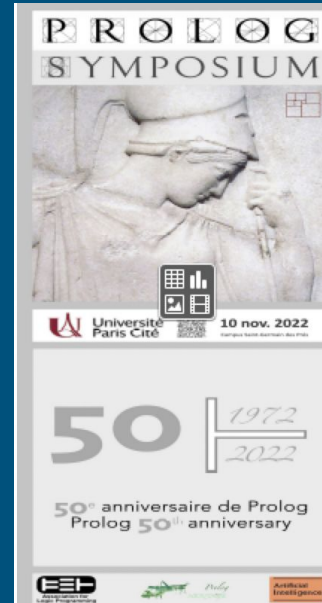# Prolog's Educational Potential

Verónica Dahl
Leader of the Prolog-50 Education Campaign
Prof Emeritus, SFU and Researcher, NSERC

# Overview, Towards making Computational and Logical Thinking through Prolog and its successors a core subject in the educational curriculum and beyond

- Where we are vs. where we want (need?) to be
- Short and long term aims.
- Agreements, achievements; and remaining doubts on the main questions:
  - Why teach Prolog?
  - When?
  - How?
  - With what support? Sample tools.
  - To whom should we teach Prolog?
  - At what level?
- Sample Projects
- To-Do List

# Context

- We've given the world a language like no other, pregnant with all kinds of under-explored, badly needed possibilities, e.g.:
    - Universalizing reliable reasoning capabilities
    - Providing actors and decision makers with substantiating tools  (Examples: Logical English for Logical Law, Logical judges - Bob Kowalski [10], Viviana Mascardi [12])
    - Replacing (e.g. through default reasoning- Gopal Gupta [8]) or at least complementing ML-based AIs with more sustainable, sound reasoning  [15, 21]
- Yet curricula around the world has not caught up with the need to teach Prolog properly,  despite Prolog's successful (although sometimes hidden) presence throughout the world. LP IS UNDER-REPRESENTED!

# More human resources are needed! LP is *under-inclusive*, following old, still influential policies

Inclusiveness is paramount to our growth: We are a relatively small niche of people (typically white, élite, able-bodied, straight, cisgender, male people from the Global North- unrepresentative of Humanity at large --this is the case also in AI, in STEM).

Origin: *officially adopted elitist views of Education (e. g. Horace Mann's* as "equalizer of men" - but not all: only white, Anglo, Christian-, and certainly not women [13])

Result: a persisting, individualistic style of teaching, no chance for conversations on ethics, no social aims => just a factory of élite professionals as tools [7]

*Truly inclusive policies that can achieve parity [17] would, in addition, provide us with the human resources we need.*

Photo: A typical ICLP demographic composition
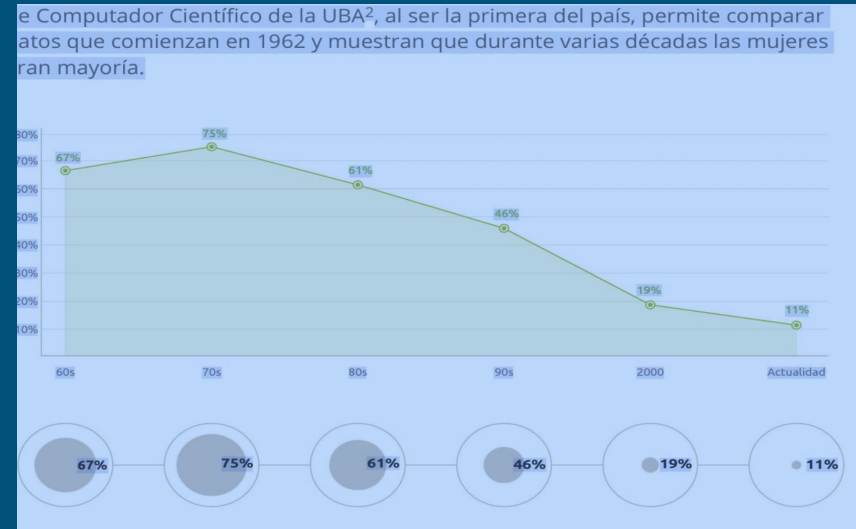
(from ICLP'12, Budapest [16]).

# A Foolproof Way out?: LET's MAKE SPACE

Because **when given space, people take it.**

E.g.

