Drawing to Support Animation Comprehension

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Abstract. This study explored the contribution that self-generated drawings may make to the immediate and delayed comprehension of an animation depicting a complex scientific phenomenon. Sixty-seven 7th graders participated in a pre-test, post-test, and delayed post-test design. After viewing an animation of Newton's Cradle, the students produced three progressively condensed sets of drawings to depict what they had observed. They then produced a written verbal explanation of what happens in the animation. Multiple regression analyses revealed that the overall quality of the drawings predicted both immediate and delayed comprehension. Finer-grained analyses indicated that the graphic representation of an inconspicuous yet highly relevant aspect (motion transmission) predicted students' performance two months after viewing the animation.

Keywords: Animations; Self-generated drawing; Learning with animations; Comprehension of dynamics.

Introduction

Educational animations are increasingly common in learning environments supported by technology. Designers of these environments typically regard dynamic visualizations as intrinsically beneficial for learning and superior to static graphics. However, the supposed benefits of animations are disputable (Tversky, Morrison, & Bétrancourt, 2002). Why then do animations sometimes not live up to designers' expectations? The construction of an internal representation in the form of a mental model from external representations lies at the core of comprehending an animation (Lowe & Schnotz, 2008). Lowe (2003) found that learners are more likely to extract perceptually salient information and neglect more subtle but conceptually relevant aspects. This can prejudice their construction of a high quality mental model from the external representation.

One way to overcome this and other animation interpretation problems may be to implement instructional interventions that encourage more productive processing of the available information. *Writing to Learn* approaches suggest a possible strategy. Although there are various explanations for why writing to learn can be effective in different content areas, its benefits are generally attributed to the transformative activity that occurs in the mind of the learner during writing (Klein, 1999; Tynjälä, Mason, & Lonka, 2001). Perhaps equally beneficial forms of processing activity could also be invoked by other forms of information transformation. For example, self-generated drawing is capable of supporting learning of text-based information (Van Meter & Garner, 2005). However, generative drawing *per se* may also be useful, irrespective of whether or not textual information is the starting point. Benefits could arise from the internal processes that a learner engages in during the transformation of one representation into another. In this study we explored self-generated drawing as a strategy for learning from an animation.

Two research questions guided our study: 1) Does the information depicted in various sets of self-generated drawings help to predict immediate comprehension of the Newton's Cradle phenomenon? Further, what specific aspects of the phenomenon are significantly related to immediate comprehension? 2) Do self-generated drawings also help to predict delayed comprehension?

Method

Participants. Sixty-seven students in seventh grade (29 girls and 38 boys) were involved in a pre-test, post-test, and delayed post-test design[1].

[1] We are very grateful to Gaia Mantovani for data collection.

Materials. Participants viewed an abstract animation illustrating the behavior of pendulums in a five-ball Newton's cradle. This device consists of a set of balls that are suspended from cords and free to swing to-and-fro. The animation was presented alone, without written or spoken accompaniment.

Self-generated drawings. Participants were asked to produce three sets of depictions (with six drawings, three drawings, and one drawing respectively) to represent in an increasingly condensed way what they had observed in the Newton's Cradle animation. Inter-rater reliability for the scoring of the three sets of depictions, measured by Cohen's *k*, was .89, .93, and .94, respectively. Participants' prior knowledge, interest in science, and achievement in science were also measured.

Immediate comprehension. After drawing, participants' were asked to explain in writing what happens in the animation. Inter-rater reliability for coding of the explanations was .88.

Delayed comprehension. After two months, participants were asked again to explain what had happened in the animation they viewed. Inter-rater reliability for this coding was .95.

Results

Correlational analyses showed that the three total scores for each set of depictions correlated positively with comprehension at both times, as well as with each other. Prior knowledge, interest, and achievement in science also correlated with drawings and comprehension measures.

Immediate Comprehension

Multiple regression analyses were performed with immediate comprehension as the criterion variable and the total scores for each set of depictions (controlling for prior knowledge, interest, and achievement in science) as predictors. Participants who generated higher-quality drawings were more likely to comprehend the scientific phenomenon at a deeper level, as revealed in their verbal descriptions written after viewing the animation (Table 1).

Table 1: Standardized β Coefficients of Regression Analyses for Variables Predicting Immediate Comprehension (N = 67), with Total Scores for Each Depiction Set Entered Separately

	Six drawings	Three drawings	One Drawing
	B	*B*	*B*
Variables			
Step1			
Prior knowledge	0.27*	0.27*	0.27*
Interest in science	0.25	0.25	0.25
Achievement in science	0.10	0.10	0.10
R^2	0.20**	0.20**	0.20**
Step 2			
Prior knowledge	0.12	0.16	0.19
Interest in science	0.14	0.14	0.23
Achievement in science	0.02	0.07	0.04
Total score for drawings	0.55***	0.46***	0.30*
R^2	0.45***	0.39***	0.28***
Change in R^2	0.25***	0.19***	0.8*

* = $p < .05$; ** = $p < .01$; *** = $p < .001$

In addition, finer-grained regression analyses revealed that the representations of the phase of motion transmission, which is not perceptually salient but is conceptually relevant, was a predictor for the sets of six (β = 0.33) and three drawings (β = 0.28), but not for the final summarising graphic representation.

Delayed Comprehension

A similar series of regression analyses was also computed to examine the unique contribution of self-generated drawing to delayed comprehension. Outcomes indicated that students who repeatedly self-generate drawings of a higher quality and students who with higher achievement in science, were more likely to show superior comprehension of the phenomenon two months after viewing the animation. From finer-grained regression analyses, the high relevance (but low salience) component of motion transmission emerged as the only aspect in all sets of depictions that contributed to delayed comprehension (β = 0.28, 0.25, and 0.25, respectively).

Discussion

For all sets of self-generated drawings, richer and more accurate the drawings were associated with higher levels of comprehension while prior knowledge of the topic was linked to post-test comprehension in the first step of the regression analysis. Delayed comprehension was also predicted by the overall quality of all three sets of drawings. In this case achievement in science also uniquely contributed to it in the second step of the analysis, while in the first step prior knowledge and achievement in science were significant predictors. Finer-grained analyses revealed that the graphic representation of motion transmission in all three sets of drawings predicted students' performance two months after viewing the animation. This outcome raises the possibility that participants who represented the animation conceptually rather than perceptually basis were able to construct a relatively stable mental model of the phenomenon. Further studies are warranted to tease out the contribution that self-generated drawings may make to the construction of internal representations from scientific animations. Given the exploratory nature of the study, a control group was not involved. This methodological limitation should be addressed in subsequent investigations. As dynamic visualizations are increasingly common in multimedia learning environments, a fully designed experimental investigation about the use of self-generated drawing, which may improve the effectiveness of learning from animations, is an important direction for future research.

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