Use of tools in teaching logic

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ENS Rennes, France

ICLA - Panel on logic education

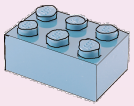
March 4, 2021

Why tools for teaching logic?

motivated student

Why tools for teaching logic?

making logic
easy to learn



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motivated student

Focused on specific notions
Toy examples
User-friendly

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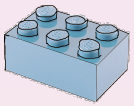


Focused on specific notions
Toy examples
User-friendly

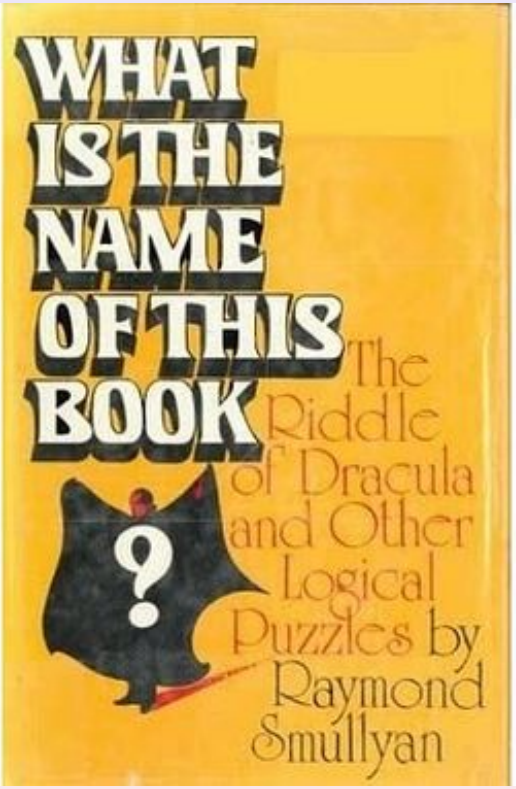
motivated student

Making
learning
fun/challenging

Progressive
Exercices

Outline

Textbooks and recreational Books



- Teaching with toy examples
- Very progressive list of exercises

Outline

Why tools for teaching logic?

Interactive tool

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Active learning

motivated student

Making learning fun/challenging

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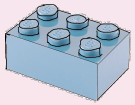
Progressive Exercices

making logic easy to learn

↑



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Toy examples
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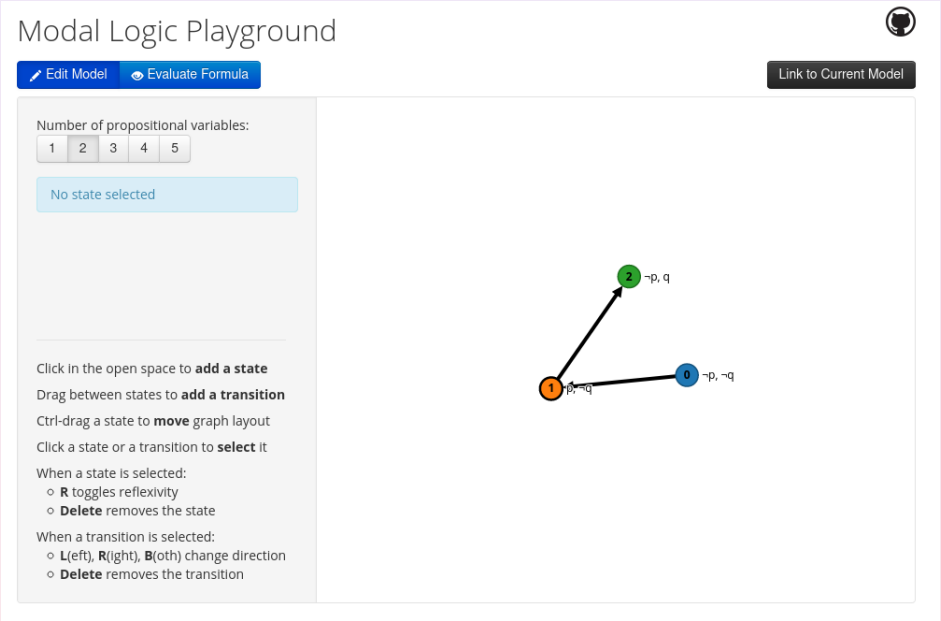
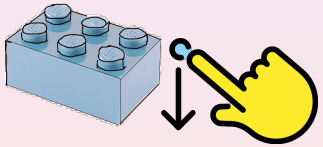
Interactive tools

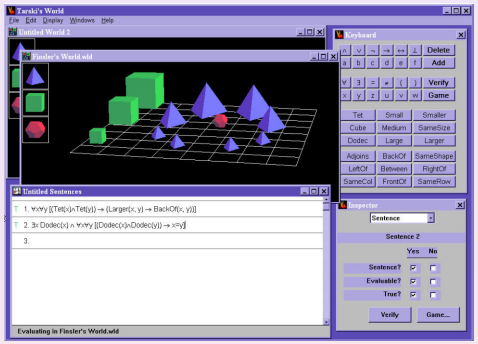
http://logicinaction.org/





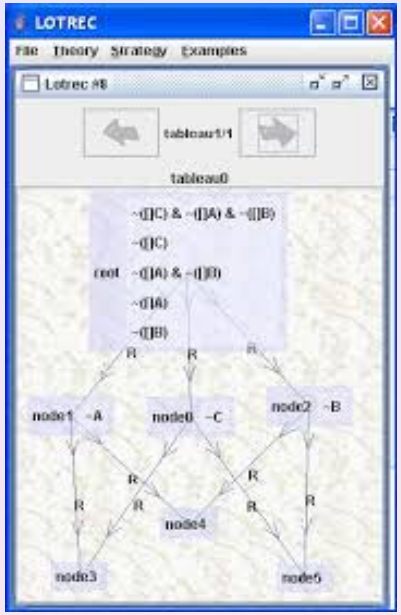
Play with epistemic puzzles with DEMO and SMCDEL:
https://github.com/jrclogic/SMCDEL

