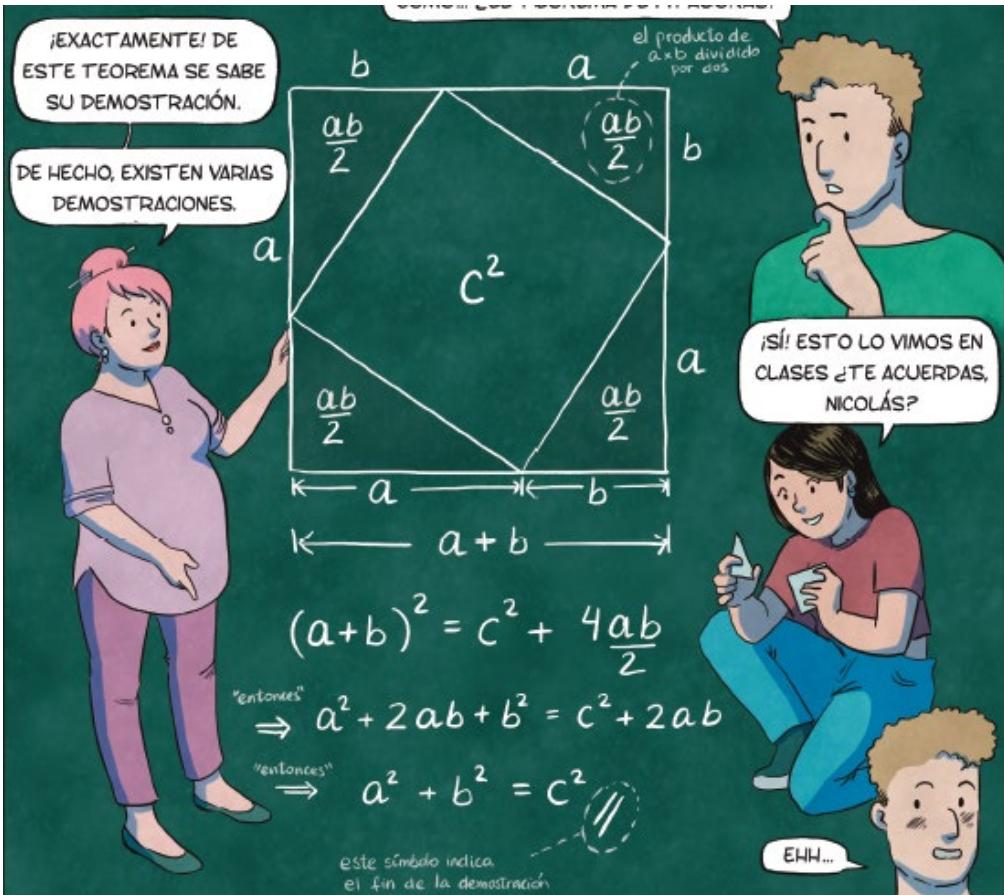


Visualizing mathematics with sketchnotes and comics

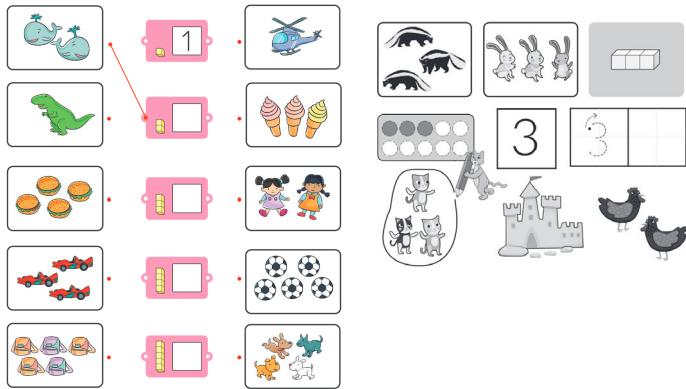


Constanza Rojas-Molina
CY Cergy Paris Université
www.crojasmolina.com

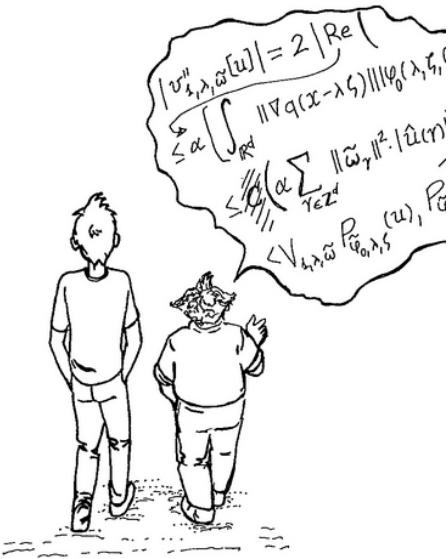
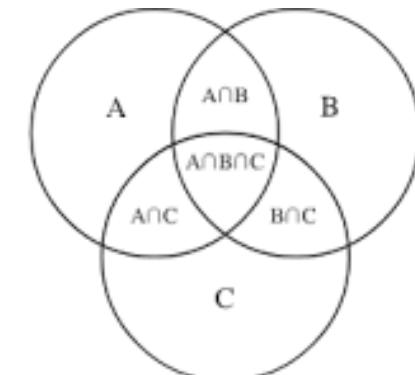
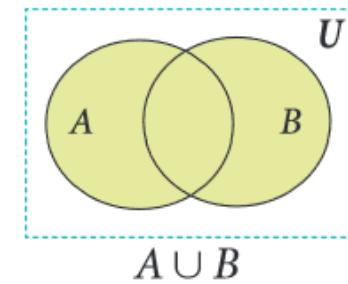
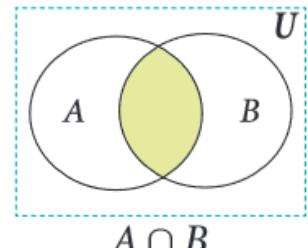
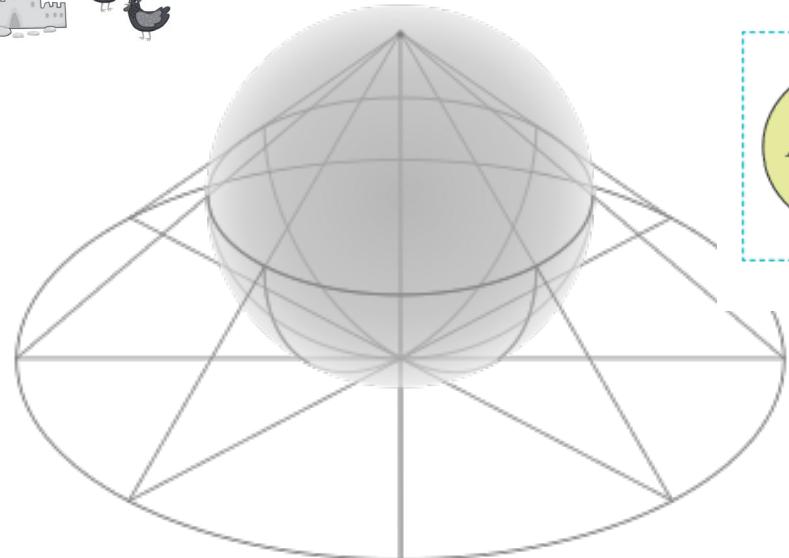