- "The Four Hidden Figures of the Space Race" (operation Apollo) **were black [3]!**
- In the '70's, **75 % of students** in the still spacy new career of CS at its inception in Argentina **were women! [18]**

(clearly disproving the myth of "natural " disinclination: it took proactive chasing-away for élites to replace the "other" when these new fields became desirable)



e Computador Científico de la UBA², al ser la primera del país, permite comparar atos que comienzan en 1962 y muestran que durante varias décadas las mujeres ran mayoría.

67%  75%  61%  46%  19%  11%

60s  70s  80s  90s  2000  Actualidad

67%  75%  61%  46%  19%  11%

Y las mujeres, dónde están? Fundacion Sadosky [18].

# How? Introduce children/youngsters to logic and a more human-friendly computer language



"Prolog Bus" ( French community initiative, documented by Bob Kowalski)

Short Term (summer of 2022):

- online introductions to human-friendly, logic-based computer programming for students (JUST HOW YOUNG?)        AIMING WELL!

  and teachers:

  - emphasizing the declarative reading of logic programs- JUST HOW DECLARATIVE?
  - compatible with curricula employing ASP or other LP varieties
- Identification of position paper themes

# Teaching Achieved:

- May 21- June 5: *Prolog for AI Thinking*, - Eric Fung (University)
- June: *Intro to Prolog and its KR & AI uses*- Gopal Gupta (High School or College, 17 year olds, 200 registrants, approx.100 completed)
- October: *Prolog through solving Detective Mysteries*

Laura Cecchi (Elementary School: 8-10 year olds, 56

registrants, 16 facilitators, 4 inexperienced schoolteachers)

# Why teach Prolog?                When?

## Reliable thinking, logic, computing :- Prolog

- It *helps teach everything else*
- It teaches *how to reason soundly*
- It can fill the need to make AI (and CS in general) *explainable, transparent, accountable, sustainable.*

- Before imperative languages [1, 4]

- ASAP (before gender role mandates have gelled)

# How to teach Prolog?

## Most common anchors:

## Perhaps more effective:

- Through what students already know, e.g.:

  - Mathematical problem solving

  - As a KB language

Familiarity & Concepts first:

- Use Prolog-written aids to teaching other subjects (logic, grammar, taxonomy…)
- Read and use ready-made packages
- Through active, engaging fun, e.g. games and puzzles
- Through human language concepts
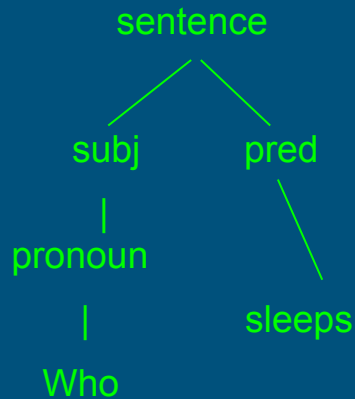
# A neglected approach to use what is known: human language concepts!  (→ syntactic sugar)

**Constant** = godess

(Linguistic) **variable**= "who"

**Rewrite rules**,  notation

**Term** = derivation tree  sentence(subj(pronoun… )

**Strategy**= top-down, bottom-up, L-to R,...

(Existential) **quantification**= elicited by "Who"

**Reversibility**= generate or recognize

**Modularity**=  change the lexicon                etc.

---

Example: through tiny NL grammar  fragments

noun → [godess].

pronoun → [who].

…

sentence → subj,

        pred.

 predicate → verb.

    …

```
            sentence
           /        \
        subj        pred
         |             \
      pronoun          \
         |            sleeps
        Who
```

Leads to Syntactic Sugared, more friendly support for learning, e.g. Logical
English (Bob Kowalski, [10])
                    (https://logicalenglish.logicalcontracts.com/p/sister.pl)

```
 5  the templates are:
 6  *a person* is sister of *a person*.
 7  *a person* is female.
 8  the parents of *a person* are *a mother* and *a father*.
 9
10  the knowledge base sister includes:
11  a person X is sister of a person Y if  X is female
12      and the parents of X are a mother and a father
13      and the parents of Y are the mother and the father
14      and X is different from Y.
```

```
is_sister_of(A, B) :-
    is_female(A),
    the_parents_of_are_and(A, C, D),
    the_parents_of_are_and(B, C, D),
    A\=B.
```

?-  show prolog.

