

FOLL-E: Teaching First-Order Logic

PEG 2.0

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Whoami

- Simon Vandeveld
- Post-doctoral researcher @DTAI, KU Leuven, Belgium
- Research in logic-based AI
- Penchant for CompSci education
 - 10 yrs programming teacher for children (spare time)
 - First Codefever (<https://codefever.be>), then CoderDojo (<https://coderdojobelgium.be>)
 - lead of local CoderDojo



Are there resources for teaching logic to children?

No :-)

... but there are some *adjacent* works

In 1982, Kowalski wrote report on teaching Prolog to children ¹

→ mostly focused on teaching (logic) programming, not on declarative meaning of FOL

At uni level, e.g.,:

→ proof-based: Tarski's world², Hyperproof³

→ general: FOST⁴, LogicChess⁴

Kowalski, R. A. (1982). Logic as a computer language for children. ECAI, 2-10. ¹

Barwise, J., & Etchemendy, J. (1991). The Language of First-Order Logic. Center for the Study of Language and Information. ²

Barwise, J., & Etchemendy, J. (1992). Hyperproof: Logical reasoning with diagrams. ³

Mauco, V., Ferrante, E., & Felice, L. (2014). Educational software for first order logic semantics in introductory logic courses. ⁴

Why teach FOL?

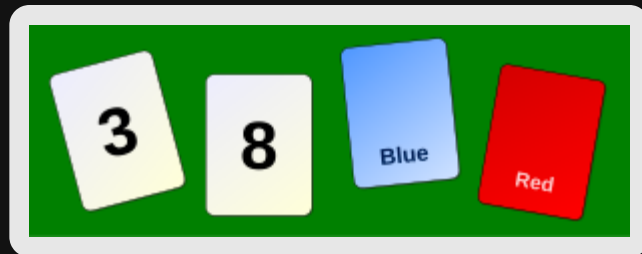
- Important foundation of maths, philosophy, compsci, ...
- Computational thinking
- A pillar of Artificial Intelligence!
- Sharpens reasoning skills, critical thinking

Why teach FOL?

Example: Wason selection task

Four cards, each with:

1. Number
2. Color



(image from Wikipedia)

Proposition: *If a card shows an even number on one face, then its opposite face is blue.*

→ which cards do you need to check to verify?

Solution: 8 and red

$$\forall x \in Cards : even(number(x)) \Rightarrow color(x) = blue.$$

Difficulties

- FOL by itself does not do *anything*
- Not "fun": no animation, sound, graphics, ...
- Steep learning curve
- Scary mathematical symbols ($\forall \in \Rightarrow \Leftrightarrow \mathbb{R} \dots$) to haunt your nightmares

→ can we build a better learning environment?