@e.a.casanova

Maths: a visual language



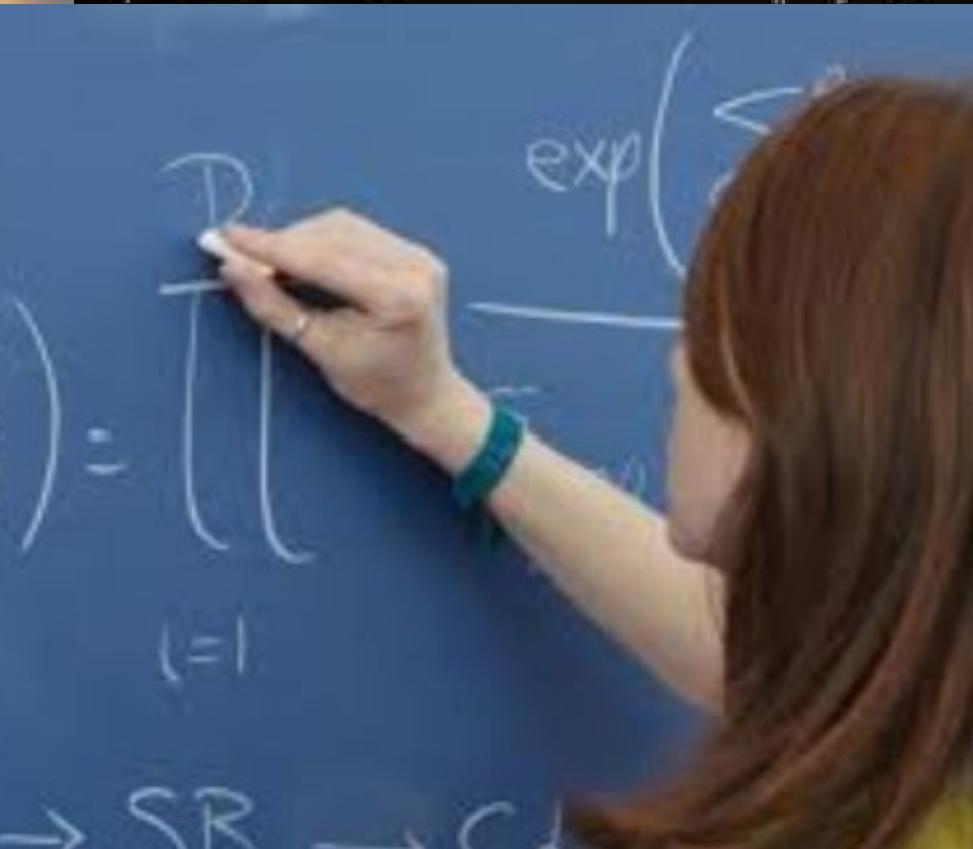
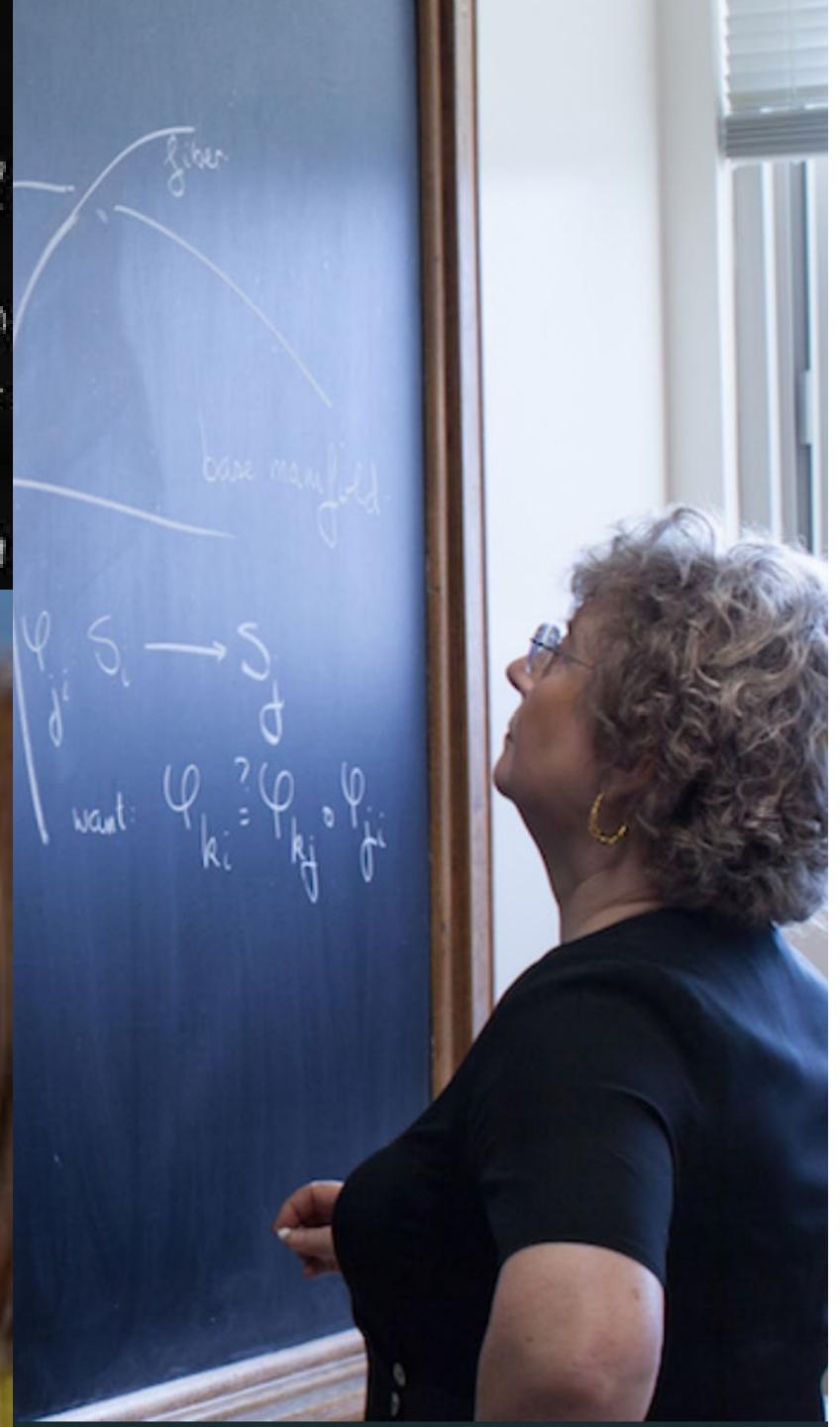
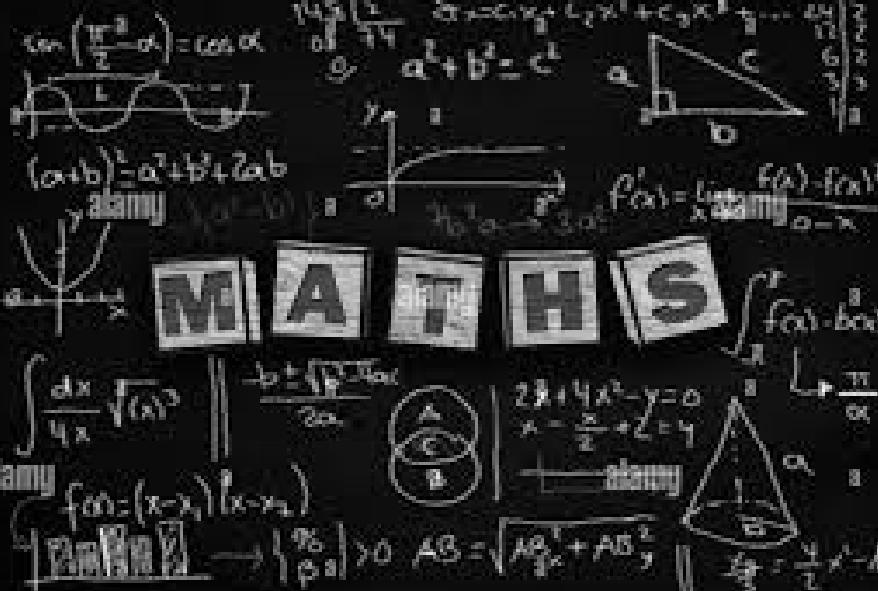
$$(X, Y) = \left(\frac{x}{1-z}, \frac{y}{1-z} \right)$$



I. Sketchnotes (visual note-taking)

(A very personal point of view!)

II. Comics, A sequential art



I. Sketchnotes

(visual note-taking)

I. Sketchnotes

the 5 Basic Elements



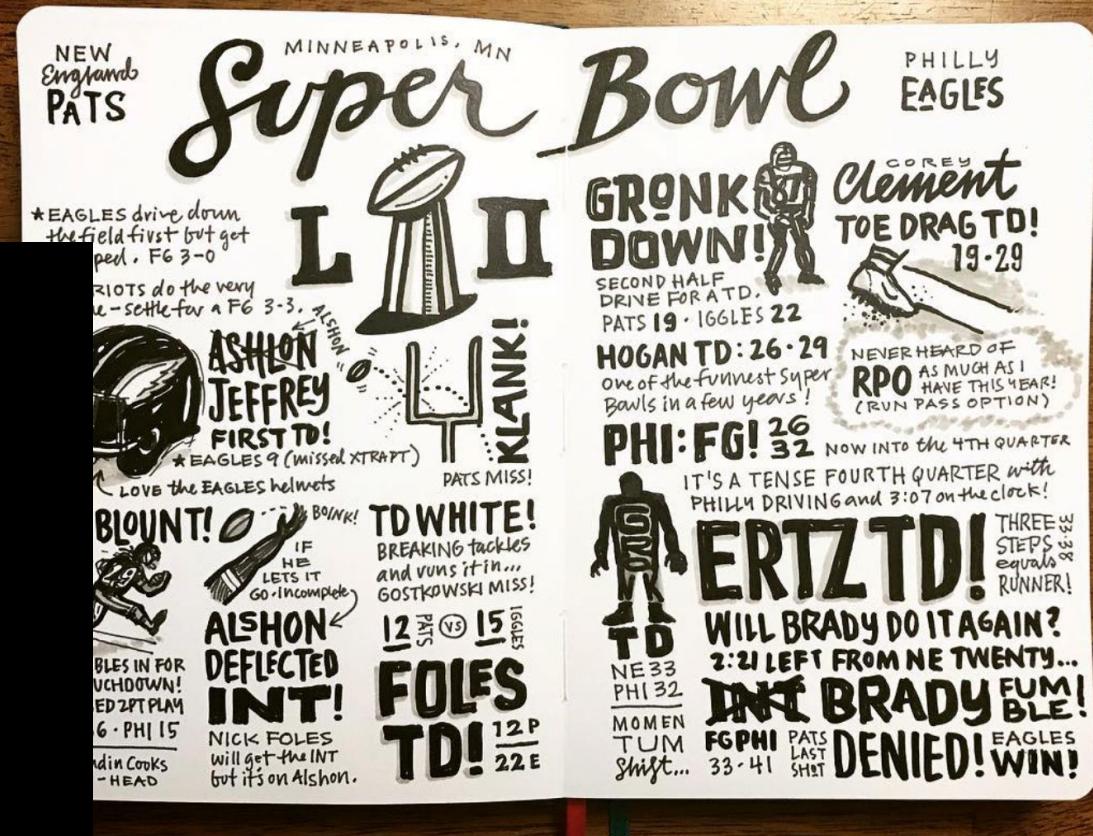
EVERYTHING YOU WANT TO DRAW CAN BE CREATED WITH THESE 5 ELEMENTS.

Can you identify the 5 basic elements in these simple drawings?

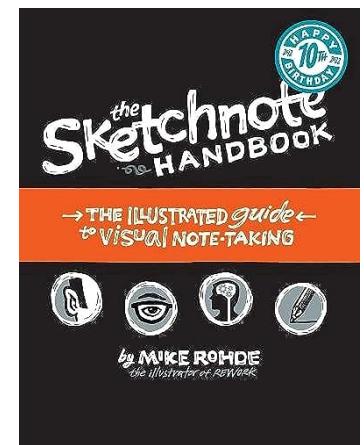


ONCE YOU REALIZE how the objects around you are made from these 5 elements, it becomes easier to draw all sorts of things.

IDEAS. NOT ART!



Mike Rohde,
The Sketchnote
Handbook.