Examples▲  History▲  Solutions▲

```
3  en("the target language is: prolog.
4
5  the templates are:
6  *a person* is sister of *a person*.
7  *a person* is female.
8  the parents of *a person* are *a mother* and *a father*.
9
10 the knowledge base sister includes:
11 a person X is sister of a person Y if  X is female
12     and the parents of X are a mother and a father
13     and the parents of Y are the mother and the father
14     and X is different from Y.
15
16 scenario alice is:
17 the parents of alice are mary and john.
18 the parents of harry are mary and john.
19 alice is female.
20
21 query sister is:
22 which person is sister of which other person.
23
```

answer sister with alice.

Query sister with alice: *a person* is sister of *a person*

Answer: alice is sister of harry

**true**                                                                1

?-  *answer* sister with alice.

Examples▲  History▲  Solutions▲                    ☐ table results  Run!

-> <u>CLEARER AIM:</u> Website of Prolog education (or Computational Thinking Education through Prolog) with resources that educators can use or adapt, classified by age & stage, regularly updated

## <u>Packaged Materials for specific audiences</u>:

- Paradigms of Computation teaching materials

- (adaptable) syllabus as pedagogically adequate orderings of :
  - *Prolog programming concepts* vs.
  - *Prolog-related or Computational skills*

- Games that help teach

- Killer apps to help convince advocates of the need to introduce Prolog into curricula

## <u>Pointers</u>:

- existing Prolog teaching sites and courses

- systems and environments: browser vs. server based, privacy issues, infrastructure needed, medium for text, tools for automating the teaching

# Sample Materials for different levels

Elementary Level: Students as Detectives must discover who committed a robbery, from feeding clues received in successive stages  to Prolog as their helper  (Laura Cecchi)

Elementary and High School: Syllabus and sample implementation w/ games such as

Populate a geometry world from declarative descriptions (Jose Morales, Salvador Abreu); Games such as "avoid landing on a mine using logic clues" (Michael Genesereth) Teaching arithmetic through Prolog (Jean Rohmer, [14])

University Level: covering AI and CS students, non CS students, comparative language courses

All levels (incl. informal) + Advocates: grammar that generates input to Dall-e (Paul Tarau); grammar that generates solutions to quantifiable ecological and social problems, using Doughnut Economics as a compass (Veronica Dahl, [5]) ; CLP rendition: Salvador Abreu

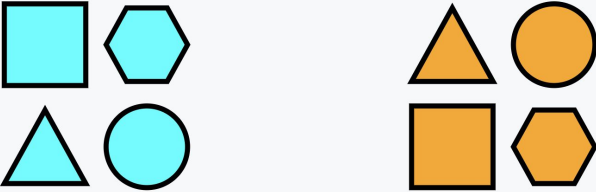http://www.programmierkurs-java.de/blocklyprolog/

# A syllabus and interactive course for young students (Jose Morales, Salvador Abreu)

- A simple **syllabus** and **example implementation** to guide students in learning to program by way of Prolog.

- **Interactive course** (based on browser-side **Ciao Playground** and **LPdoc**)
- Structured as **basic** (encoding knowledge as facts, asking simple and complex queries, rules as shorthands) and **advanced topics** (introduce compound terms and recursion)

- Some requirements:
  - Assumes (relies on!) no previous experience with programming languages and no knowledge of computer architecture.
  - Use a subset of standard Prolog, we do not want to rely on advanced features (e.g. tabling, constraints, ...)
  - Provide "practical" examples for every concept
- This could mean young children (around 10yo) or students of non-technical topics, for instance in the humanities.

