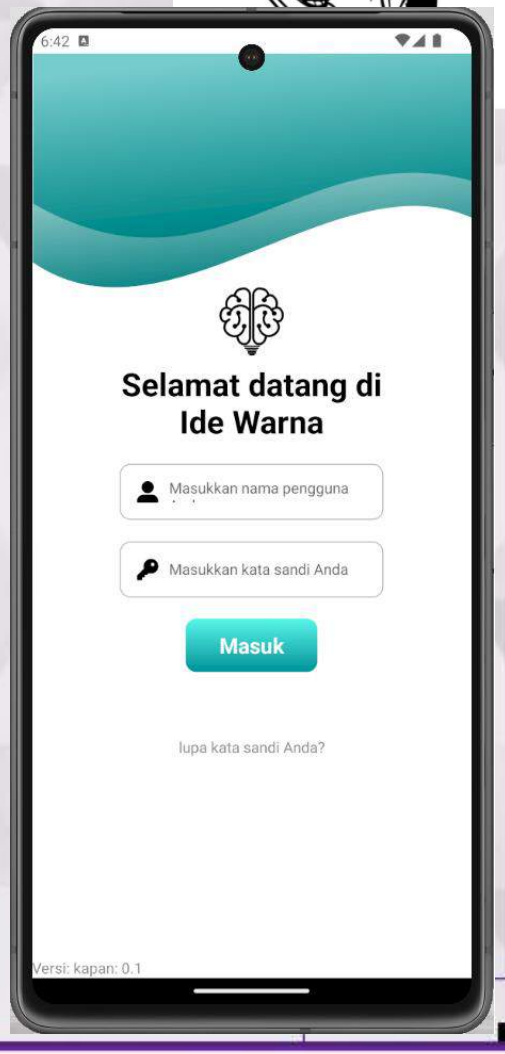
Login


5:58
Bienvenido a Colorea Ideas
Ingrese su nombre usuario
Ingrese su clave
Entrar
¿Olvidó la contraseña?
Versión: 0.1

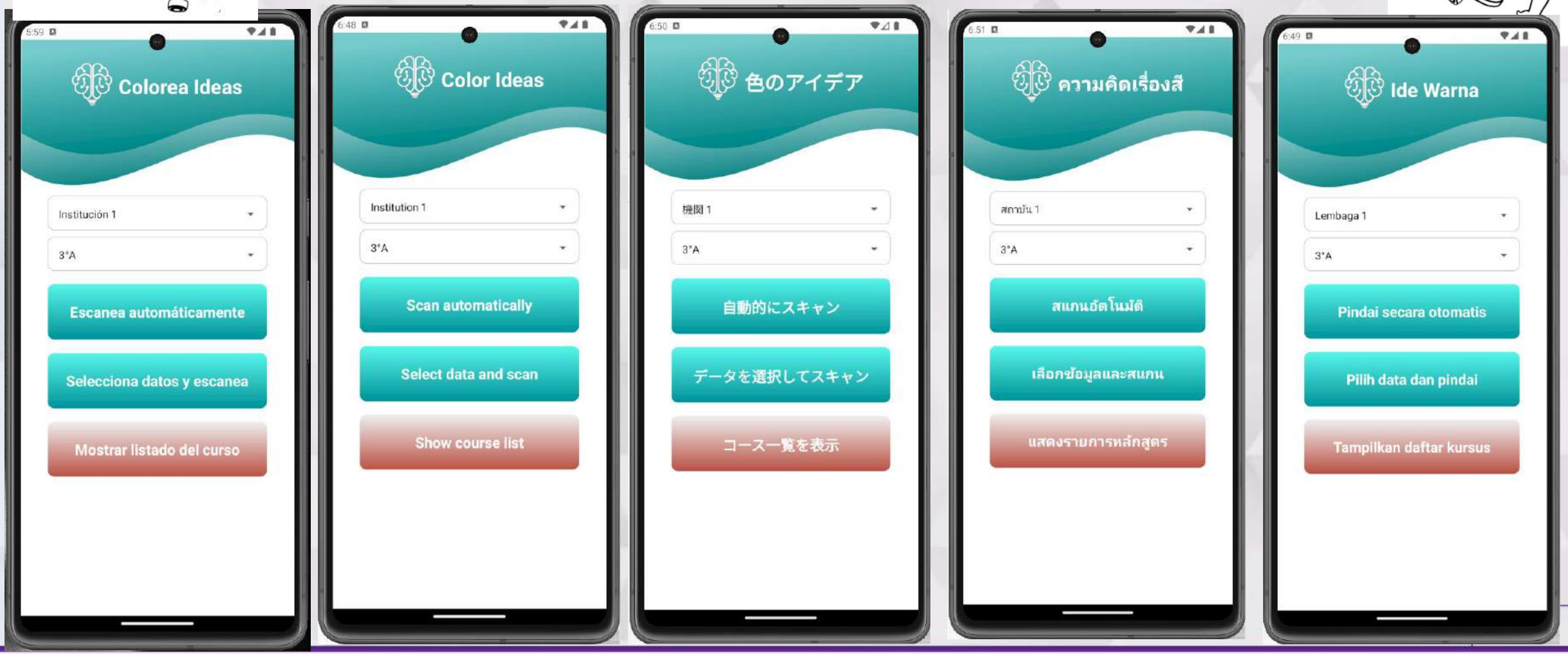

6:38
Welcome to Color Ideas
Enter your username
Enter your password
Login
Forgot your password?
Version: 0.1