#Noethember (2018)

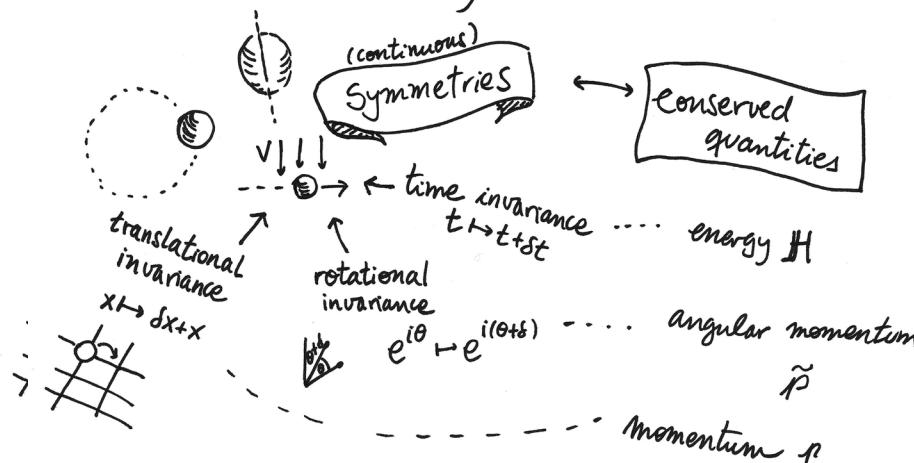
30 days of drawings about Emmy Noether

In collab with the blog The Aperiodical, UK

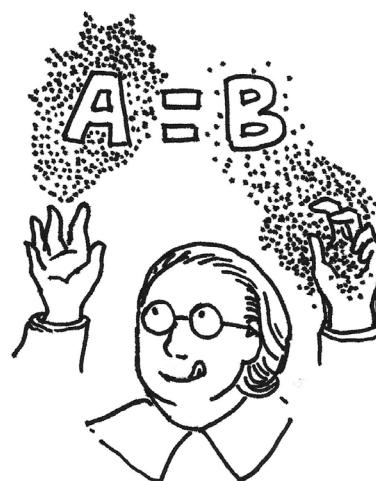
#Noethember Day 19



#Noethember Day 22



#Noethember Day 23



The Aperiodical

Excerpt from the List of Prompts

19. Much of Noether's work in abstract algebra was studying rings – sets of objects with two different ways to combine them – such as the ring of whole numbers (integers) with addition and multiplication. Of particular interest are ideals, which are particular subsets of a ring.

22. Noether's (first) theorem states that every differentiable symmetry of the action of a physical system has a corresponding conservation law. It explains the mathematical origin of conservation of energy and momentum in physics.

23. "If one proves the equality of two numbers A and B by showing first that $A \leq B$ and then that $B \leq A$ it is unfair; one should instead show that they are really equal by disclosing the inner ground for their equality." – Emmy Noether

Bibliography

Emmy Noether in Bryn Mawr (Springer, 1983)

Emmy Noether, on Wikipedia

#Noethember (2018)

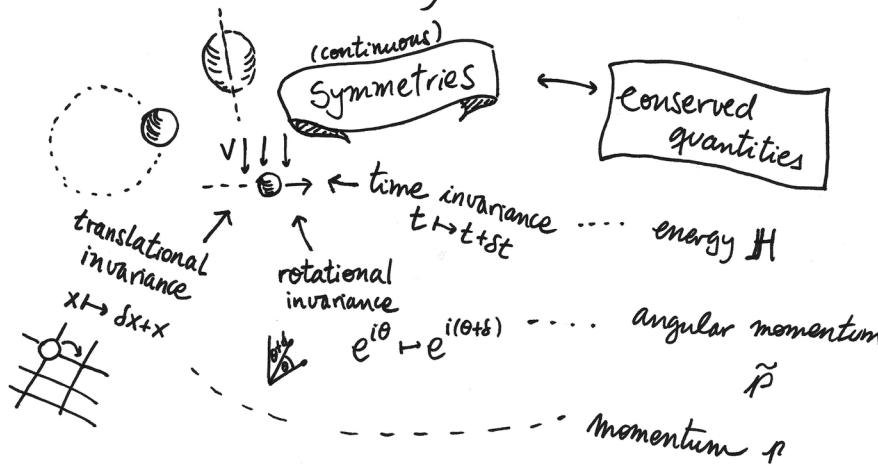
30 days of drawings about Emmy Noether

In collab with the blog The Aperiodical, UK

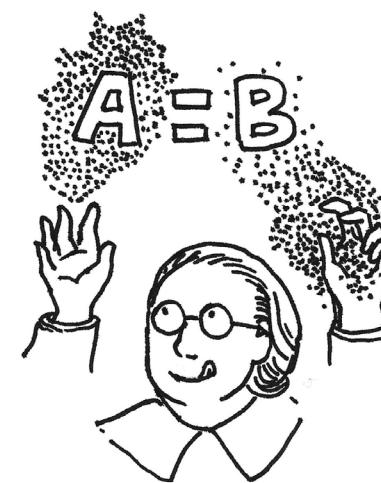
#Noethember Day 19



#Noethember Day 22



#Noethember Day 23



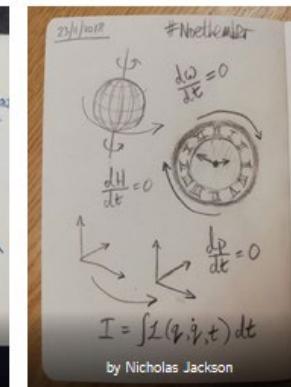
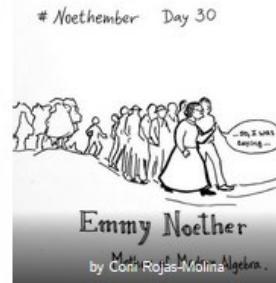
The Aperiodical

Search

You're reading: Events

#Noethember: a retrospective

By Katie Steckles and Constanza Rojas-Molina. Posted January 21, 2019 in Events



#Noethember (2018)

2018

Articles published in the US (Blog of the AMS), in France (Images de mathématiques), Spain, Italy, Germany.

2021

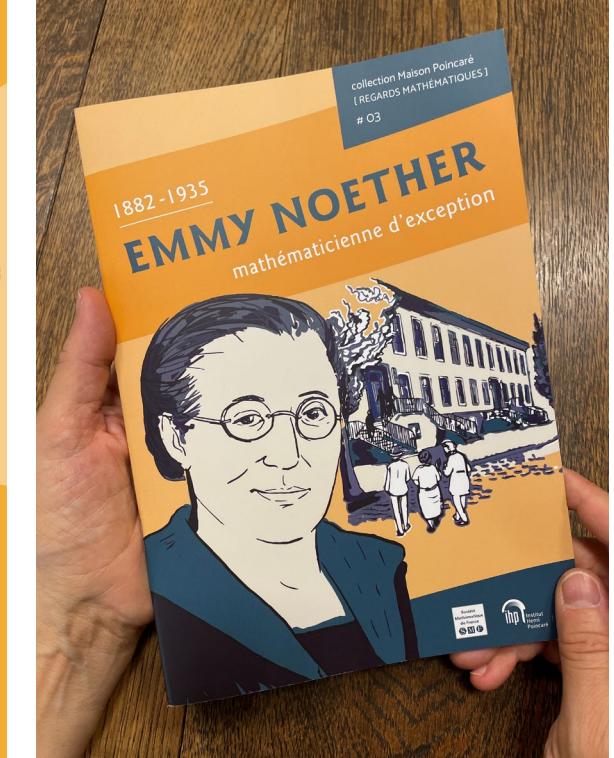
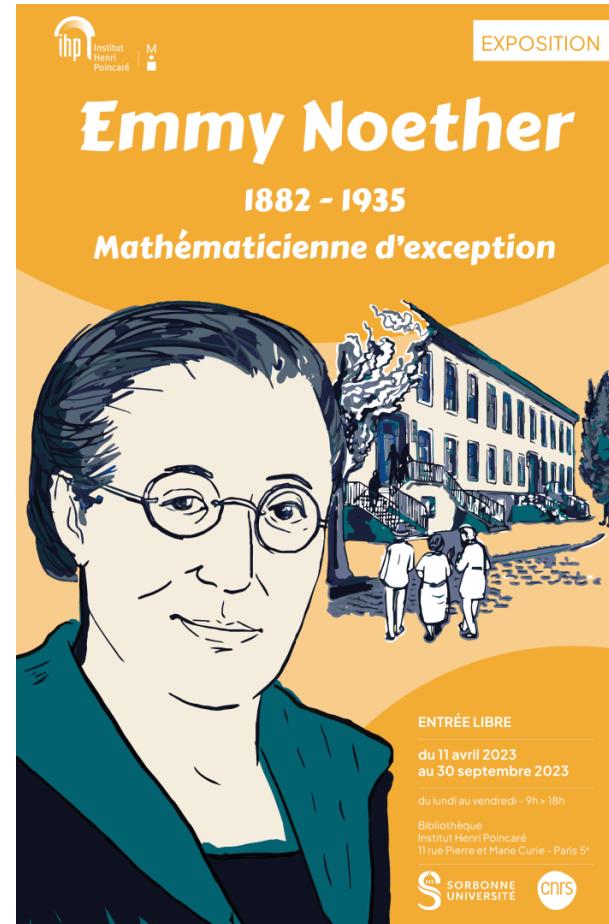
- Indian Mathematics Magazine Bhavana.

2023

- Exhibition on Emmy Noether, Institut Henri Poincaré (IHP), Paris.
- Maths/art residence Mathémartistes, U. of Angers, France.