**Task**

You have found the following description of the picture, which unfortunatelly is wrong. Can you fix it? Read carefully what each sentence (facts) means and see it if describes what you see in the picture.



```
1   above(triangle,square).
2   above(circle,hexagon).
3   right_of(hexagon,square).
4   right_of(circle,triangle).
```

**EXAMPLE TASK** (above): "*Amend the facts so that the figure on the right looks like the figure on the left.*"

# Grammar that generates input to Dall-e 2  (Paul Tarau)
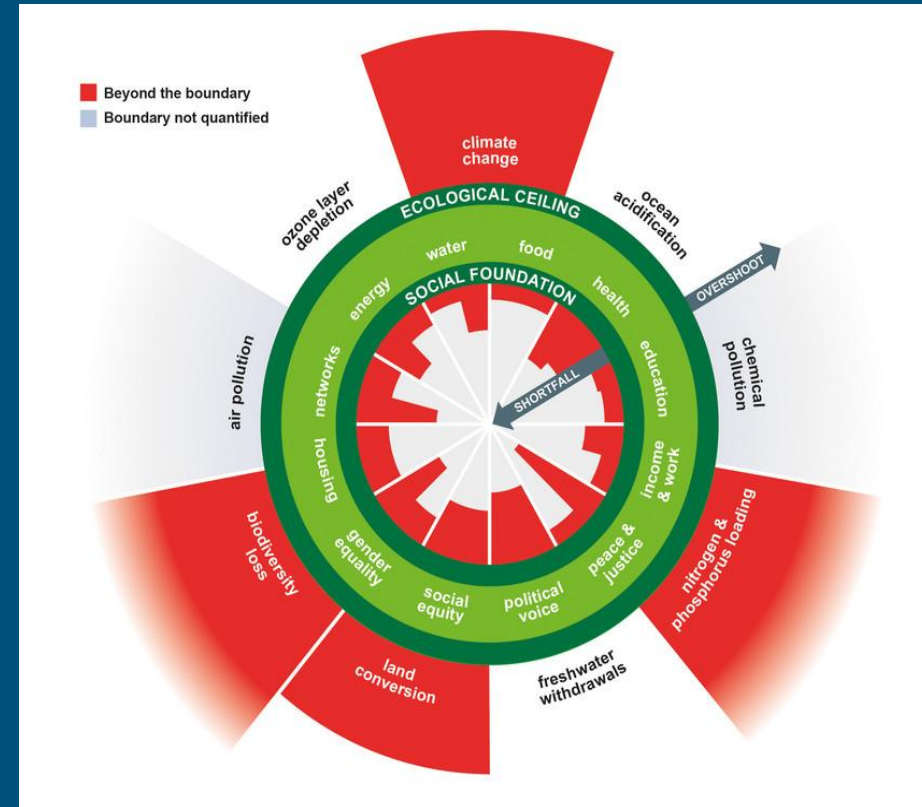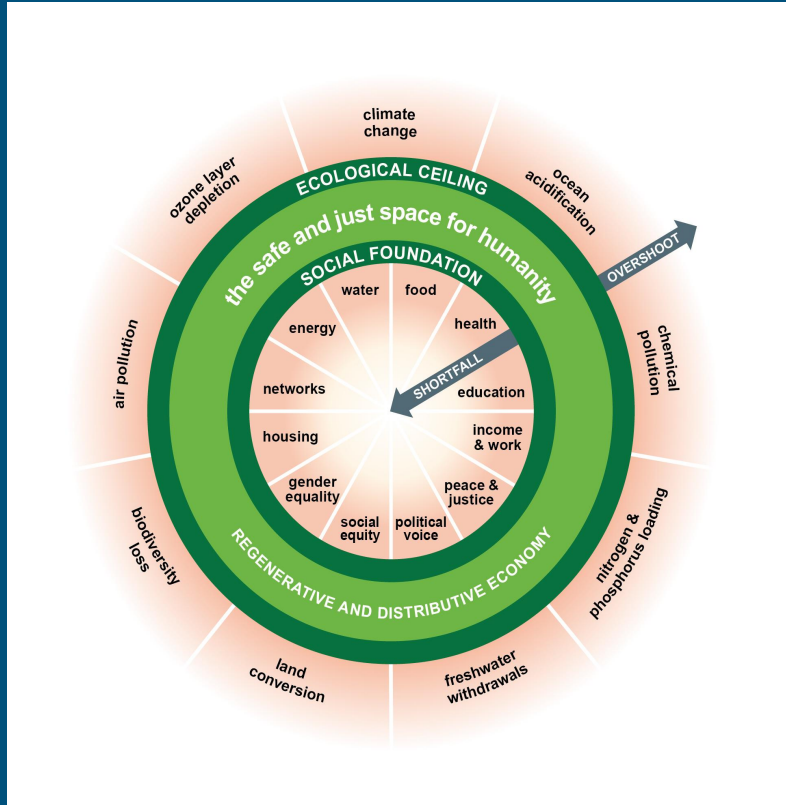
Front end to Dall-e 2, which generates

