iSTOA: Artefacts for mathematical interactive learning exercises

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iStoa: Artefacts for mathematical interactive learning exercises
Real vs Virtual

Real learning environment

Real world teaching environment are rich of artefacts

Definition

An artefact is a preexisting object instrumented in a unique manner to support a learning process. It’s an intermediate between the learnt concept and the internal representation of the learner.

Example

Dice, tokens, paper, pen, etc.
Virtual learning environment

- Focus on the exercise nature: multiple-choice questions, short answers, jumbled sentences, crosswords, matching exercises
- Teacher can write contents based on these pre-programmed elements
- Focus on exercise and not artefact
Virtual artefacts

- Computerised environments give us new type of artefact: micro-world one is an interesting example.
- Virtual learning environment can be enriched with artefacts, (i.e. not only the exercise nature)
Pedagogical artefact based activities

In our iStoa learning environment, the basic unit is the artefact:

- **artefact** – dice, grid, tokens or complex as geometric canvas and it is parametrised.
- **exercise** – based on an artefact set, it follows a common model and it is parametrised.
- **pedagogical scaffolding** – based on a parametrised exercise sequence. It is anchored in a knowledge network.
iStoa model on artefact based activity

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Our methodology

- We concentrate on the multiplication learning domain
- We use the literature of the domain assisted with a mathematics teacher
- Analysis of a large body of pedagogical documentation
- In the next slides we expose a few examples...
The product $a \times b$ is introduced with a rectangle of dots. A rectangle of dots $3 \times 4$ can be represented as $3 + 3 + 3 + 3$, 3 lines of 4 dots, 4 columns of 3 dots, etc.
Partial dot rectangle

It is used to understand that the number of dots in a rectangle depends on the number of columns and lines.
Series of series

To understand the writing $a \times b$ as a general way to express series of item series, we associate this writing to different type of series, not only to rectangle of tokens.

Example
Artefact extraction

Visual decomposition of a product

To calculate the product of two numbers, number decomposition is a key point. A rectangular grid cut in two pieces is used as a support to decompose a product like $6 \times 7$ as $6 \times 5 + 6 \times 2$.

Example

$$6 \times 7 = (6 \times 5) + (6 \times 2)$$
Visual decomposition of a product with numbers

A more general artefact to visualise product decomposition, enhanced with number input fields.

Example
Expanded vertical writing of a product

To abstract step by step the writing of a product, an expanded form is introduced. It is just a vertical sum of the simplified products elaborated with the decomposition artefact.

Example

\[
\begin{array}{c}
\times 3 \\
14 \\
\text{3} \\
\text{12} \\
\hline
\text{4} \\
\text{2}
\end{array}
\]

\[
\begin{array}{c}
14 \\
\times 3 \\
\hline
12 \\
\text{3} \\
\hline
42
\end{array}
\]
Live example...

In the $iStoa$ environment...
Pros & Cons

Pros:
- Virtual artefacts help to design activity closer to real pedagogical activities
- Parametrised artefacts ensure good re-usability in activities of one teaching domain

Cons:
- Writing artefacts is resource expensive and not in the scope of teachers
- Artefacts are hardly reusable across different teaching domains
- The mimic of real, physical artefacts is not the end of the story, computerised environment open the perspective of new artefact impossible in the physical environment (ie interactive geometry)
Conclusions

- From a pedagogical literature corpus we detected used artefacts for one teaching domain (multiplication at year 9).
- In the literature, we analysed from a macro-level (pedagogical activities) down to a micro-level (what are the artefacts?).
- In the computerisation process, we followed a reverse path: implementation of parametrised artefacts, then interactive exercises and pedagogical scaffolding.
- Our methodology ensures we implement parametrised artefacts compatible with the initial pedagogical aim found in the literature.
- In our \textit{iSTOA} project, pedagogical scaffolding are anchored in a notion network. It models the teaching domain and the learners knowledge. We plan to use it for semi-automatic learning process.

See you at \url{http://www.istoa.net}