2024

- Exhibition and reading of theater play by A. Panati (U. Toulon and Paris)



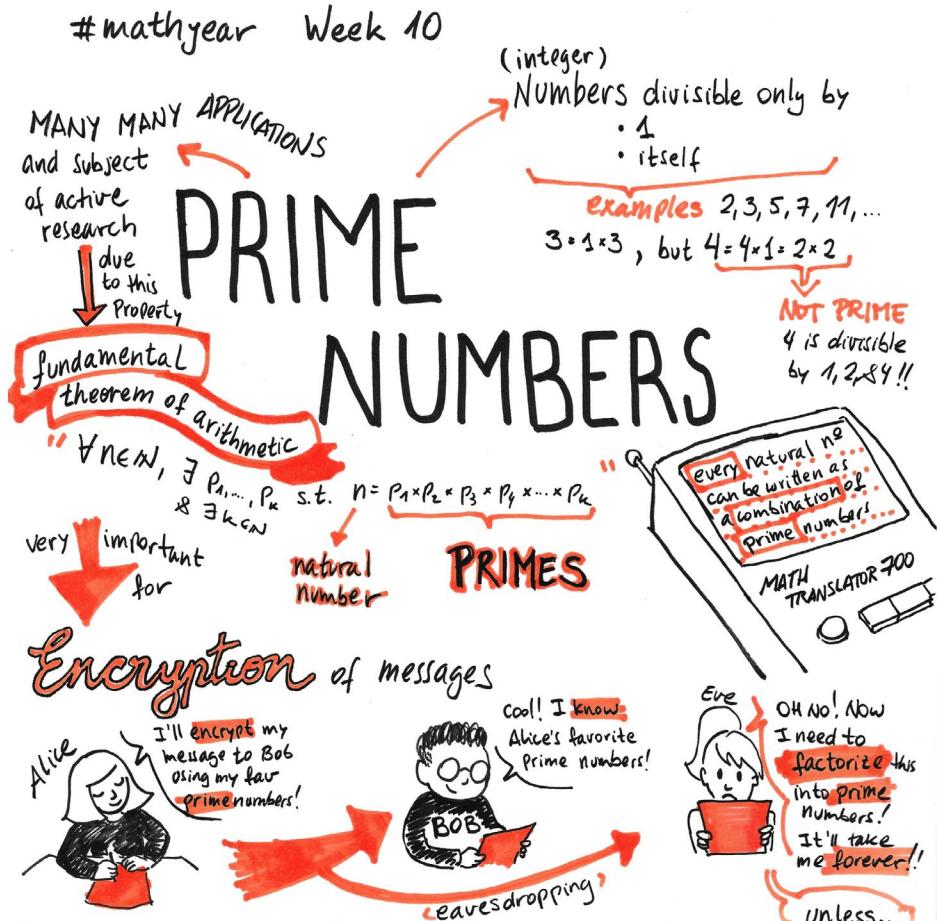
#Mathyear (2019--)

52 weeks of maths and its interactions

A drawing challenge



In collab with
Marlene Knoche
@sanguinikDE (DE)



In DMV magazine



The #mathyear challenge

< User's guide >

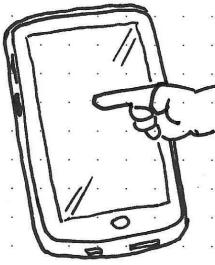


El desafío #mathyear

<manual de uso>

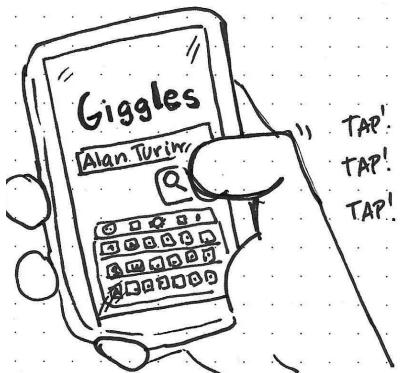


Lápices/
crayones/
marcadores



La lista de
temas

- 1 teléfono Smartphone
- o 1 tableta
- o 1 compu



... y a dibujar!



15'-30' minutos
toma una
foto y subela
a redes sociales
con el hashtag

#mathyear

der mal- und skizzenblock.

50 Blatt
190 g/m²
20 x 20 cm

idee.



Lista de temas Abril- Julio

Abril: las matemáticas como un lenguaje

30.03-05.04. Noah Chomsky y la jerarquía de Chomsky
06.04-12.04. Teoría de automatas
13.04-19.04. Lenguajes de programación
20.04-26.04. Mi fórmula favorita

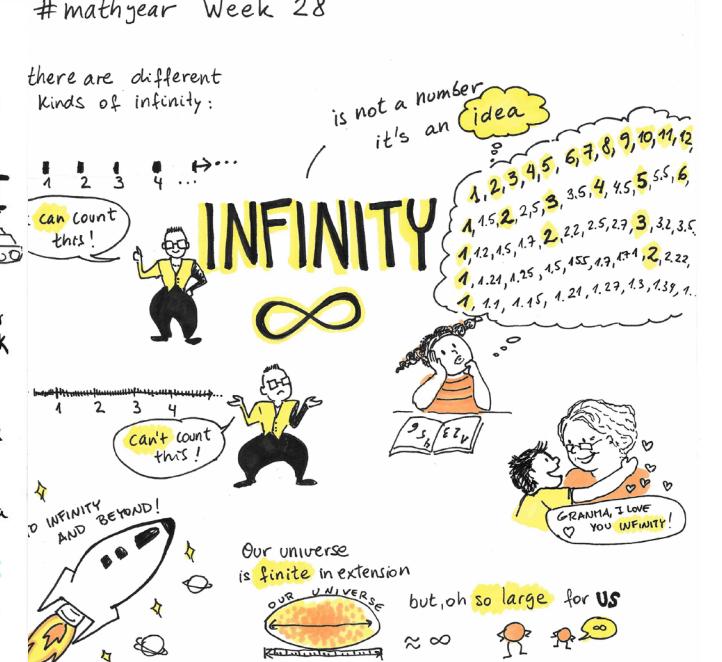
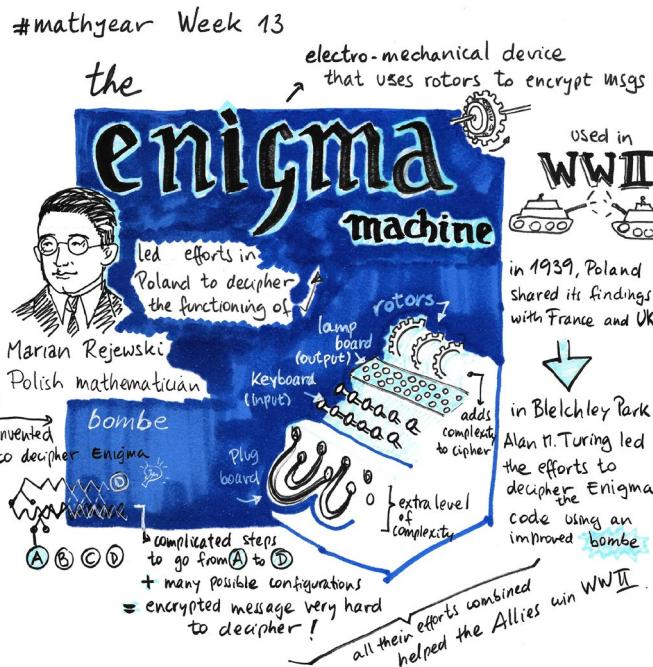
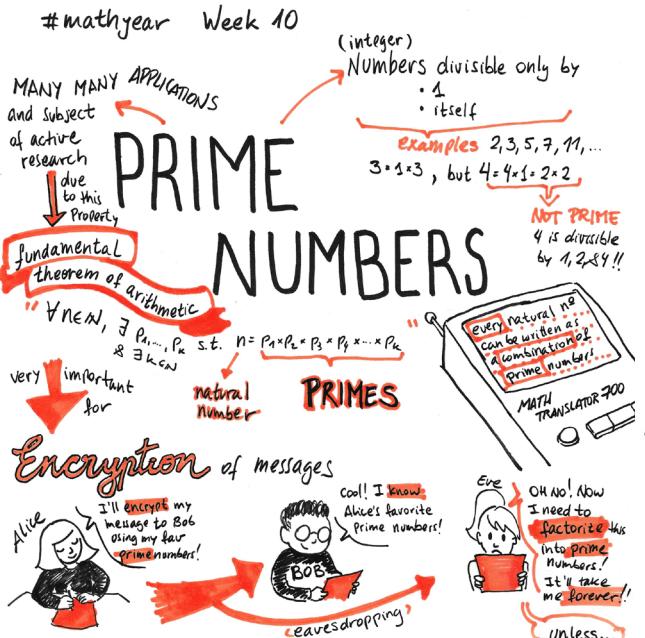
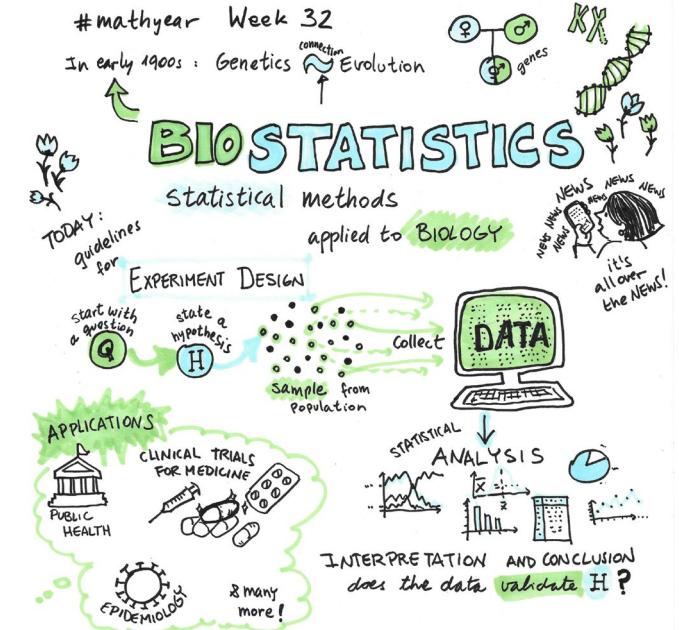
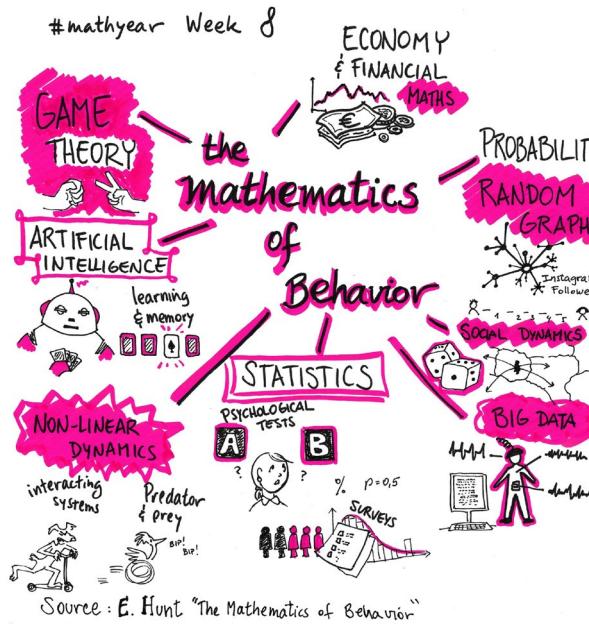
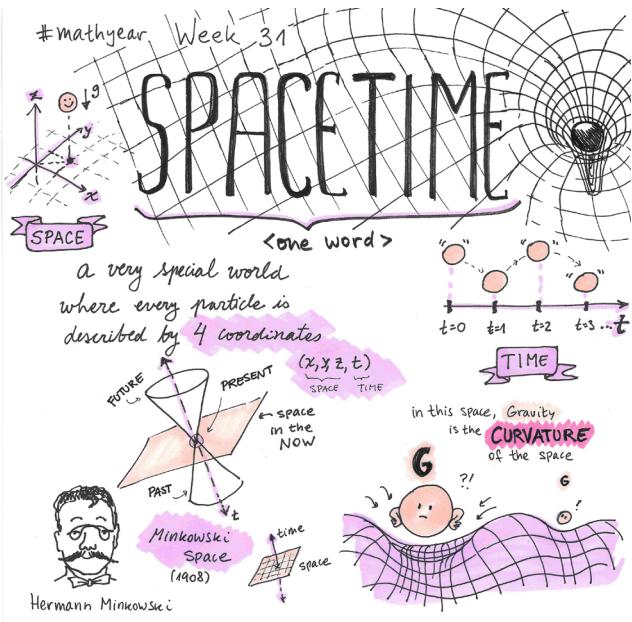
Mayo: las matemáticas y la física