Toy tools for first-order and modal logics



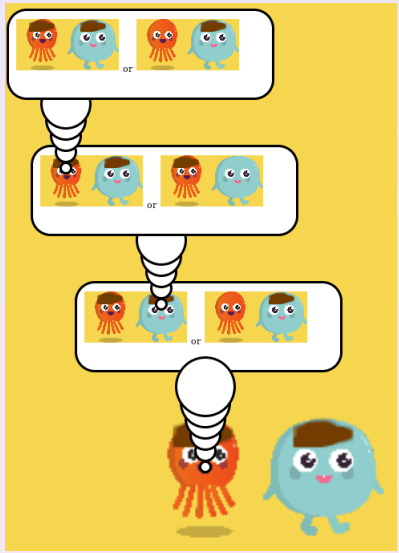
Tarski's World

First-order logic



Kripke's World (Lotrec)

Modal logics

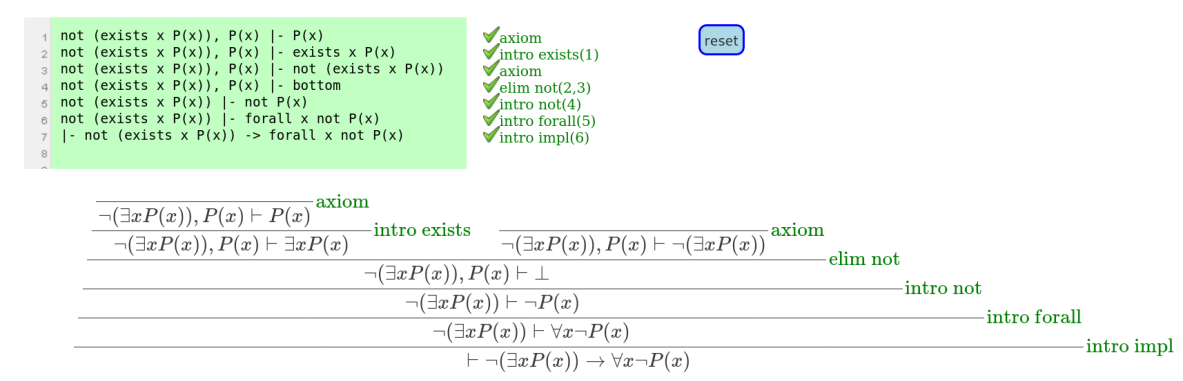


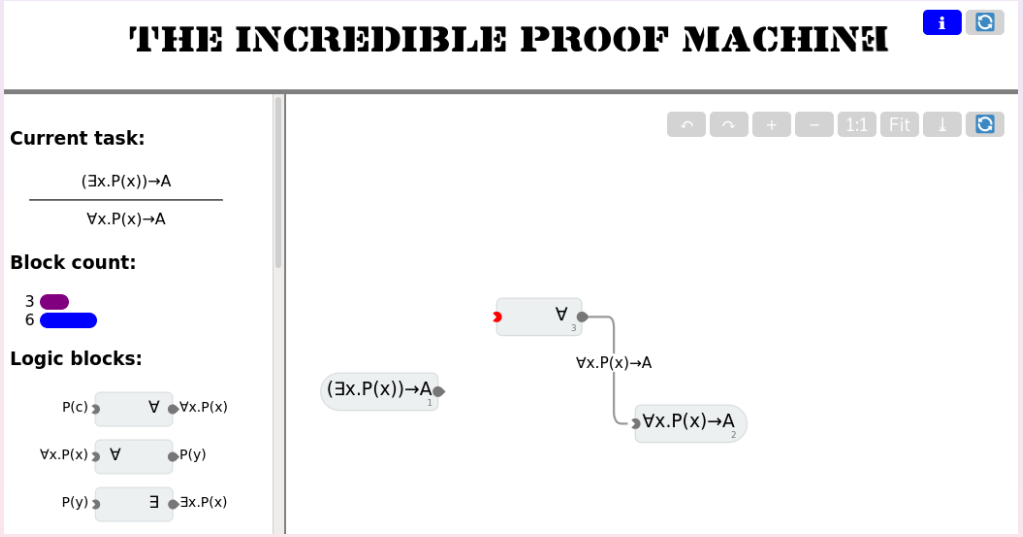
Hintikka's World

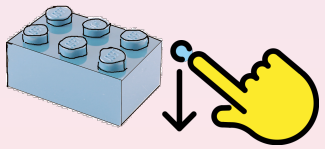
