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New approaches to researching the pedagogical benefit of representations and interactivity

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New approaches to researching the pedagogical benefit of representations and interactivity

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Abstract:
Recent developments in digital data capture technologies are opening up new possibilities for researching the alleged pedagogical benefits of computer-based representations. This research suggests how integrated analysis of learners' gazes, actions, writing, sketches and utterances can better illuminate subtle cognitive strategies. In particular, the findings challenge the commonplace that it is always beneficial for learners to see and manipulate dynamic multiple representations.

The study, involving eighteen participants, explored how strategies for tackling certain tasks varied when these tasks were presented in different computer-based 'instantiations':

- **Static**: non-moving, non-changing, non-interactive
- **Dynamic**: capable of animation following keyboard inputs
- **Interactive**: directly manipulable using a mouse

The tasks involved multiple mathematical representations: numbers, graphs and algebra.

Participants' shifts in attention were recorded using an unobtrusive eye-tracking device and screen capture software. Use of the keyboard and mouse was automatically logged, while utterances and gestures were captured using a camcorder. Participants' notes and sketches were recorded in real-time using a Tablet PC (Figure 1).
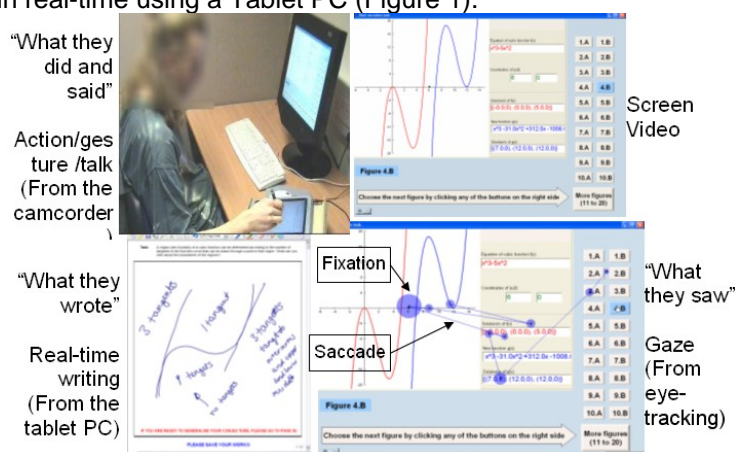

Figure 1: Examples of the video data captured

Note in the gaze video that the blue lines ('saccades') indicate paths the eyes took across the screen; while the blue circles ('fixations') show where the eyes lingered for a length of time, indicated by the size of the circle.

By logging the frequency and duration of fixations on defined areas of the screen over time, it is possible to study participants' attention in detail. So, for Participant 1 (P1), for example, 75% of his fixations were on graphs, and just 3% on algebra. But his attention changed over time: far from P1's attention to numbers being evenly distributed during the task, it was concentrated near the start, and then he largely shifted attention from numbers to graphs thereafter.

Integrating the various data sources can provide the context for such attentional shifts that utterances alone might fail to illuminate. The study took advantage of the latest analysis software that facilitates synchronisation and coding of multiple digital video streams, software events, fieldnotes and transcripts. This enabled the identification of a range of cognitive strategies. Two classes of strategies of particular interest identified were 'representation-specific' strategies (for viewing and manipulating particular representations) and 'imagining' strategies (in which participants appear to be engaged in mental visualisation, as evidenced, for example, by eye movement over the path of an invisible curve).

The varied reasons for shifts between strategies are not yet well understood, but we would argue that this kind of empirical approach offers real potential for exploring relationships between computer-based representations, interactivity, and learning. For example, it was found that participants' choice of strategies generally varies between tasks; but that for a given task, participants tend to use similar representation-specific strategies to each other. It was also found that imagining strategies were more likely when tasks were presented in static instantiations than in dynamic or interactive instantiations.