27.04-03.05. Las matemáticas como un lenguaje para la física
04.05-10.05. Historia de la física
11.05-17.05. Mi física o físico favorita
18.05-24.05. Las 3 leyes de Newton
25.05-31.05. Mecánica cuántica

Junio: el arte y las matemáticas

01.06-07.06. Geometría
08.06-14.06. La proporción dorada
15.06-21.06. Gödel, Escher y Bach
22.06-28.06. La música



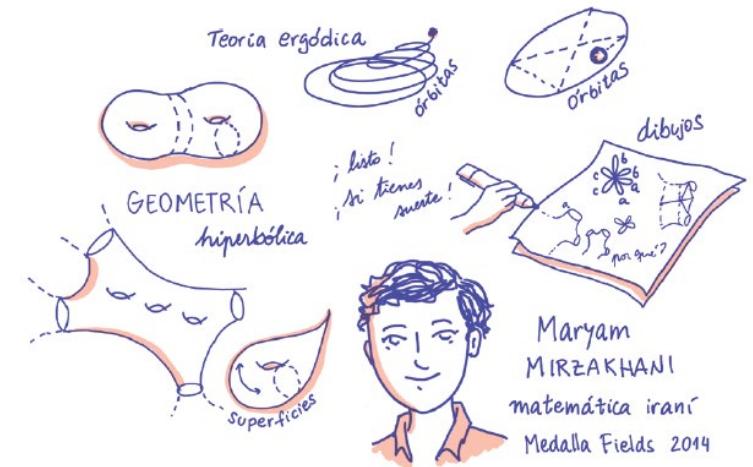


More info in
The Handbook of
Mathematical Science
Communication
(A.M. Hartkopf/ E.
Henning)

La gran aventura, 2023



Leslie Jiménez Palma (U. Chile)

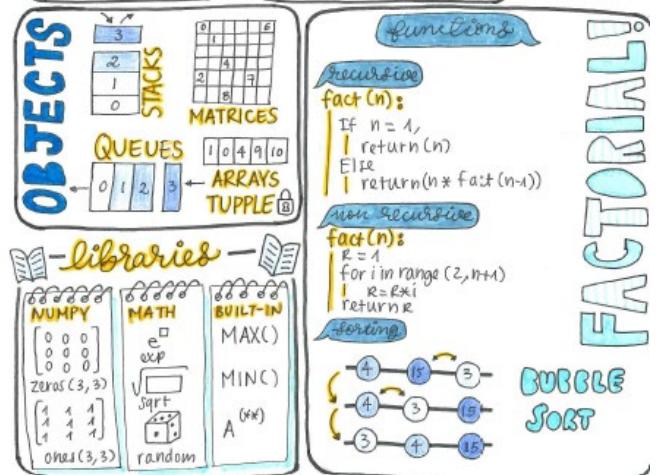
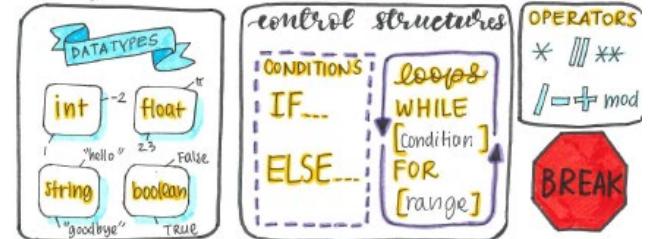


In the classroom

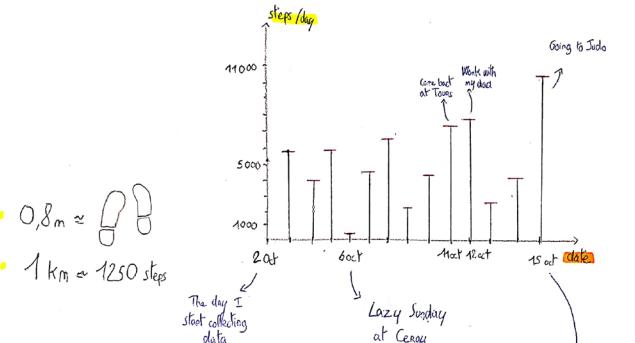
Bachelor in Data Science,
CY Cergy Paris Université - 2020

COMPUTER SCIENCE

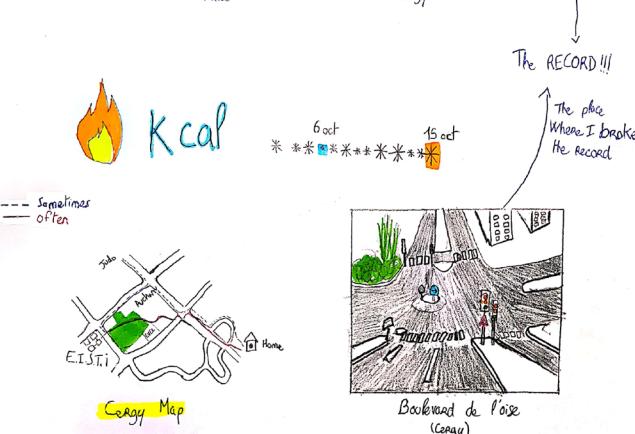
python: algorithmics and
programming



How is my daily walking ?



- $0,8 \text{ m} \approx 100$
- $1 \text{ km} \approx 1250 \text{ steps}$



Inspired by Dear Data,
by Lupi and Posavec



Next goals (w. L. Jiménez):

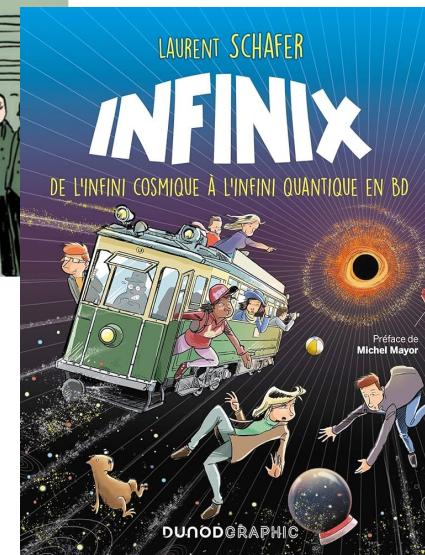
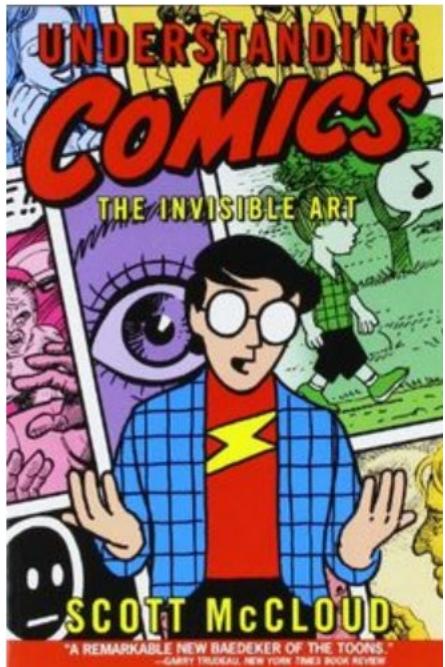
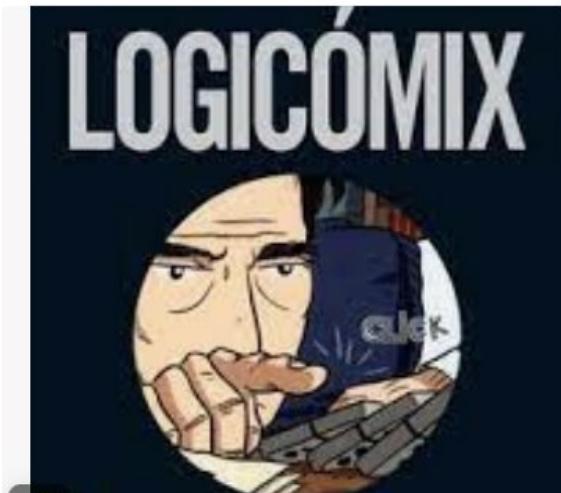
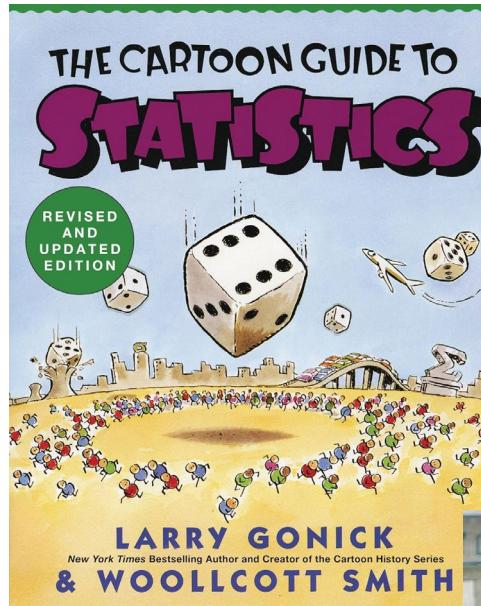
- Create didactic material for teachers based on book La gran aventura (CH and FR)
- Design learning experiences
- Evaluate impact