Dynamic Epistemic Logic

$\sim$ serious games

Tools for teaching formal proofs



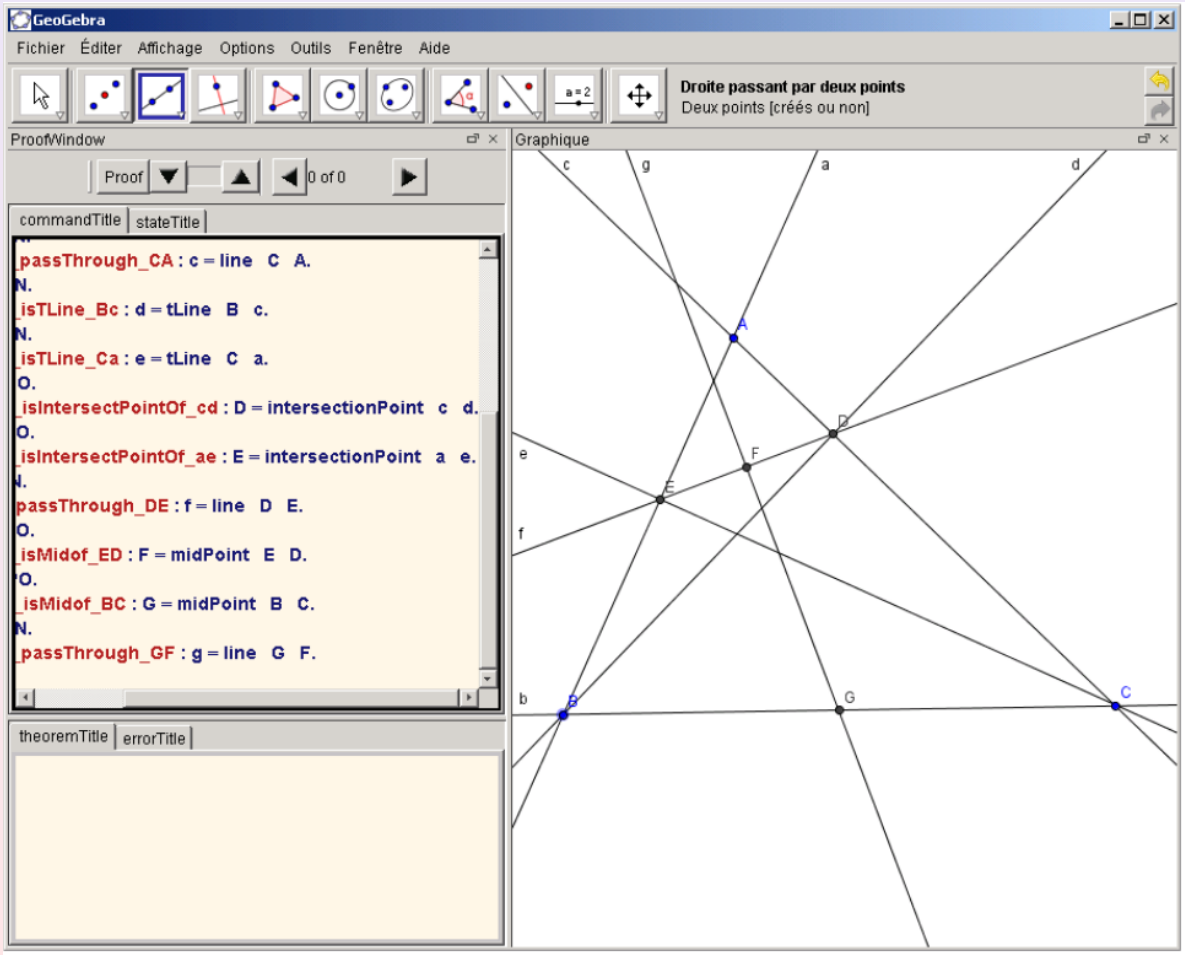




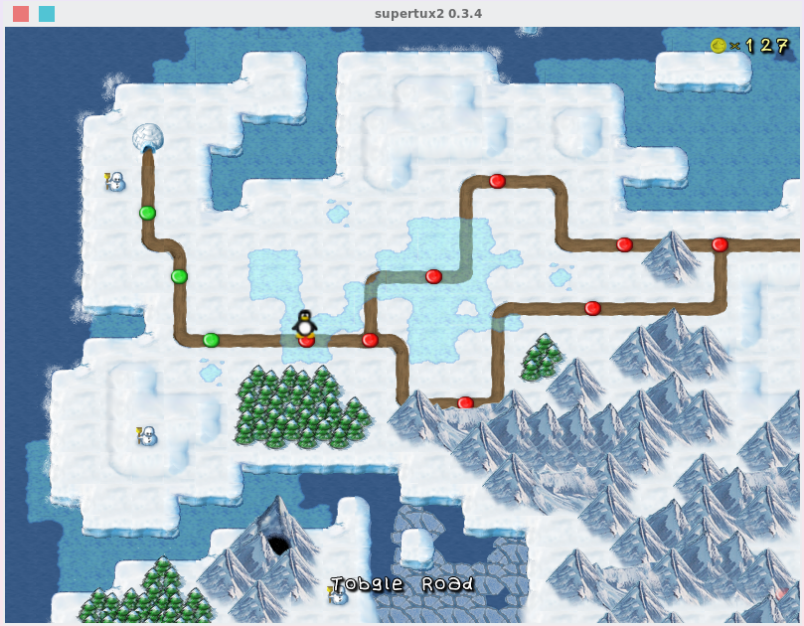
Many toy tools: Panda, Pravda, Pandora, $J\forall P\exists$, Proof lab, Hyperproof (Openproof project), Bonsai, `http://incredible.pm/`, etc.

