maths Blocks

Visual blocks for mathematical syntax

www.mathsblocks.com

Supporting internalisation of mathematical syntax using blocks

Anthony Morphett David Wakeham

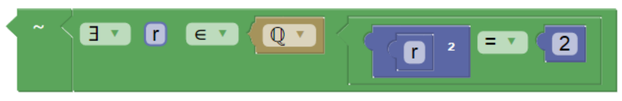
School of Mathematics and Statistics
The University of Melbourne

Project: Maths Blocks

An interactive system for constructing & manipulating mathematical expressions using virtual blocks.

Some basic blocks, which can be combined into compound blocks

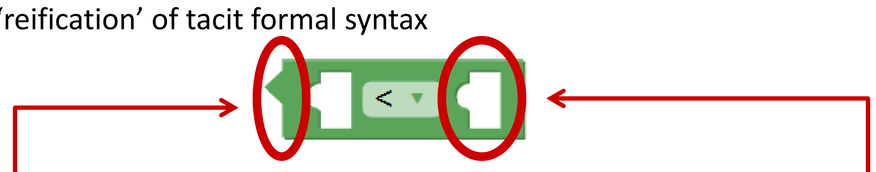
Blocks can be combined by dragging



Mathematical expression "~∃ r ∈ ℚ $r^2 = 2$" constructed with blocks

- Visual blocks correspond to syntactical elements
- Additional visual cues indicate syntactic categories (eg. types)

  ⟶ 'reification' of tacit formal syntax



Notch shape and block colour indicates block's 'output type'

Blank space indicates required input, shape indicates required 'input type'

- Visual grammar of blocks mirrors mathematical grammar

  ⟶ only syntactically valid statements may be constructed

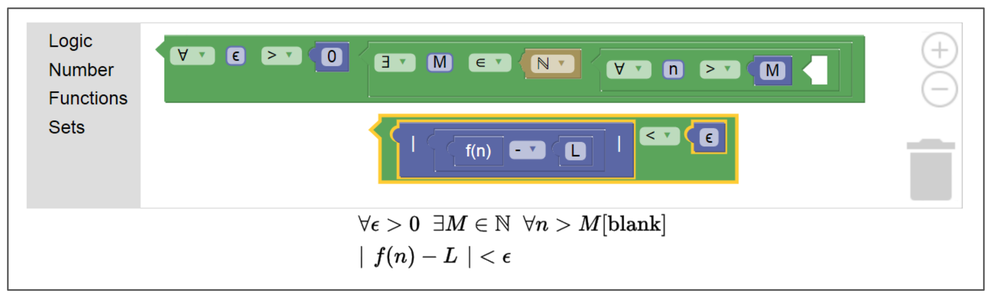
  ⟶ prevent syntax errors

- Web-based – runs in browser
- Flexible, multi-purpose framework
- Open-source
- Based on Blockly project by Google
- Inspiration from Scratch, App Inventor & other block languages

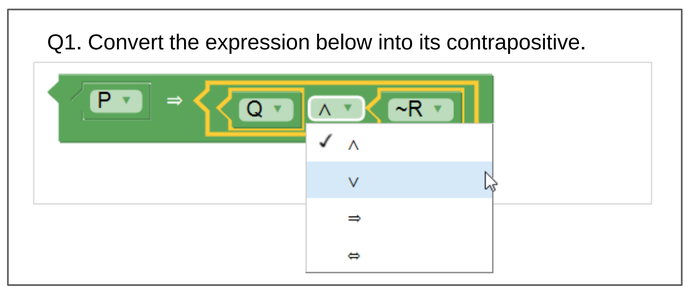
Rationale

- Mathematical syntax a common area of difficulty, in particular:
  - Quantifiers: $\forall \epsilon > 0$ $\exists M \in \mathbb{N}$
  - Logical connectives: $\wedge$ $\vee$ $\Rightarrow$
  - Relations: $< \leq \neq$
  - Set operators: $\in \cup \subset$
- Rarely taught explicitly/formally
- Students expected to master syntax informally through use
- Support learning with interactive activities
- Use visual cues to make formal syntax visible