II. Comics, a sequential art

II. Comics

Examples of comics about maths

- The Cartoon Guide to... Gonnick, 1993
- Logicomix, Doxiadis, Papadimitriou, 2008
- Emmy Noether (online comic), Agrapidis, Mistrello, 2019
- Infinix, Schafer, 2021
- Sofia Kovalevskaya, Milani, 2023



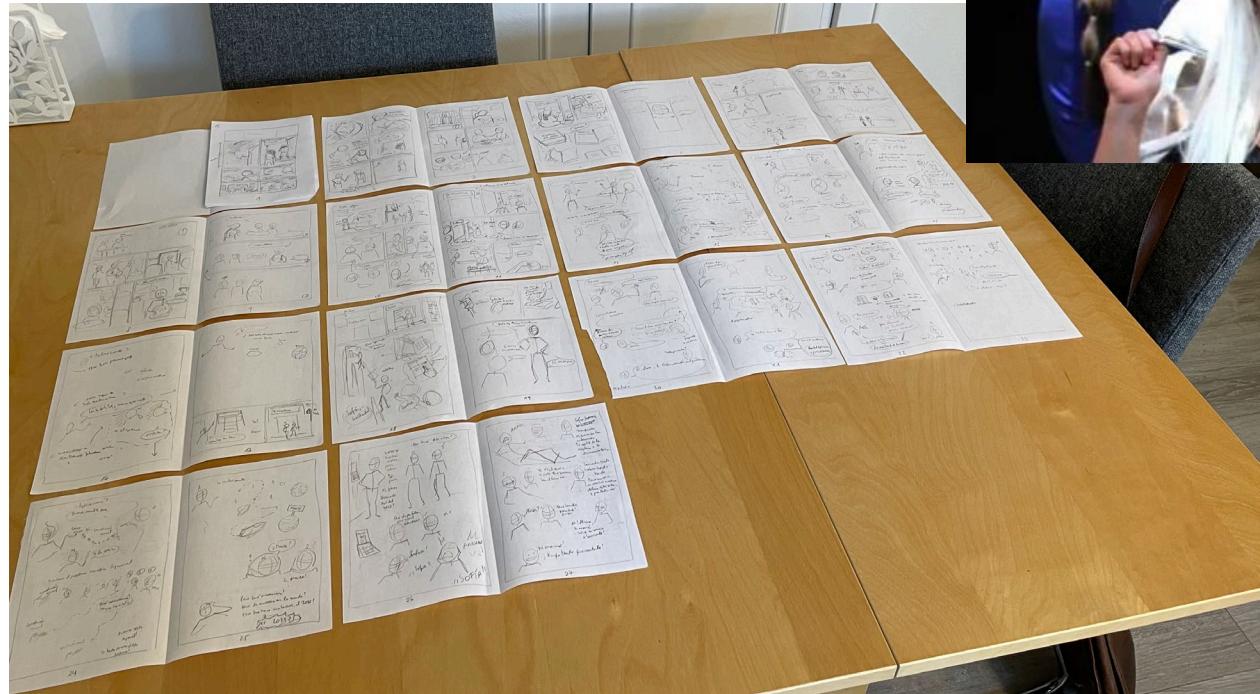
About comic as format

- Understanding Comics, McCloud, 1993
- *Unflattening*, Sousanis, 2015
- M. Farinella, The potential of comics in science communication, Journal of science communication, 2018

Comic “Alicia’s mysterious conjecture”



Comic adaptation of the theatre play by mathematician Alberto Mercado (U. T. FSM, Chile)



Play « 4,2,1 »
Theater troupe
La coraje,
Valparaíso, Chile



The Collatz Conjecture



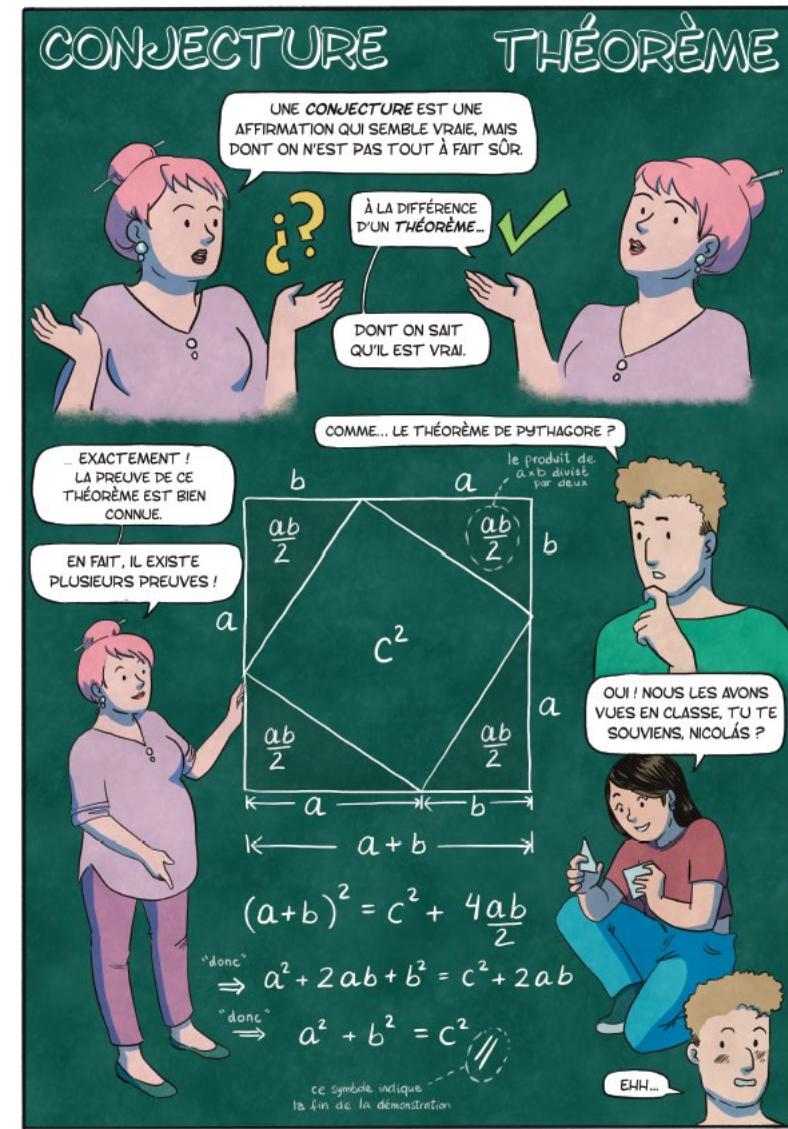
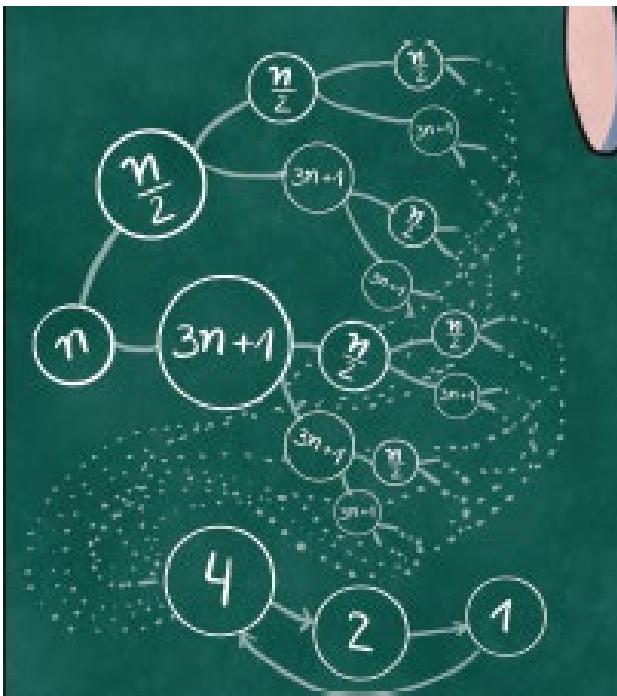
Scientific content

- The Collatz Conjecture or 3n-1 problem
- Theorem and conjecture
- Biographies of scientists...