Coq and Geogebra = Geocoq

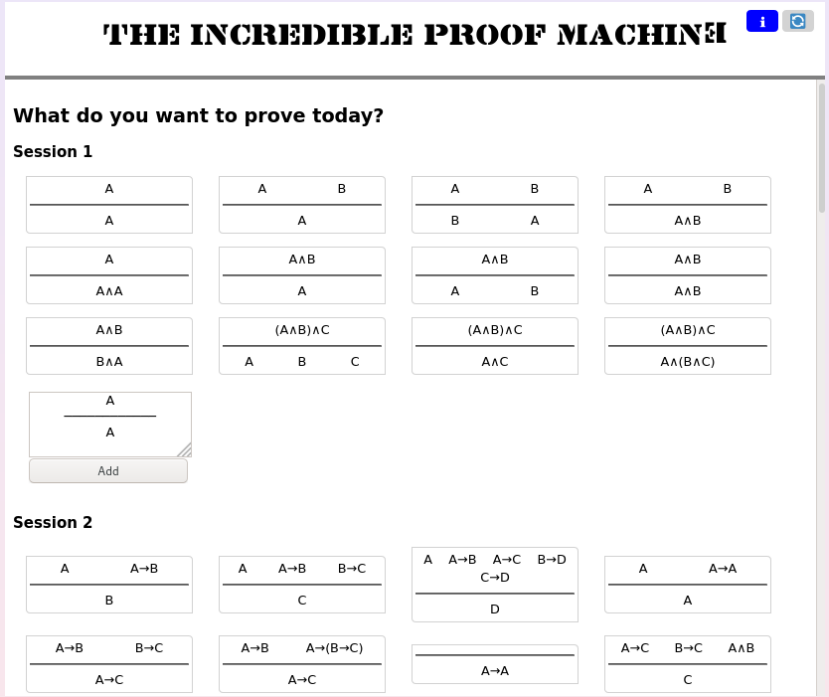
http://geocoq.github.io/GeoCoq/



Progressive exercises - interface inspired from video games



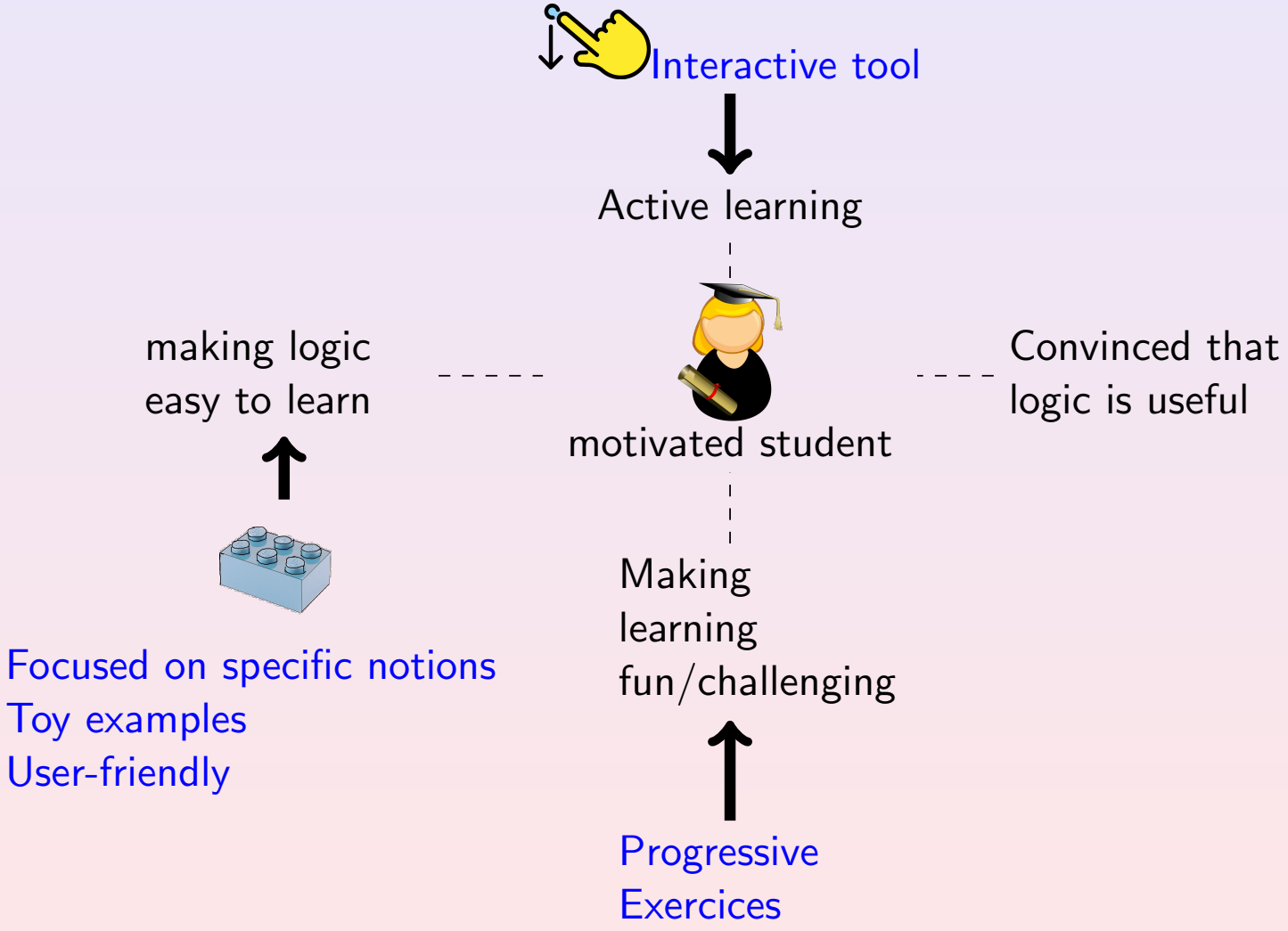
Progressive map in SuperTux



Progressive map
in the incredible proof machine

Outline

Why tools for teaching logic?