Difficulties

```

vocabulary V {
  type Country := {B, F, G, N, L}
  type Color := {Blue, Red, Yellow}
  borders: Country * Country -> Bool
  color_of: Country -> Color
}

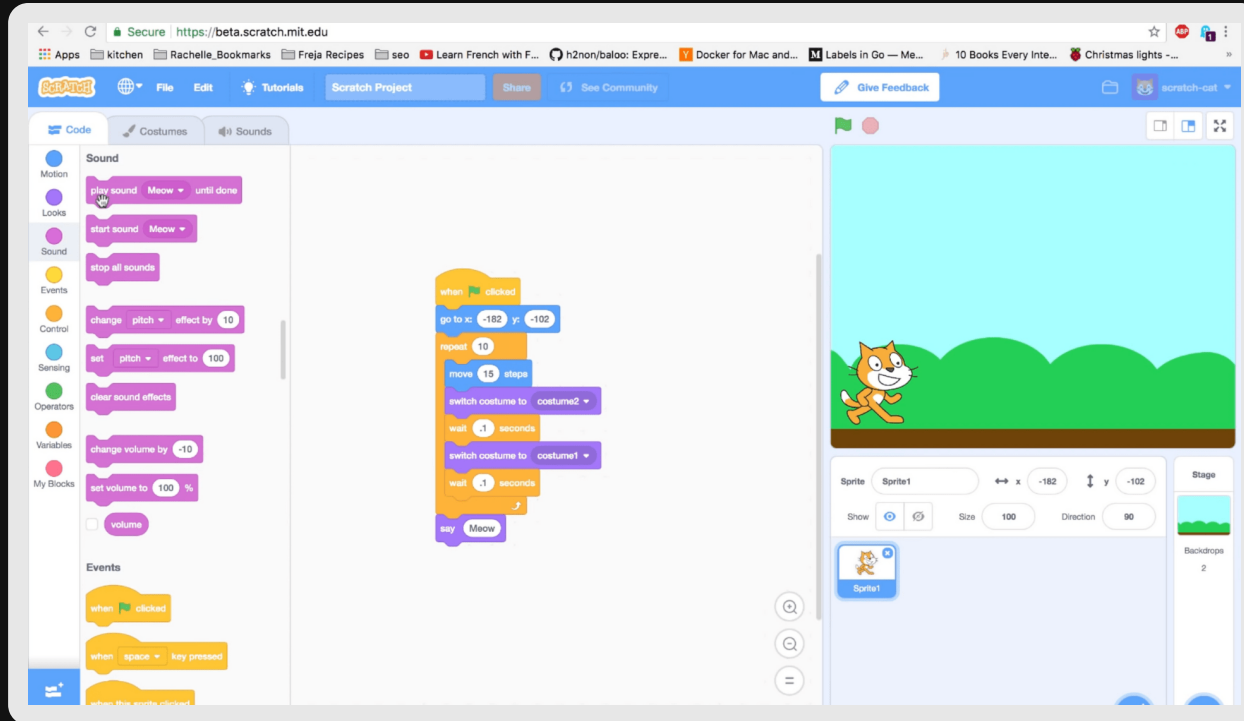
theory T:V {
  color_of(B) = Red.
  !c1, c2 in Country: borders(c1, c2) => color_of(c1) ~= color_of(c2).
}

structure S:V {
  borders := {(B, F), (F, G), (B, G), (B, N), (B, L), (L, G), (L, F)}.
}

procedure main() {
  pretty_print(model_expand(T, S))
}

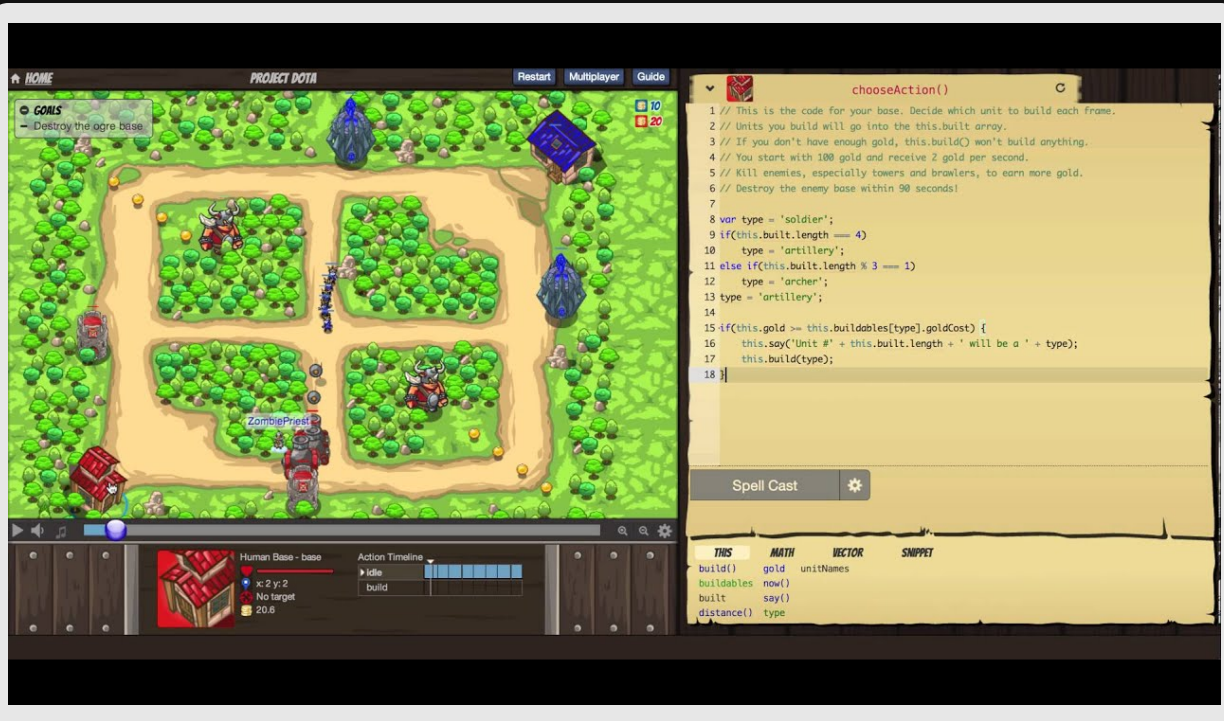
```