Example: Blocks for first-order logic

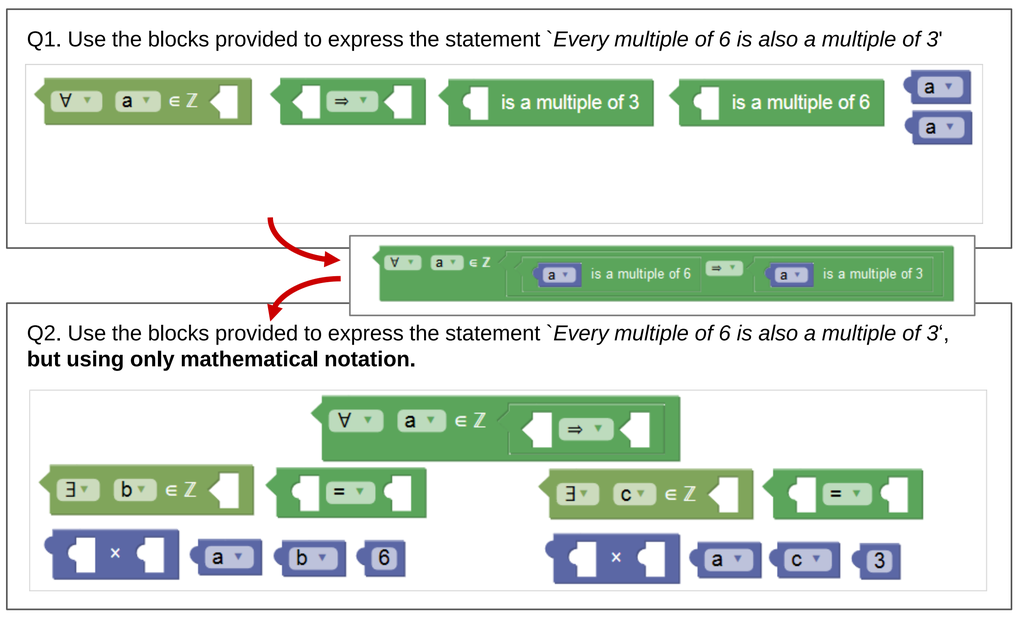


Workspace showing a construction in progress.
Constructed expressions are also shown in familiar typographical form below the workspace.



Manipulating a logic expression

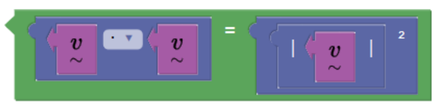
Example: Supporting semantic reasoning



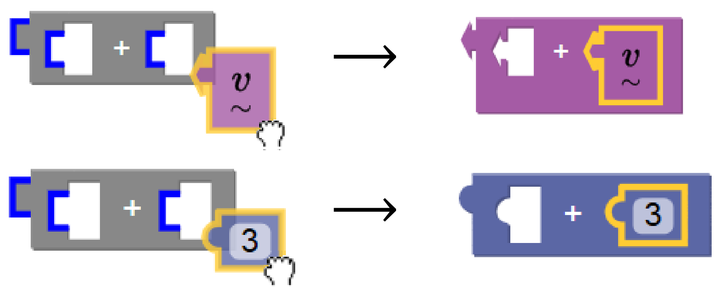
Sequence of exercises using 'higher-level' blocks.
Blocks provide scaffolding for syntax, allowing focus on semantics.

Example: Blocks for vectors and scalars

Block shape & colour help distinguish between vector, scalar quantities



A vector identity expressed with blocks



Block for abstract operation, eg. addition, takes on shape and colour of inputs

Research

Aim: To investigate how interactive graphical blocks can

- improve student awareness of syntactical structure
- improve students' ability to identify and construct meaningful and syntactically valid mathematical expressions

Methodology:

- Design-based research
- Student trials – pilot – 2nd year undergraduate analysis students
- Video analysis

Observations & conclusions: (preliminary)

- Block system has potential to increase awareness of and fluency with syntax
- Need carefully designed exercises with reflective component for best effect
- Students lean on natural language intuitions in absence of formal grammar rules
- High expressiveness (completeness) of block language is needed for negative feedback
- More work needed to see whether benefits transfer to offline context

Future directions:

- Wider coverage eg. set notation
- Use at lower levels, eg secondary schools

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