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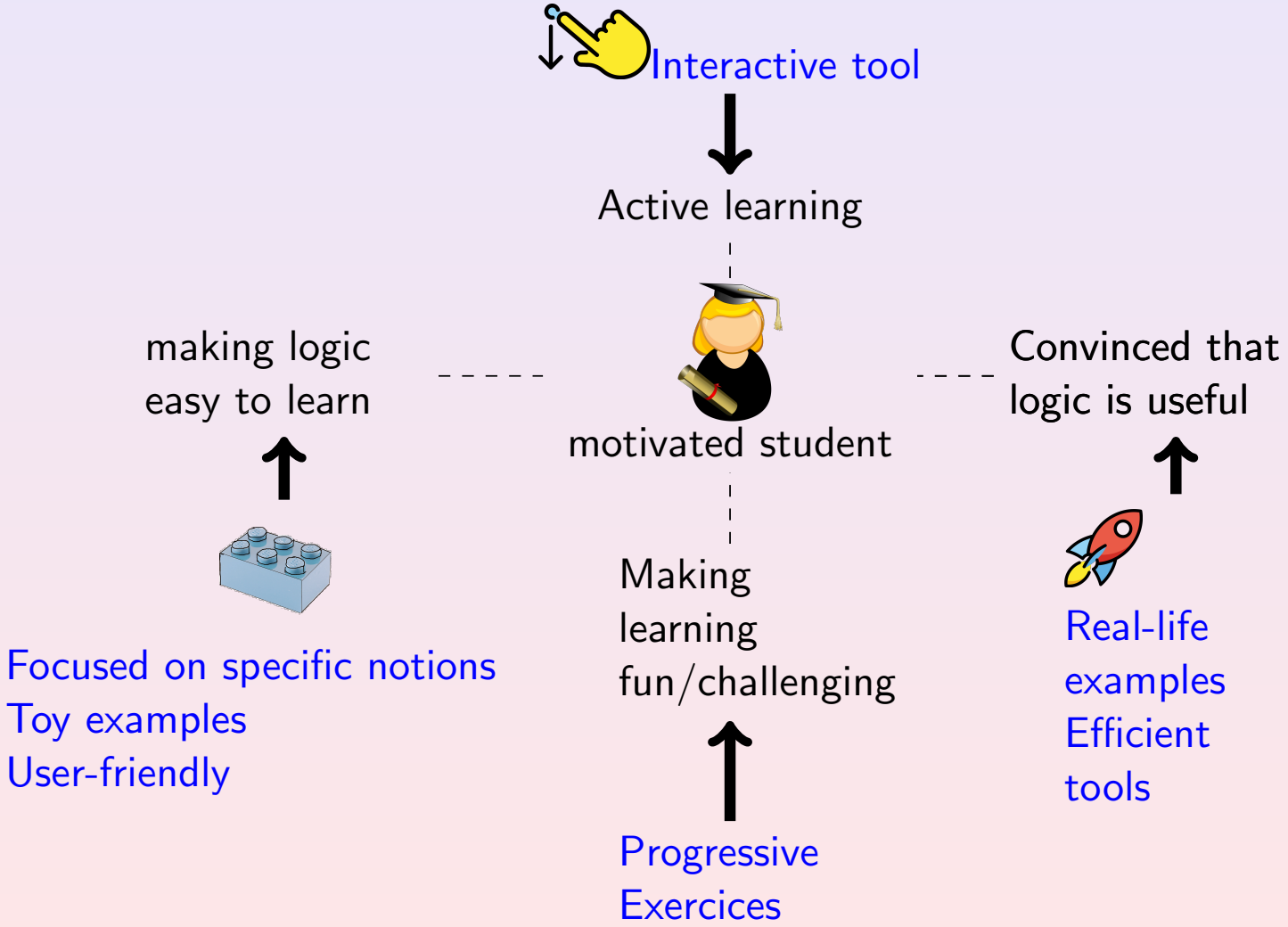

Why tools for teaching logic?

Interactive tool

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Active learning

motivated student

making logic easy to learn

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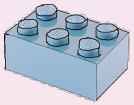