NL descriptions of scenes in a given

domain that can then be fed to Dall-e to

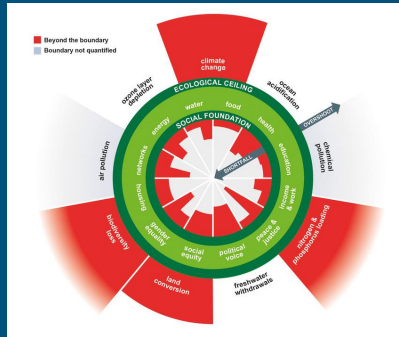create realistic images of the scenes

Input:

Photo of a cat playing on the golden moon
With a trumpet

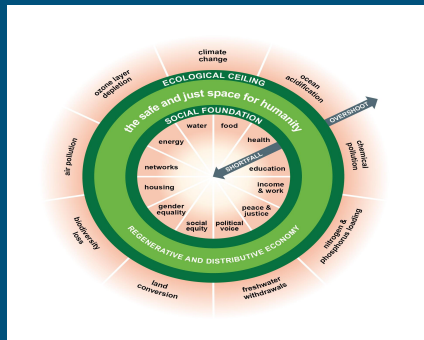# Research-promoting games: Eco-social Solutions (Dahl [5])

# Research-promoting games: Eco-social Solutions



How to get from

where we are



To where we

want to be

- *Enter numeric assessments of (one or various) eco or social problem*, e.g.

  status= 35 billion tons/year of Co2,

  goal = 0 emissions)

- *Enter possible reducing actions, e.g.* prohibit_nonessential_plastics= -2

  *+ side effects, e.g.* would create unemployment of X & health gains of Y

- Run & analyse resulting combinations of solutions.

# Successful Projects → greater LP presence (<->?) Greater human presence in LP

- Yuanlin Zhang: huge grant for a project that uses logic as a layer before using R as the programming language, in high school. He is translating his ASP materials from another project (LP Based Integration of Science and Computing for middle school students) into Prolog

- Laura Cecchi has interested the Provincial Council of Neuquén in letting her try out her Intro for Kids Prolog project at elementary schools

- Theresa Swift has lined up resources in the form of a network of high school teachers willing to try out any of our proposals.

- Laurent Cervoni and Laure Bourgeois will offer two Hackathons for students ( in Schools of Engineering and universities, end of 2022/ early 2023

# To grow through inclusion: A WORD OF CAUTION, LEARNED FROM HISTORY

*Beware of backlash (cf. that of the '80s, which succeeded, <u>with much media and institutional help to institute a "geek culture" hostile to the "other"</u>, in capturing even those computational spaces where women were majority)*

HOW TO INVITE THOSE GROUPS CHASED AWAY BACK IN? Given role modeling is crucial,

THE KEY QUESTION: How can *the people running the show* share their power with diversities, esp. in leading roles?

- How can we structurally transform STEM Education altogether? [17, 7]
- *How can achieving this lead to a much stronger representation of reasoning & LP?*

INFAMOUS MEDIA CAMPAIGN INCLUDED ADS LIKE:

# To-Do List: JOIN US!

- ALLIES: Team up with adequate other initiatives, e.g. UNESCO's initiatives for Computational Thinking in Education; find representatives per country
- Entice decision-makers to add Prolog to existing curricular programs:
  - **Enlist teachers through great ready made little programs**
  - **Enlist decision-makers** by showing them clearly superior Prolog renditions of powerful examples, compared with other languages

- Help introduce greater role in ACM's curricular recommendations
- Advertise
- Make space proactively, wherever we can:

help detect and deactivate biases encoded in language [11, 20], help introduce fairer laws [19], help universalize encouragement & role modeling, help deconstruct negative stereotyping, protest exclusion, help achieve parity in representation, …

COLLECTIVELY: Join or initiate collective action (e.g. UNESCO's [17] to convert our spaces into fully representative of, and welcoming to, all. Help fill in gaps in data [7] and build equity into both data collection and algorithms [7, 21,22] .

Every bit helps!