6:43
へようこそ 色の アイデア
ユーザー名を入力して下さい
パスワードを入力してくださ
ログイン
パスワードをお忘れですか
バージョン: 0.1

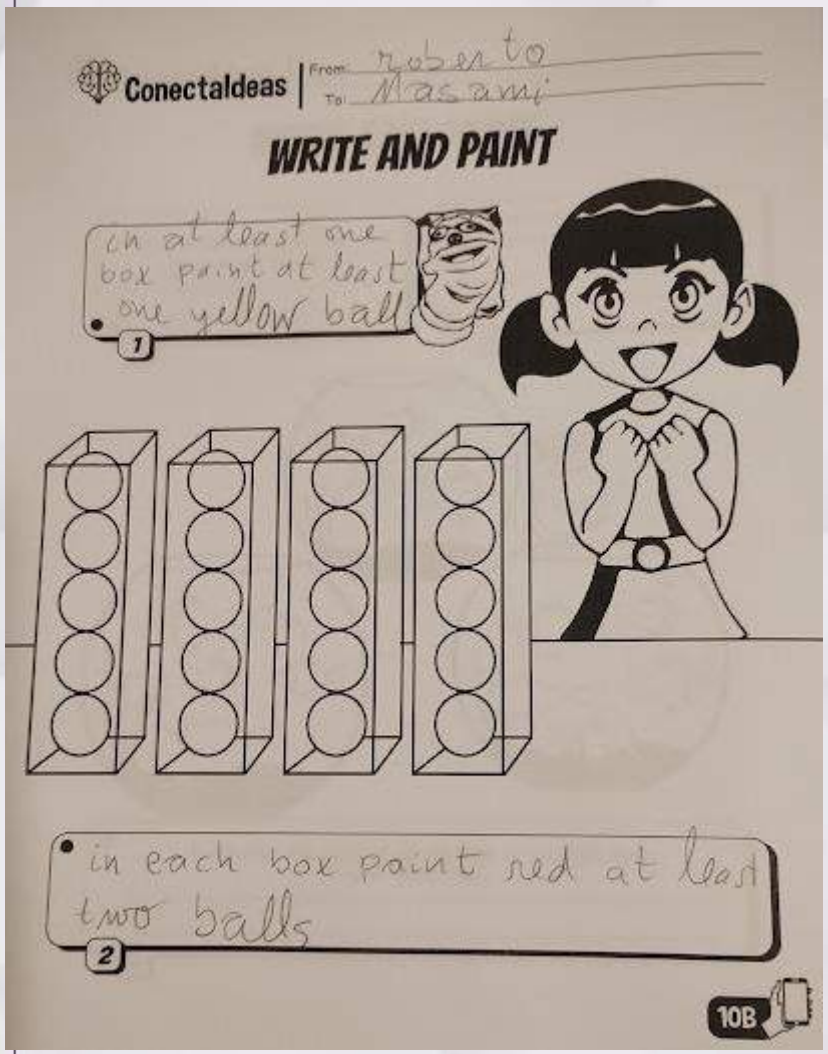

6:44
ยินดีต้อนรับสู่ ความคิดเรื่องสี
กรอกชื่อผู้ใช้ของคุณ
ใส่รหัสผ่านของคุณ
เข้าไป
ลืมรหัสผ่านหรือไม่?
เวอร์ชัน: 0.1

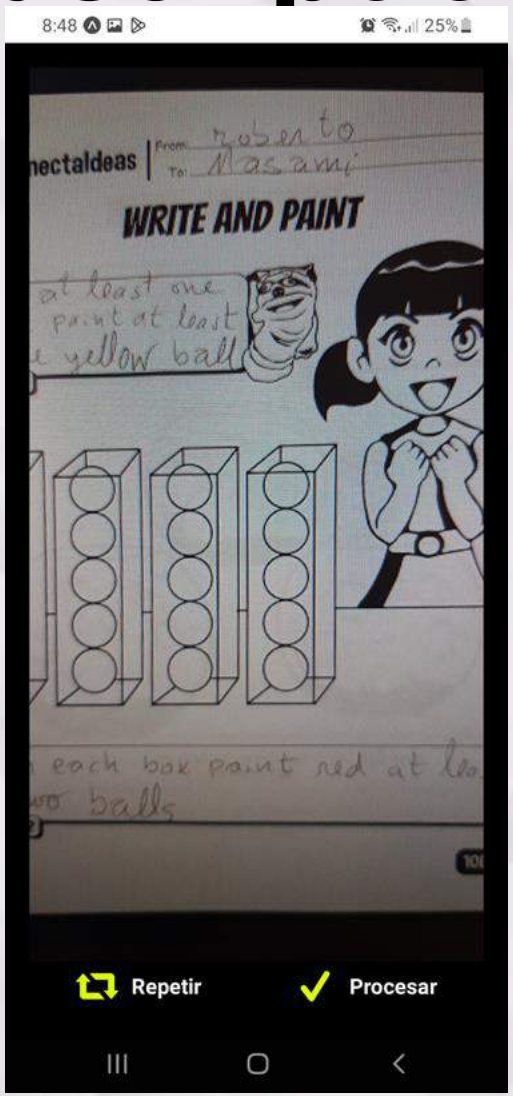

6:42
Selamat datang di Ide Warna
Masukkan nama pengguna
Masukkan kata sandi Anda
Masuk
lupa kata sandi Anda?
Versi: kapan: 0.1