Focused on specific notions
Toy examples
User-friendly

Convinced that logic is useful

↑

Real-life examples
Efficient tools

Making learning fun/challenging

↑

Progressive Exercices

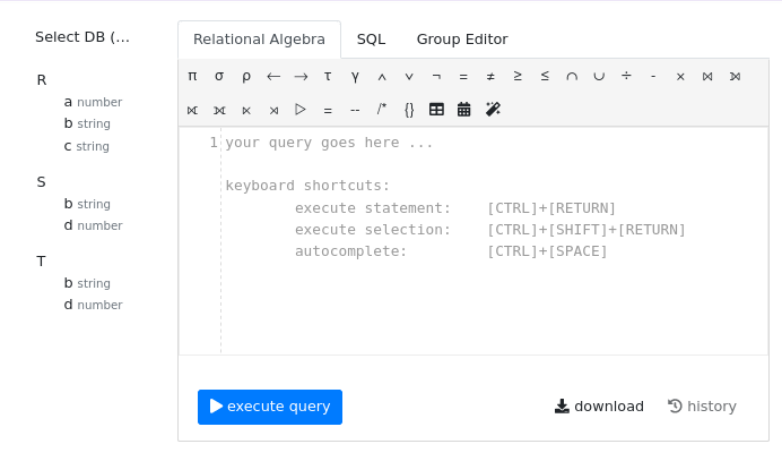
→ Contradictory needs

Outline

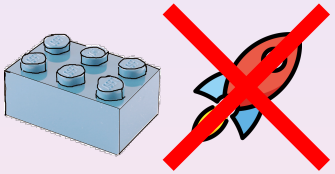
Database

RelaX

`https://dbis-uibk.github.io/relax/landing`

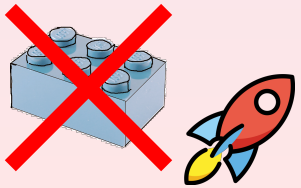


Specific for teaching relational algebra



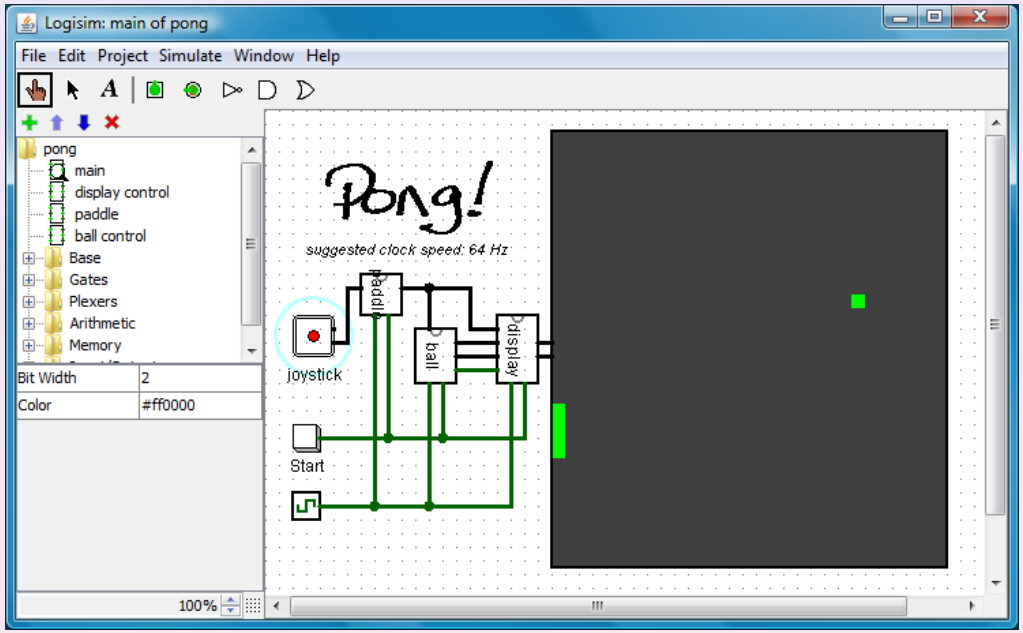
VS

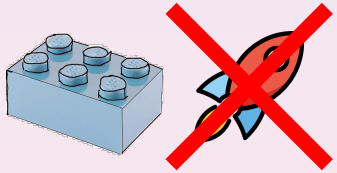
Direct manipulation of SQL



Outline

CPU design



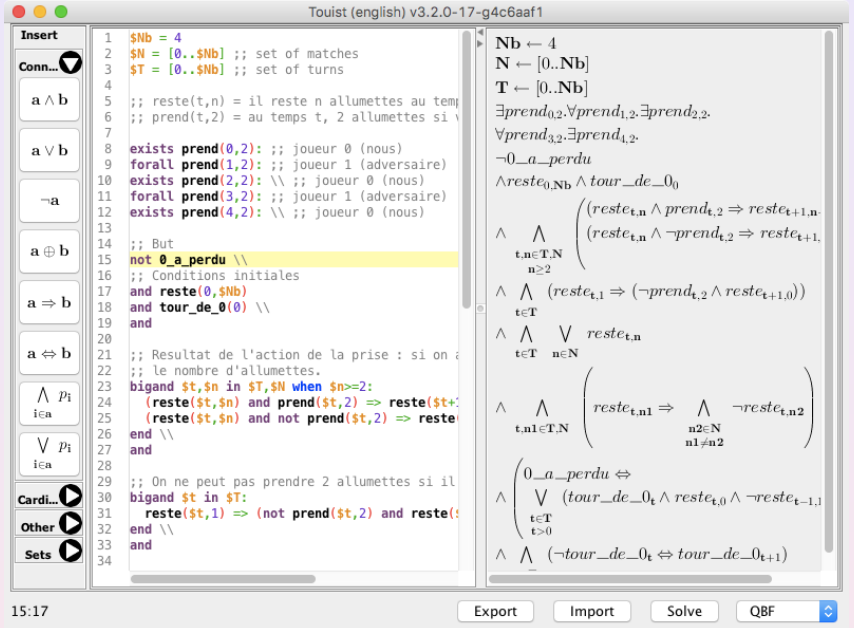


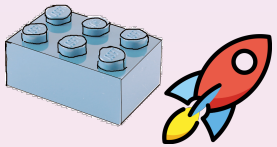
Logisim for student to understand computer architectures