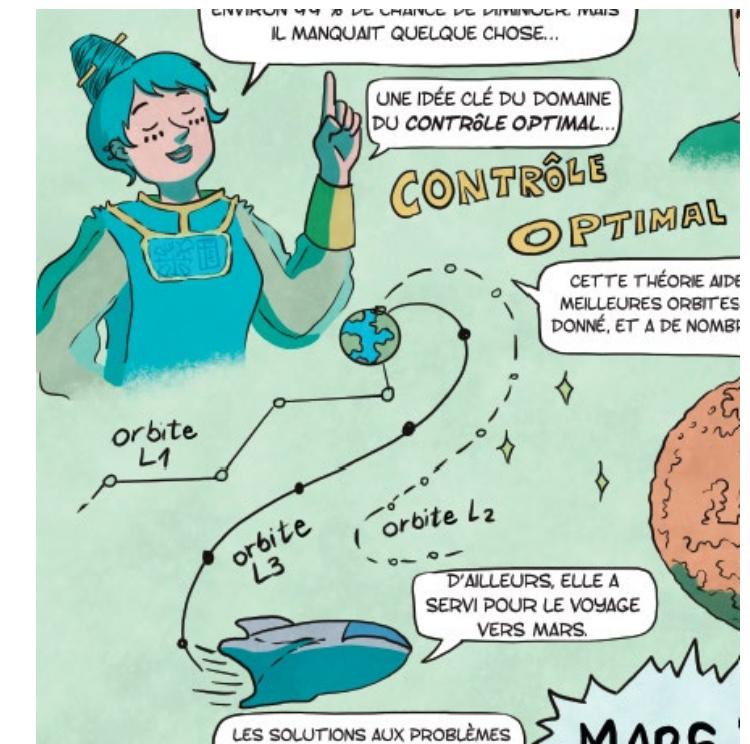
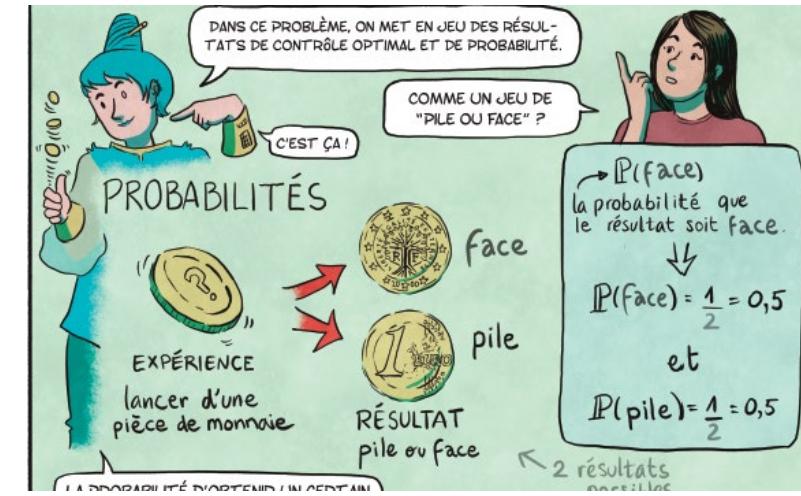
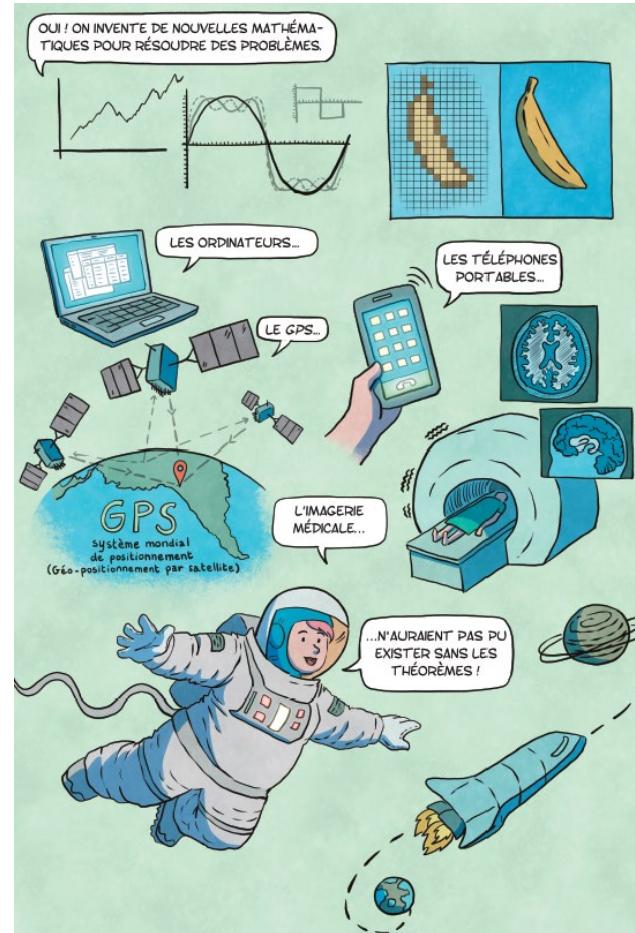
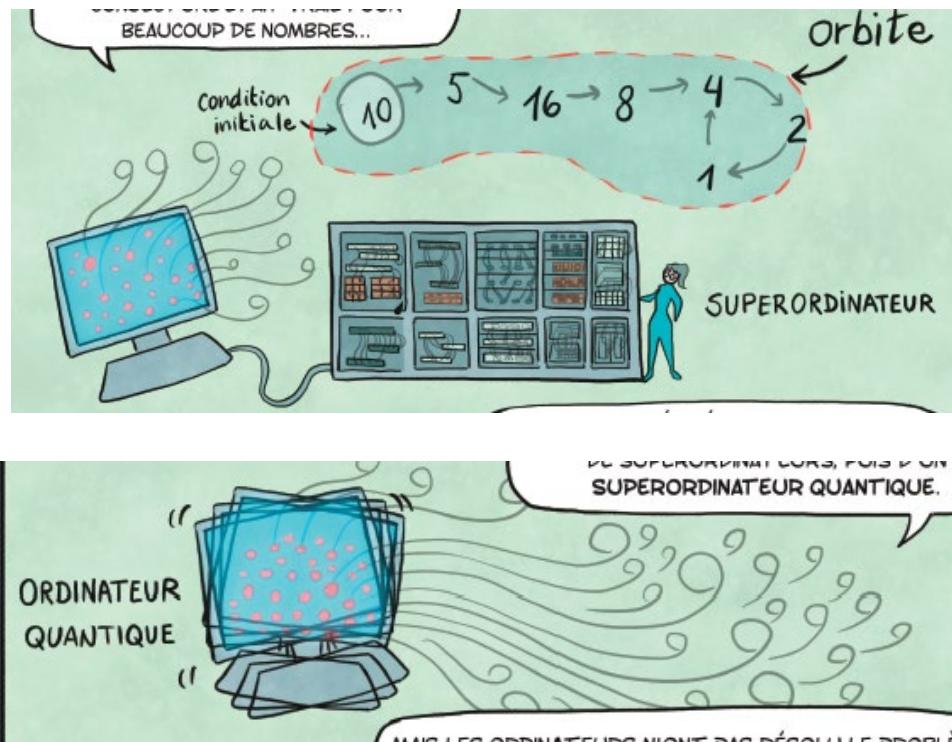
Rosalind Franklin (1920-1958) CHIMISTE BRITANNIQUE. APRÈS AVOIR OBTENU SON DOCTORAT, ELLE A TRAVAILLÉ ET DÉVELOPPÉ UNE VASTE CARRIÈRE DE CRISTALLOGRAPHIE À RAYONS X. ELLE A ÉTÉ PIONNIÈRE DANS LA DÉCOUVERTE DE LA STRUCTURE MOLÉCULAIRE DE L'ADN, UN RÉSULTAT POUR LEQUEL ELLE N'A REÇU AUCUNE RECOMPENSE AVEC

Katherine Johnson (1918-2020) MATHÉMATICIENNE AMÉRICAINE. ELLE A OBTENU SON DIPLÔME DE MATHÉMATICIENNE À UNE ÉPOQUE DE SÉGRÉGATION RACIALE AUX ÉTATS-UNIS, OÙ LES PERSONNES NOires N'ÉTUDIAIENT GÉNÉRALEMENT QUE JUSQU'À L'ÂGE DE 14 ANS. ELLE A TRAVAILLÉ COMME INSTITUTRICE, A ENTAMÉ DES ÉTUDES SUPÉRIEURES EN MATHÉMATIQUES ET A MENÉ UNE LONGUE CARRIÈRE DE CALCULATEURICE À LA NASA, PARTICIPANT À D'INNOMBRABLES MISSIONS SPATIALES.



Scientific content

- Fields of research in mathematics
- Scientific advances in which Mathematics have several applications and might take time



The learner's ecosystem

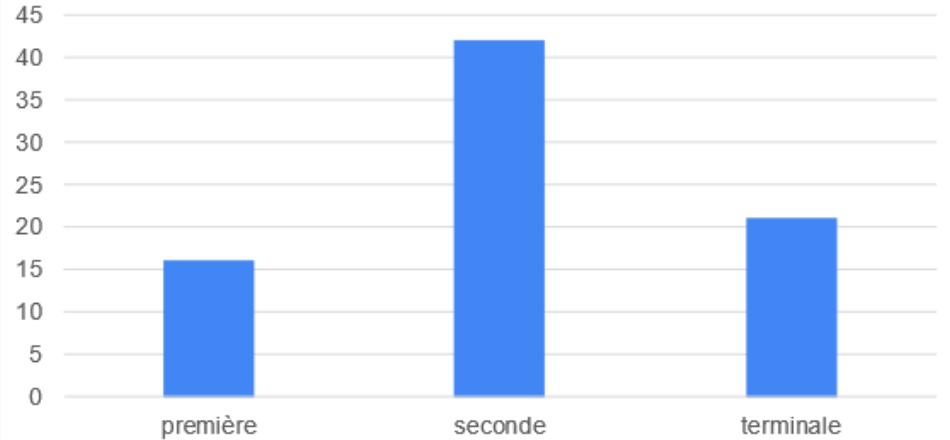


Impact evaluation

High schools in Bayeux, France

Lycée Alain Chartier (Prof. Olivier Longuet)

Lycée Jean d'Arc (Prof. Flavie Auburg)



Seconde – Première - Terminale

105 answers PRE reading, 79 answers POST reading

Troisième 15 PRE, 11 POST

Positive: characters are the same age as readers, interactions with family and friends, clear language and clear drawings, biographies

To improve: definition of word « orbit », more details in mathematical notions, balance text/images.