Scratch



<https://scratch.mit.edu>

CodeCombat



<https://codecombat.com>

Design Goals

Representation:

- No finicky syntax
- Clear structure
- Encourage experimentation, trial-and-error
- Encourage collaboration

Task:

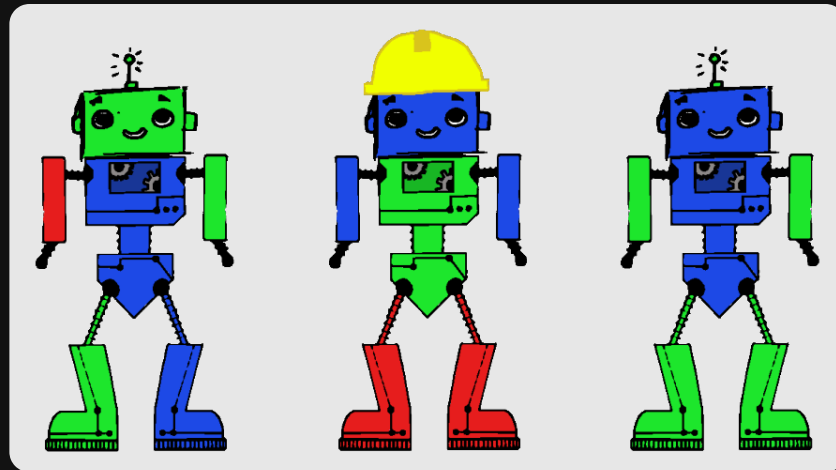
- Focus on model theory
- Clear and immediate feedback
- Gradually increase in difficulty
- Engaging and fun

→ But: what application domain?



Application domain

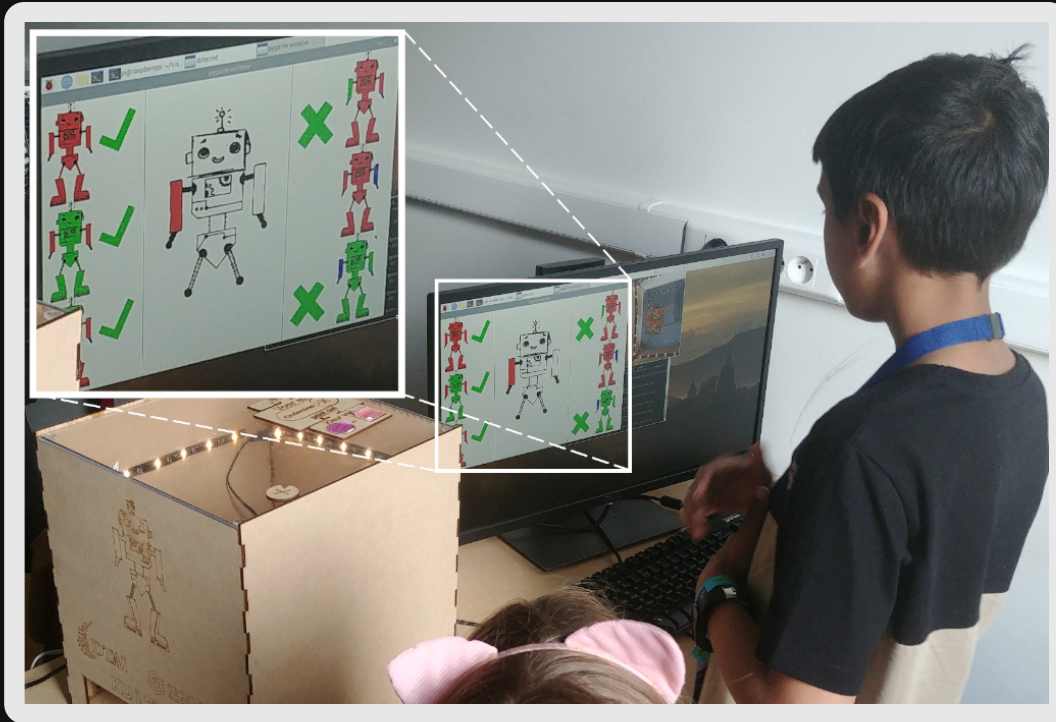
- Robot designs
- Fun, cartoony, colorful!
- Each component may have different color (RGB)
- Optional helmet