- Draw Boolean circuits
- Simulation

Outline

SAT, SMT, FO Solvers + user-friendly software

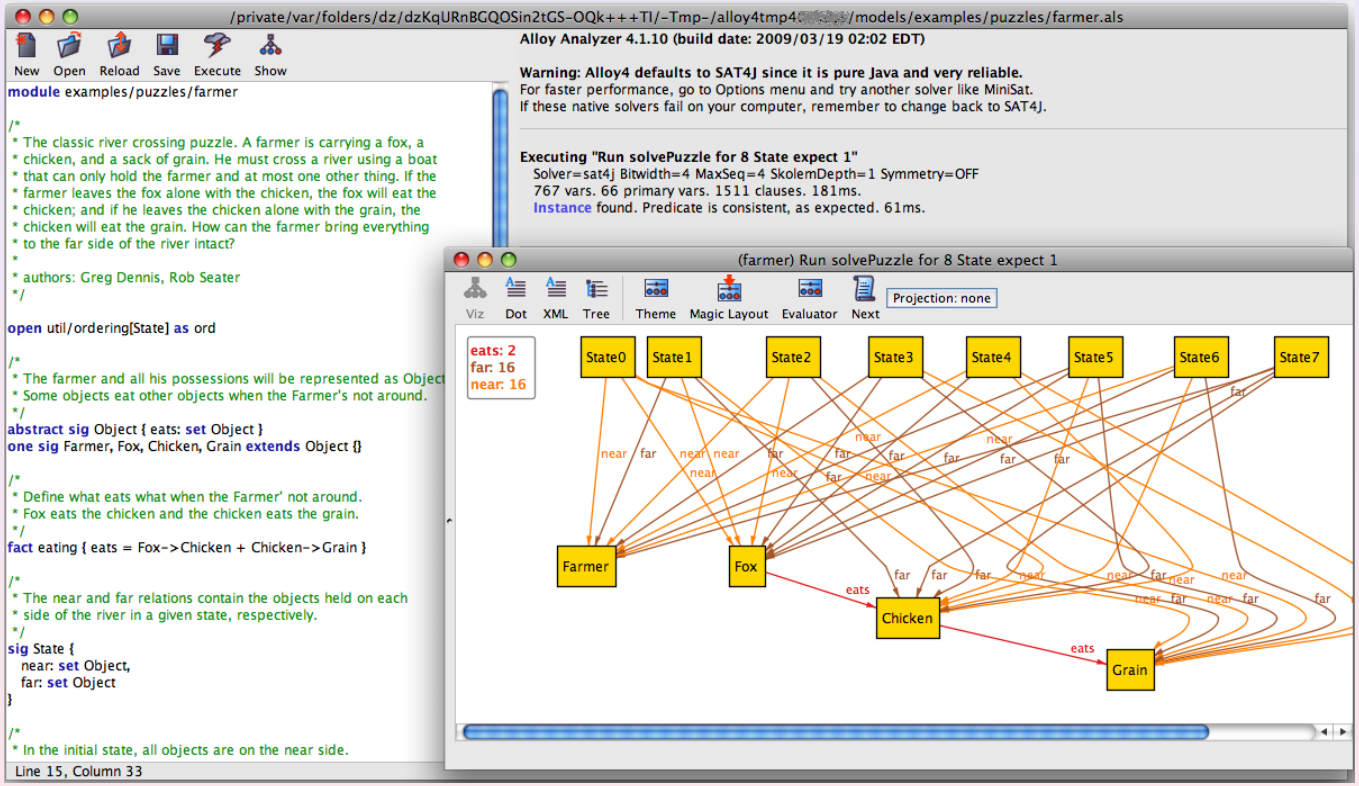


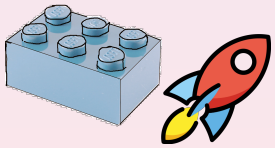


Course with Logic4Fun, Touist

- Modelling problems (e.g. Sudoku, planning, etc.)
- Appreciate the succinctness/expressivity of a logical language
- Compare the size of encodings VS the complexity of the logic

Higher-level constraint languages





Prolog, Answer set programming `https://potassco.org/`, Alloy

Teaching algorithmics behind logic

$$(p_1 \vee \neg p_3) \wedge (p_2 \vee p_3 \vee \neg p_1)$$

DIMACS format

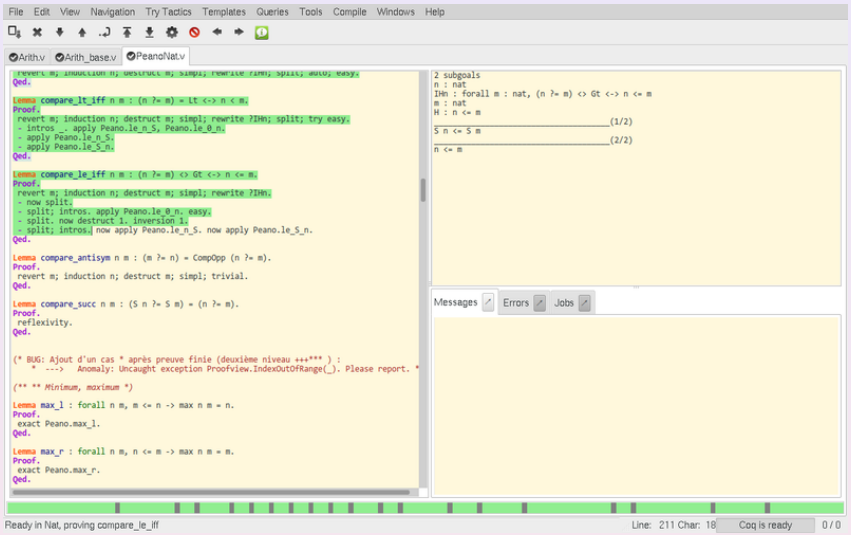
```
1 -3 0
2 3 -1 0
```

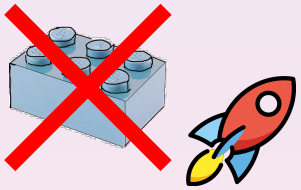
Implement a SAT solver from scratch

- Direct reductions to the DIMACS format
- DPLL algorithm
- Heuristics
- Backjumping and Clause learning

Outline

Proof assistant for program verification



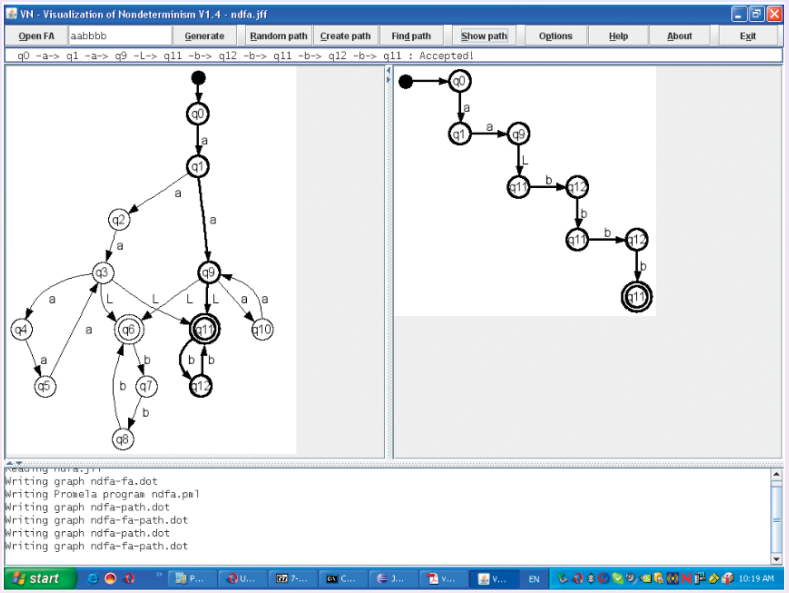


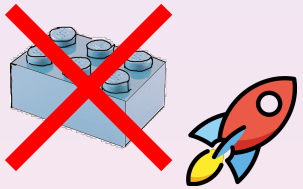
Course based on Scala and Isabelle/HOL

`http://people.irisa.fr/Thomas.Genet/ACF/`

- Either prove that a function is correct w.r.t. a specification
- or generate a counterexample