# Most importantly:

CREATE SOME  GLOBAL ENTITY  to Make Computational and Logical Thinking through Prolog and its successors a core subject in the educational curriculum and beyond

# Thanks galore to our fantastic Prolog Education Team:

Bob Kowalski

David S. Warren

Enrico Pontelli

Gopal Gupta

Jacinto Dávila

Jean Rohmer

José Morales

Laura Cecchi

Laurent Chaudron

Laurent Cervoni

Manuel Hermenegildo

Michael Genesereth

Paul Tarau

Salvador Abreu

Stefania Costantini

Theresa Swift

Veronica Dahl

Yuanlin Zhang

My personal thanks to the most inspiring teacher/mentors I've ever had, in chronological order:

- Henry Dahl, who fueled my love for justice
- Yolanda Mansilla- my love for math
- Paulina (Piqui) Socolovsky - my love for CS
- Mauricio Milchberg , who inspired me to join the dots
- Alfredo Hurtado, who fueled my love for linguistics
- Alain Colmerauer, for giving Prolog to us all

# To the audience and readers:

MANY THANKS!!

# A Few References

[1] Beux, S. et al, (2015) *Computational thinking for beginners: a successful experience using Prolog.* CILC, pp. 31-45.

[2] Campos, R. (2010) *Can the learning and teaching process be improved apart from standards adopted by most professors and established in academic books?* CLEI Electronic Journal

[3] Carey, S. (2021) *Hidden Figures: 7 Black Programmers you should know,* Infoworld.

[4] Dahl , V. et al (2010) *Logic Programming: Teaching Strategies for Students with no Programming Background.* In: Proc. WCCCE'10: Western Canadian Conference on Computing Education.

[5] Dahl , V. (2021) *Doughnut Computing: Aiming at Human and Ecological Well-being*, 6th Int. Conf. on the History and Philosophy of Computing.

[6] Dahl, V. and Navarro, J. (2022) Doughnut Computing in City Planning for Achieving Human and Planetary Rights, IWINAC 2022.

[7] D'Ignazio , C. and Klein (2020) *Data Feminism*, MIT Press.

[8] Gupta, G. ( ) Fold-SE: Scalable Explainable AI. In https://arxiv.org/abs/2208.07912

[9] Hicks, M. (2018) *Programmed Inequality: How Britain Discarded Women Technologists and Lost its Edge in Computing.* International Kindle Paperwhite.

[10] Kowalski, R. and Datoo, A. (2021) *Logical English Meets Legal English for Swaps and Derivatives*.

# References (cont.)

[11] Lakoff, R. (2001) *The language war,* International Kinder Paperwhite.

[12] Mascardi V. and Pellegrini,  D. (2020) *Logical Judges Challenge Huan Judges on the Strage case of B.C- Valjean*

[13] Rekowsky, C. (2008) *Horace Mann's Vision in Action: Bridgewater'Normal School's Female Teachers.* Bridgewater, vol. 4, article 5 (traces the  introduction of unequal pay)

[14] Rohmer, J. Teaching arithmetics through Prolog https://www.slideshare.net/Jean_Rohmer/arithmetics-with-symboloc-ai-and-prolog-its-a-childs-play

[15] Sculley, D. et al. (2014) *Machine Learning: The High Interest Credit Card of Technical Debt.* In: Software Engineering for Machine Learning,

[16] Slide 4's Photo (ICLP'12, Budapest): https://q615e4.p3cdn1.secureserver.net/wp-content/uploads/2021/01/BP_03-scaled.jpg

[17] UNESCO Priority Gender Action Plan  https://unesdoc.unesco.org/ark:/48223/pf0000227222, UNESCO's Forum on AI and Education https://aiedforum.org/#/home

[18] Y las mujeres, dónde están? Fundación Sadosky https://www.fundacionsadosky.org.ar/?faqs=y-las-mujeres-donde-estan-3

[19]  Baines, B. et al (eds) (2004) The Gender of Constitutional Jurisprudence, CUP.

[20] https://daily.jstor.org/the-language-of-nasty-women-and-other-gendered-insults/

[21] Birhane, A. (2021) Algorithmic injustice: a relational ethics approach. Pattern, 2( 2).

[22] Birhane, A. et al (2021)  Multimodal datasets: misogyny, pornography, and malignant stereotypes. https://arxiv.org/pdf/2110.01963.pdf