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# **Incorporation of an AI object recognition app and Cuisenaire rods in a *child-rods-app-task* body-artifact dynamic functional system**

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## **Introduction and theoretical framing**

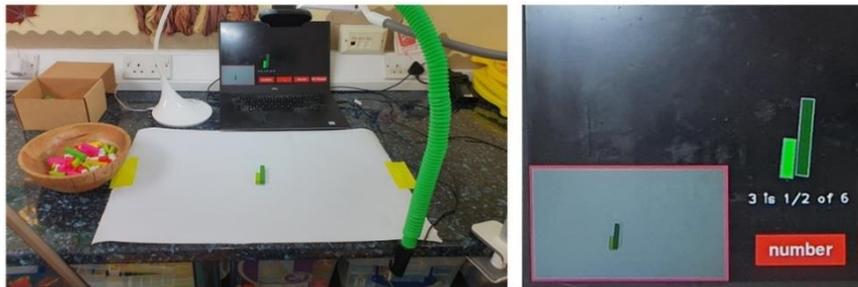
This poster describes early results of a work-in-progress pilot study of young children's use of Cuisenaire rods using an AI-based object recognition app. The aim of the pilot is to develop iteratively an experimental methodology for my doctoral study of children's block play as a dynamic system incorporating children and blocks. The initial methodological research question is: how can AI object recognition be incorporated as a controllable intervention in observing embodied instrumentation in *child-rods-app-task* body-artifact functional systems? Early tentative findings are reported.

The method piloted is to introduce an AI-based app that recognises the child's placement of Cuisenaire rods on a tabletop and can be programmed to generate audio – such as speech, or musical notes – and/or images on screen, in response, according to the blocks' lengths and positions. This responsive audio and/or imagery is designed as a researcher-controllable intervention in the multiple perception-action loops hypothesised to occur during block play, creating a *child-rods-app-task* dynamic system. In the pilot the researcher verbally set an initial task for the children to do with the app, however in future iterations the app could be programmed to generate these tasks.

Theoretically, the research design draws on Shvarts et al.'s (2021) concept of dynamic body-artifact functional systems, in which use of tools such as wooden blocks, and interactive apps, can be understood as extensions of a dynamic human body-brain system which is constantly anticipating and adjusting to the environment through multiple feed-forward and feedback perception-action loops (p.450). The *child-rods-app-task* can thus be seen as a system emerging through the child's development of body potentialities, for instance stored neural responses, in exploring the affordances of the rods and app, driven by multi-level intentionalities stimulated by the task (p.452).

## **Method**

An app was developed in collaboration with a software developer that uses AI to recognise placements of standard wooden Cuisenaire rods on a tabletop via a webcam feed, and to respond in near-real-time with computer-generated audio and imagery. The app was programmed to recognise rod arrangements once the image from the webcam feed was stable, i.e., when hands were removed from the field of view, and recorded snapshots of these stable images (see Figure 1), as well as generating data on numbers and lengths of rods in each snapshot in a spreadsheet, for subsequent review and statistical analysis. Ten 5-6-year-old children in a primary school, not familiar with Cuisenaire rods, were invited to interact with the app, singly or in pairs, for around 10-15 minutes each. After an initial period of free exploration, they were given a task, e.g. "Can you make it say the two times table?" The children's manipulation of rods was video-recorded, and any dialogue (including app-generated speech) transcribed and synchronised via timecodes with the snapshots.



**Figure 1: The experimental set-up of a webcam overlooking rods placed on the tabletop (left). The feed is processed by the app which generates graphics and audio with optional subtitles (closeup, right)**

## Results and discussion

Though tentative, as based on a small pilot study and early prototype app, findings suggested:

- All participants quickly explored, and then adapted their perception-action/body potentialities to the affordances of the *rods-app-task* system, e.g., withdrawing their hands from the tabletop once an intended arrangement was set, and waiting attentively to hear the app say the rod lengths. Then, unprompted, iteratively (1) adjusted the rods (2) withdrew hands and (3) listened, in a loop until the app spoke the intended sequence, e.g., the 2 times table (Figure 2).



**Figure 2: three snapshots from one child's 4-minute sequence of attempts to make the app say the 2 times table, iteratively placing rods, removing hands, and listening, before rearranging the rods**

- The anthropomorphisation of the app by several children in language of it *seeing* rods and *saying* rods' lengths etc., activities which closely reflect those the children are familiar with in using block manipulatives, may offer evidence in support of Shvarts et al.'s hypothesis that an artifact is incorporated into a body-artifact system when it "substitutes a part of the student's previously developed body potentialities" (p.452), e.g., verbal labelling of blocks.
- In contrast with Shvarts et al.'s experiments using a screen-based app to give visual feedback on student's gestures, the AI object recognition app enables audio-only feedback without a screen, indeed sometimes children focused on the rods rather than the screen once they understood the screen only replicated the video view. This may enable comparative testing of distinct perception-action loops and body potentialities in future, e.g., aural vs visual.

## Format

The poster illustrates the above method and findings with additional snapshots with transcriptions.

## Reference

Shvarts, A., Alberto, R., Bakker, A., Doorman, M., & Drijvers, P. (2021). Embodied instrumentation in learning mathematics as the genesis of a body-artifact functional system. *Educational Studies in Mathematics*, 107(3), 447–469. <https://doi.org/10.1007/s10649-021-10053-0>