Model checking and temporal logic





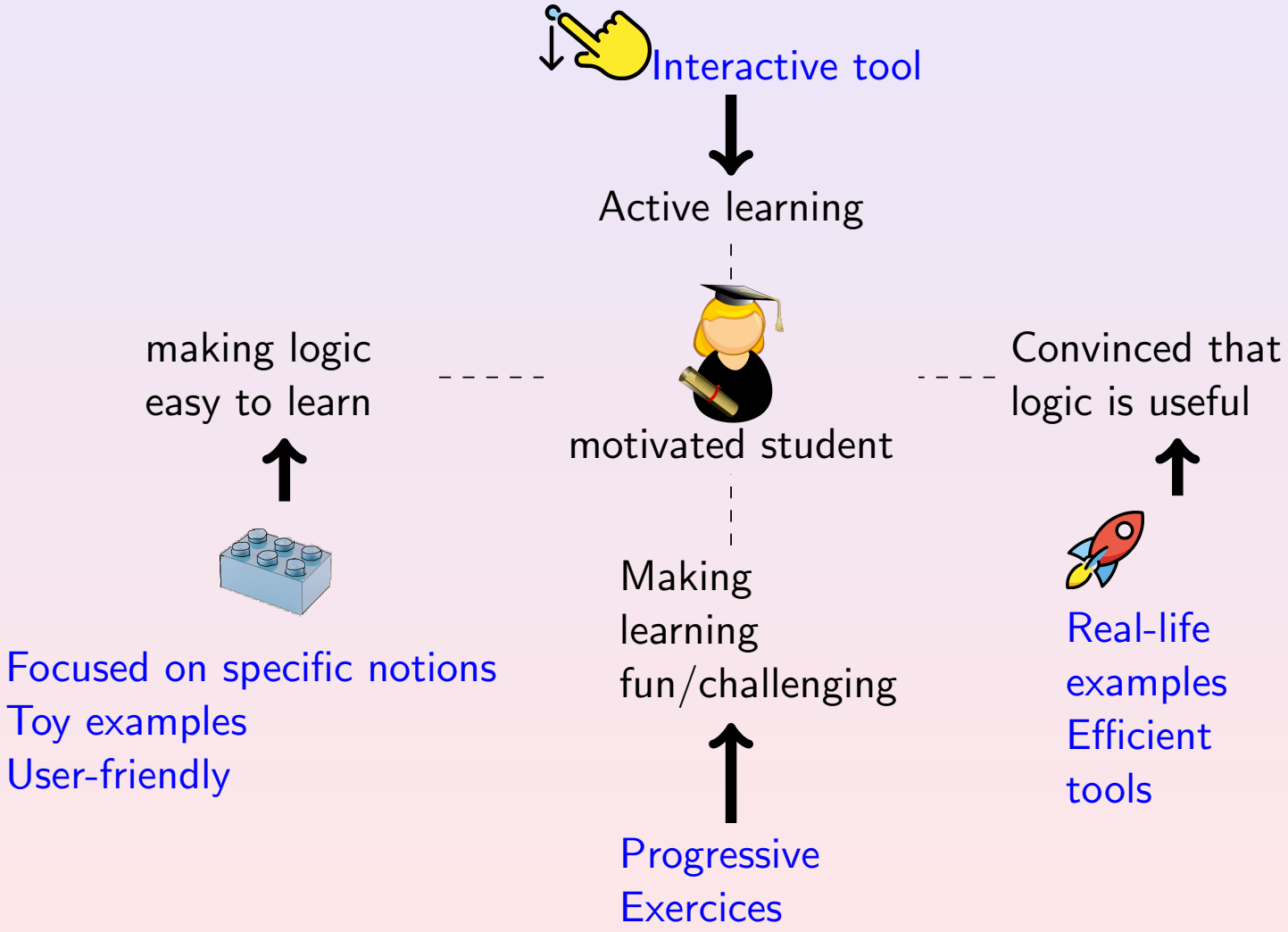
The Spin model checker is one of the leading verification tools used by professional software engineers, but to my surprise I found that it is eminently suitable as a teaching tool. *[Ben Ari, ACM 2010]*

`http://spinroot.com/spin/Doc/p40-ben-ari.pdf`

Other tools: NuSMV, uPPAAL, MCMAS, etc.

Outline

Summary: Why tools for teaching logic?



Outline

Learning analytics

How do we prove/measure:

- the benefits of using some tools?
- the quality of toy examples?
- the relevance of interactivity?
- the quality of the progression in exercises?

Outline

Tools are used and... resused!

"The SAT solver used as backend of Satoulouse a SAT GUI interface for teaching is SAT4J. The first advantage of this solver is that it is written in JAVA so it is easy to call it from the GUI."
[Gasquet et al. TICTTL 2011]

Designers of new pedagogical tools need:

- some other tools from the shelf
- Python and Javascript packages ready to use

Outline

Pedagogical tools: an opportunity to reach other people!

Example (s)

- Tools for logic and argumentation?
- Tools for logic and art?
- Tools for teaching logic to the machine learning community?
  - Logical Neural Networks. Logic for guiding learning
  - Boolean circuits as explanation for machine learning process
  - Describe goals in reinforcement learning with temporal logic.

Special thanks

- ICLA organizers
- Thomas Genet (IRISA, Rennes) (program verification)
- Simon Rockiki (ENS Rennes) (architecture)
- Zoltan Miklos (IRISA, Rennes) (database)
- Serena Vilata (INRIA, Sophia Antipolis) (argumentation)
- Srdjan Vesic (CNRS, Lens) (argumentation)
- Fahima Djelil (IMT Atlantique) (learning analytics)

Thank you for your attention!