1st Menu


Colorea Ideas
Institución 1
3°A
Escanea automáticamente
Selecciona datos y escanea
Mostrar listado del curso
Color Ideas
Institution 1
3°A
Scan automatically
Select data and scan
Show course list
色のアイデア
機関 1
3°A
自動的にスキャン
データを選択してスキャン
コース一覧を表示
ความคิดเรื่องสี
สถาบัน 1
3°A
สแกนอัตโนมัติ
เลือกข้อมูลและสแกน
แสดงรายการหลักสูตร
Ide Warna
Lembaga 1
3°A
Pindai secara otomatis
Pilih data dan pindai
Tampilkan daftar kursus

App manuscript transcription





Conectaldeas

From: roberto
To: Masami

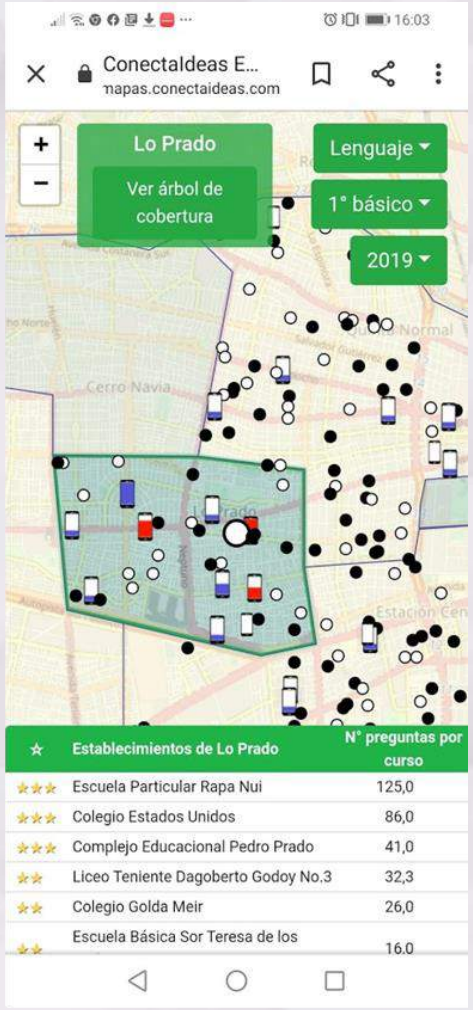
WRITE AND PAINT

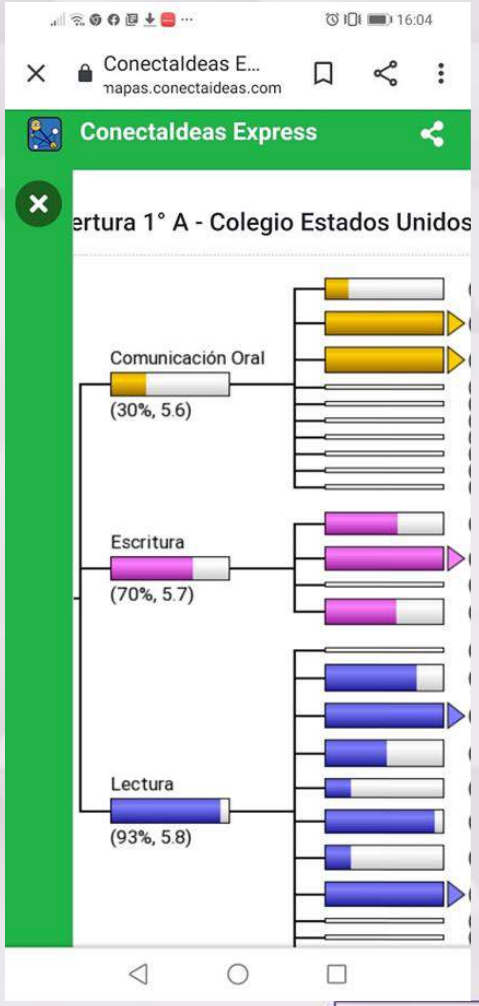
in at least one box paint at least one yellow ball

in each box paint red at least two balls

10B

Big data with students´ activities





CIAE
CENTRO DE INVESTIGACIÓN AVANZADA EN EDUCACIÓN

UNIVERSIDAD DE CHILE
INSTITUTO DE ESTUDIOS AVANZADOS EN EDUCACIÓN
IE

On Computational Thinking

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Thank you

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