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Fingers or rods? Using AI block play recognition to endorse children's mathematical re-worldings

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Research topic

What is a wooden cube? In the Kindergarten pedagogy of Friedrich Froebel (1782-1852), children and caregivers or teachers are encouraged to playfully transform a cube through storying and actions:

for example, the cube can be now a table on which something is placed for the child. Again, it can be a stool on which the mother places her feet; again, a chair on which she sits with the child; again, the hearth on which something is to be cooked. (Froebel, 1895, p.99)

Similarly in mathematics classrooms children may be encouraged to transform wooden and plastic manipulatives, such as interlocking cubes and Cuisenaire rods, into 'real world' objects through storying and actions. For example, in enacting a word problem, cubes may become oranges or cupcakes etc, which are physically gathered by the child. In 'bar modelling' these cubes (aka 'oranges' etc) may be lined up in a row to facilitate acoustic counting, and eventually this row may be storied as having a 'length', then drawn as a rectangular 'bar' and labelled with a symbolic number.

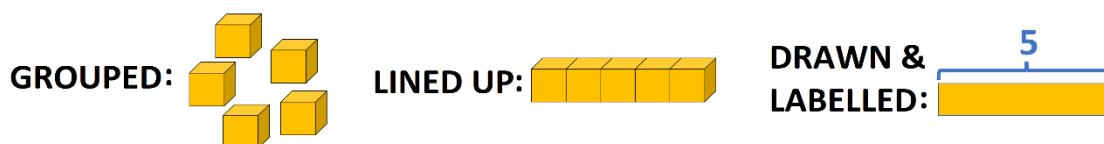


Figure 1: Typical bar modelling stages eg 5 oranges as cubes grouped, lined up and drawn as a length

In my doctoral study I am interested in studying these mathematical transformations, or 're-worldings', of wooden blocks, through children's storying and actions, often modelled and endorsed by teachers or caregivers, books, videos or apps. To support this research I was keen to explore technological tools, such as AI object detection to recognise and record children's positioning of blocks. In collaboration with a software developer, PySource, with seedcorn funding from the Bristol Digital Futures Institute, we developed an app in Python which uses artificial neural network (ANN) algorithms to recognise the placements of Cuisenaire rods on a tabletop, from a webcam, in near real time, and records the data in a spreadsheet for analysis. The rod recognition is triggered when the webcam detects no movement, ie when children take their hands away from the tabletop. In addition, the app can be programmed to respond to the placing of rods with sound files, such as speaking the colour, or length of the rod. It can also tell when two rods are placed end to end, or in parallel, and generate simple audible mathematical sentences accordingly, such as "two plus three equals five".

The app is still at a prototype stage, the ANN has only been trained on a small sample set of images so far, and requires further training and user-testing before it can be used as a reliable experimental research tool in the field. We hope as a tool it may eventually support a variety of experiments and methodologies. However, for the purposes of testing the app technically with users in a 'realistic'

experimental scenario, we developed a theoretically ‘light’ methodology to inform task design, based on analysis of observed discourse as a highly reductive artificial Wittgensteinian ‘language game’, consisting of actions and interwoven language, where the actions are restricted to a child’s placements of Cuisenaire rods on a table, and the language is restricted to the app’s utterances, and questions, or ‘challenges’, posed spontaneously by the researcher, in the form of ‘Can you make it say...?’

Method



Figure 2: The app processes a webcam feed of rods placed on a tabletop and ‘speaks’ the lengths

In a local primary school in southwest England, Year 1 children (aged 5-6), who were not familiar with Cuisenaire rods, were invited individually to play a ‘game’ with rods, the app and a researcher, where the researcher challenged the children to ‘make it say’ certain numbers or sequences, such as the number five, or the two times table, or a sum, by placing rods on the tabletop. The children have to infer by experiment the ‘rules’ of which utterance is triggered by the placement of which rod. The tabletop block play was video recorded and the dialogue, and images grabbed by the app, analysed.

Results

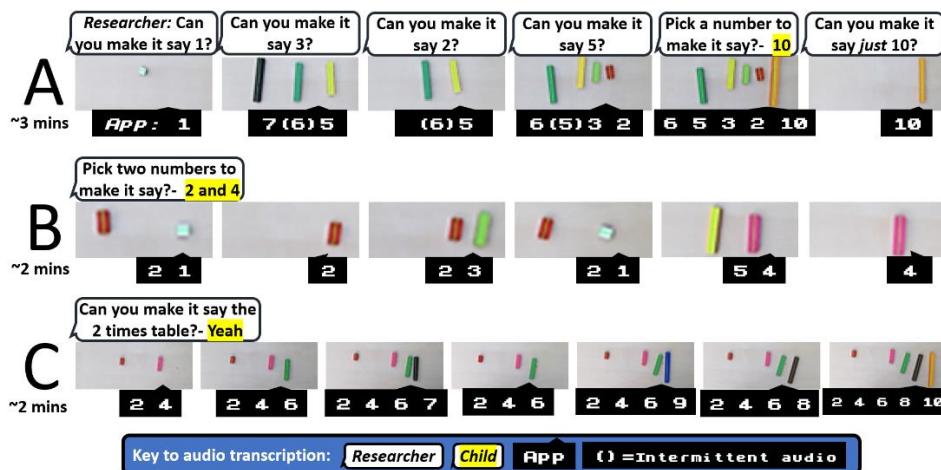


Figure 3: At first rods are placed as if ‘fingers’ eg 3 rods for ‘3’, then after experimenting , as lengths

As an early technical test we do not claim the tool was yet reliable enough for a rigorous experiment, with occasionally intermittent detection of some rods. However, on analysis of one 7-minute clip we observed an interesting shift in actions – of rod placements – consistent with a shift in inferred ‘rules’ from rods as ‘counters’ or ‘fingers’, eg placing 3 rods to (unsuccessfully) ‘make it say 3’, to rods as proportional ‘lengths’ eg placing 2, 4, 6, 8, 10 rods to (successfully) ‘make it say the 2 times table’.

References

- Froebel, F. (1895). *Friedrich Froebel's pedagogics of the kindergarten* (Vol. 30). D. Appleton.
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