Task

- Shown 7 robots:
 - three "good"
 - three "bad"
 - one showing effect
- Goal: distinguish good from bad
- Explain this to computer
- 14 levels in total

Task

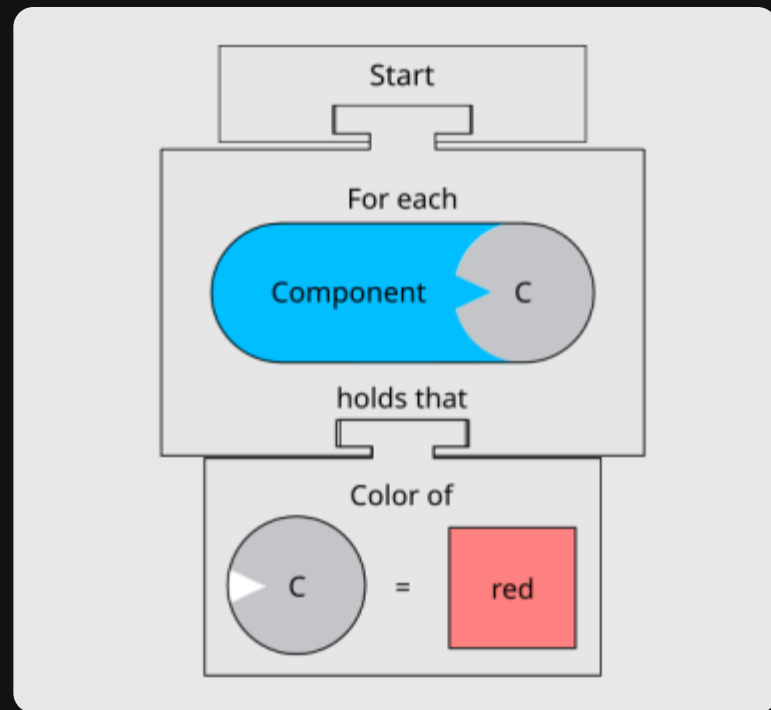


Using checkmarks and crosses, FOLL-E shows the effect of the rule.

FOL notation

- Blocks-based
- "Pegs-and-slot": syntax-free
- Fully generic, can cover all of FOL!