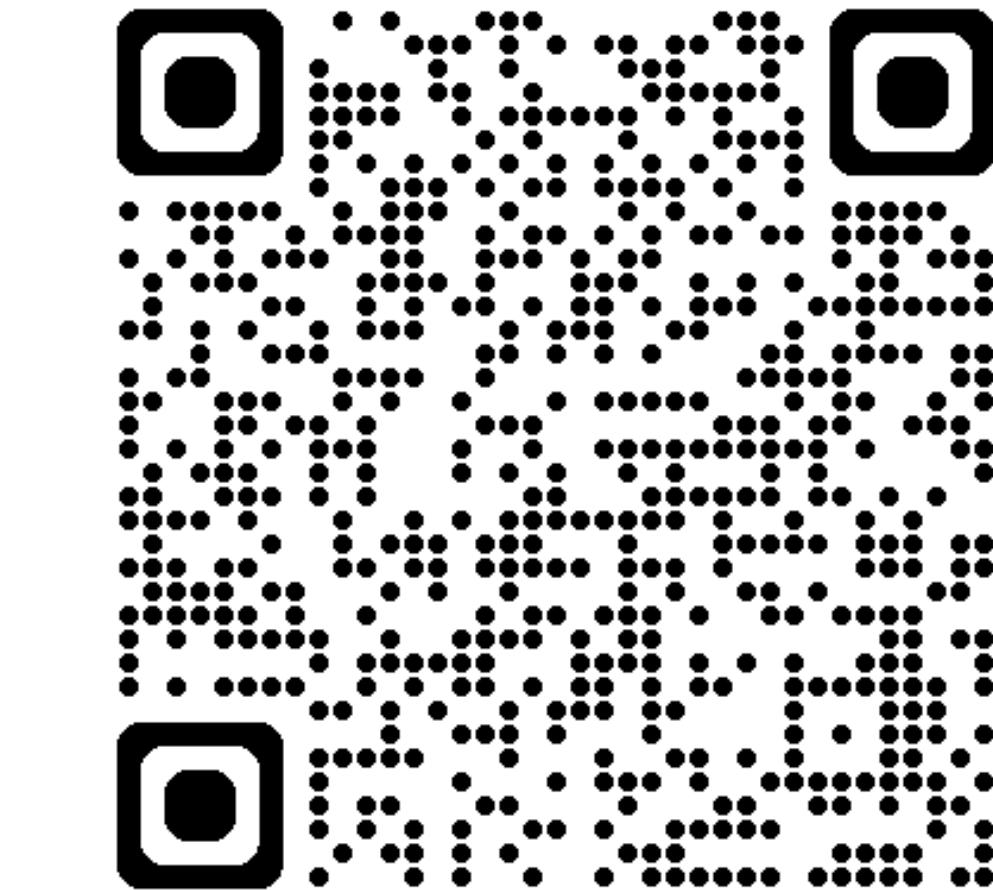
Teacher's remarks: rich in ideas, personal development, role of mistakes, good ideas for « grand oral » and problems to work in class. Esthetics better suited for a younger audience

From « Mathematics communication through comics: « Alicia's mysterious conjecture ””, by C.RM, Proceedings of the Conference Telling Science, Drawing Science, Angouleme, November 2024.

Knowledge acquisition: The post-reading survey asks students to select the statement that corresponds to the Collatz conjecture and to indicate if it is the work of one person or of many. Among lycée students, a vast majority (88.8%) selects the correct statement of the Collatz Conjecture and the fact that several people worked on it. Among collège students, 63.6% selects the correct statement of the Collatz Conjecture, while 90.0% select correctly the fact that several people worked on it.

Comparing concepts before and after reading the comic: The pre- and post-reading surveys ask the students to select a statement that describes a theorem, and one that describes a conjecture. In the pre-reading survey among lycée students, a vast majority (83%) indicates correctly that a theorem is a statement that has a proof (that is true because it can be deduced from other known principles). In the post-reading survey this percentage rises to 91,3%. While in the pre-reading survey only 47,2% of lycée students indicate correctly that a conjecture is a statement that is expected to be true but whose proof is not known, this percentage rises to 73,8% in the post-reading survey. In the pre-reading survey, 29,9% of lycée students believe a conjecture is a statement that is partially proven, which goes down to 16,3% in the post-reading survey. Among collège students the situation is similar: before reading the comic, 73,3% of students select the correct description of theorem, which goes up to 81,8% after reading the comic. Before reading the comic, 26,7% select the correct description of conjecture, which goes up to 54,5% after reading the comic. Before reading the comic, 53,3% of students think a conjecture is a statement that is partially proven, which goes down to 36,4% in the post-reading survey.

We conclude that the comic has been effective in explaining the difference between conjecture and theorem and in explaining the Collatz conjecture.



www.crojasmolina.com/comic-acip

Sketchnotes and comics

- Visual languages
- Means of communication, not (necessarily) art.
- Cheap format – massive format
- Different time scales: sketchnotes can be produced very quickly, comics need time (fanzines are a short and quick format *).
- Sketchnotes needs context, so it needs to be accompanied by text or a person. Comics provides the context.
- Space for subjectiveness and personal expression → Achtung!
Needs reviewing, as any other science communication format.
- Potential as didactic material.

Outlook:

Team up with didactitians of mathematics to design learning expériences to evaluate the instrument (comic/sketchnote) improve it, evaluate its impact and its scope.

Potential as didactic material

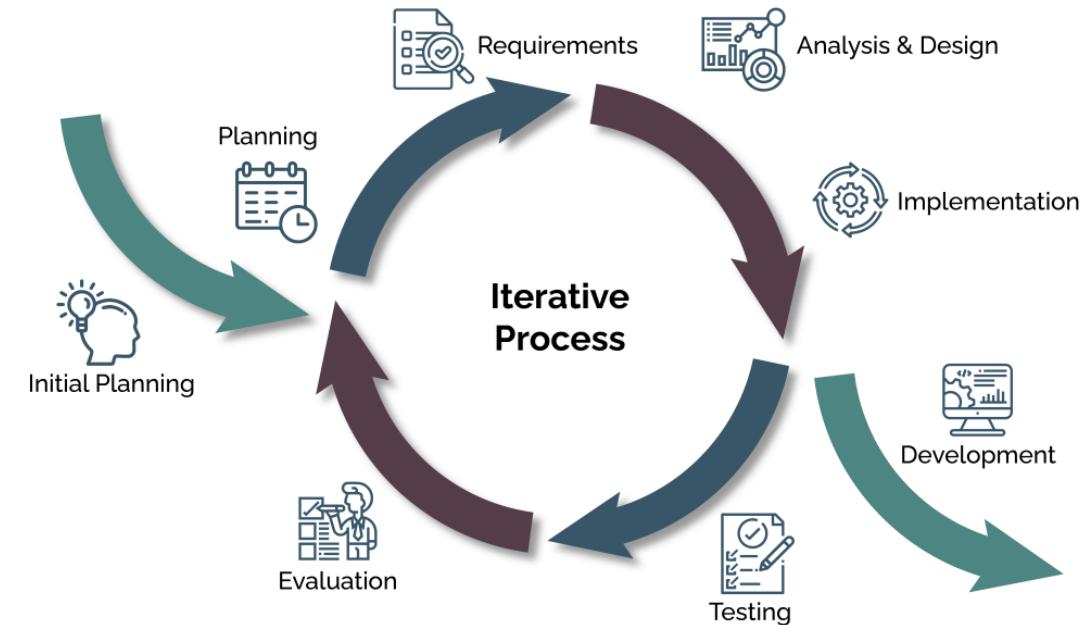
Instrument for science communication with potential for science education.

- Prepare didactic material to use in the classroom
- Need of (comparative) understanding of curricula and educational approaches in (different) countries.
- Problem: math research is **international**,
math education isn't!

A design approach for future projects:

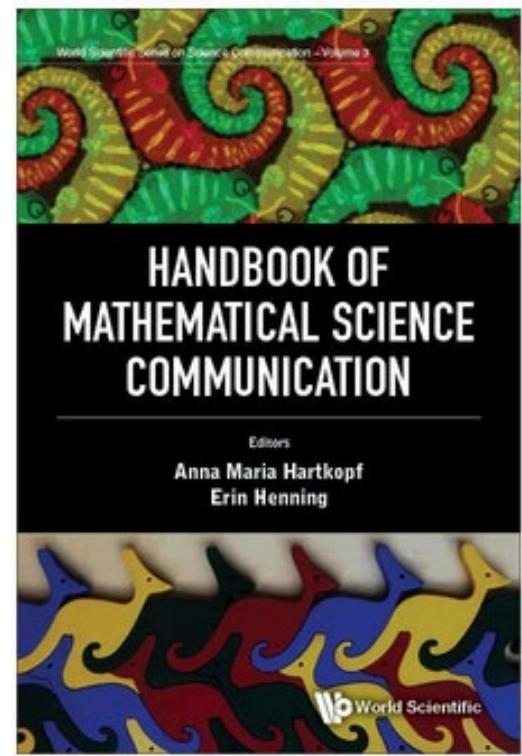
High cost: time is a ressource, feedback is precious!

Iterative Process Model



References

- C. RM., *Visualization and Social Media as Tools for Mathematics Communication: An Account of the Project "Sketchnotes of Science"*, in Handbook of Mathematical Science Communication Ed. Hartkopf, Henning (Berlin), 2023.
- L. Jiménez Palma and C. RM., *La gran aventura del conocimiento*, Ed. Planeta Chile 2023
- A. Mercado Saucedo and C. R-M., *Alicia's mysterious conjecture*, in FR and ES www.crojasmolina.com/comic-acip
- C. RM. *Mathematics communication through comics: «Alicia's mysterious conjecture»*, Proceedings of the Conference Telling Science, Drawing Science, Angouleme, November 2024.



For more illustrations, see <http://crojasmolina.com/illustration/>