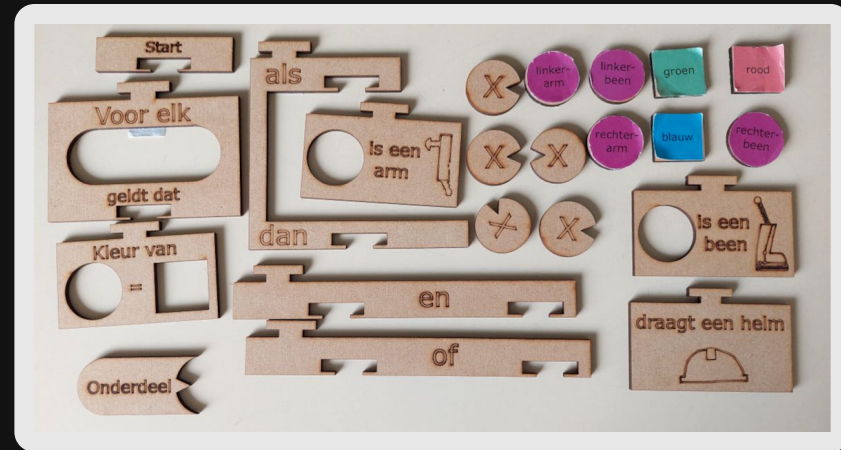
→ using mouse does not stimulate collaboration



Blocks expressing that all components are red.

FOL notation

- Laser-cut into physical blocks
- Engraved with intended meaning
- Tangible, puzzle-like
- Engaging and inviting



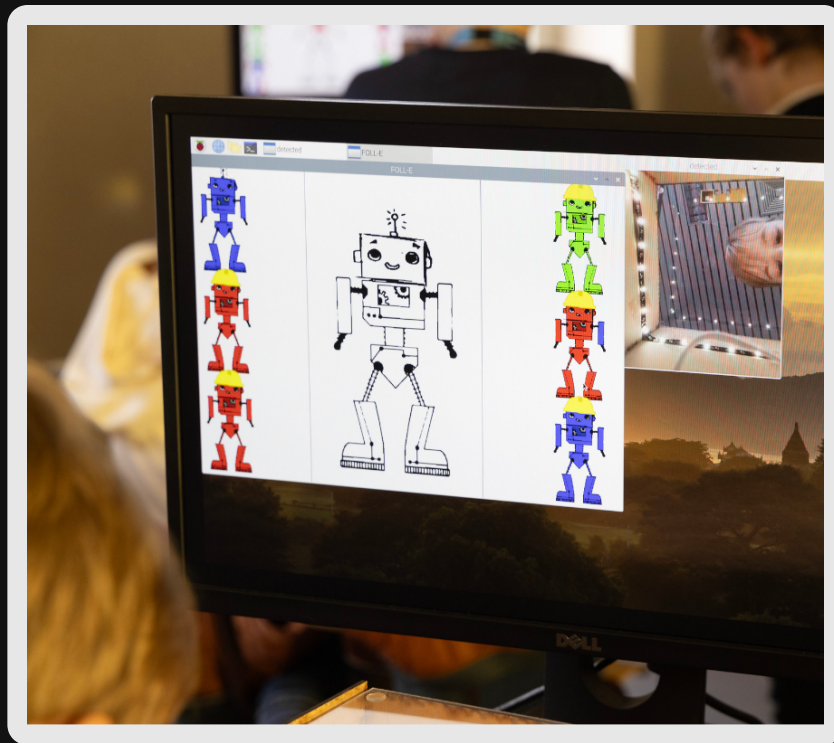
Laser-cut blocks, in Dutch

Components

FOLL-E comes in a box containing:

- Raspberry pi 3B+
- Raspicam
- LED backlight
- Set of blocks
 - Bottom side annotated using Aruco markers for detection

All you need is an HDMI monitor!



Application

- Built in Python
 - Pygame for interface
 - OpenCV for computer vision
 - IDP-Z3 as FOL evaluator (<https://www.IDP-Z3.be>)
-
- Whenever a full statement is detected, it is evaluated
 - Result is shown using checkmarks and crosses



Fully Open Source!

- <https://FOLL-E.com>
 - <https://gitlab.com/Vadevesi/foll-e>
 - Source code (GPLv3)
 - Everything ready to laser cut!
 - Boxes
 - Blocks
 - TODO: step-by-step guide on how to build it. (But pretty straightforward!)
- we are setting up a program allowing schools to loan out boxes for a day

Demo video

Foll-E: Short Demo



Thank you!

- <https://simonvandevel.de>
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- <https://FOLL-E.com>

Thank you

Slides: https://slides.simonvandevelde.be/2025_10_14/slides.pdf



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